# Evidence for understanding the implications of improving the dietary quality of school lunches

by

Jillian Marie Joyce

B.S., University of Pittsburgh, 2009
M.S., University of Pittsburgh, 2011

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Food, Nutrition, Dietetics and Health
College of Human Ecology

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# Abstract

The overall aim of this dissertation was to better understand the implications of improving the dietary quality (DQ) of school lunches. Chapter 2 includes a cross-sectional content analysis to determine whether there were significant differences in nutrient content and DQ between a best practice school lunch menu (BPM, with maximized DQ, created regardless of feasibility) and a typical school lunch menu (TM, with average DQ, from an actual school district). Results showed large significant differences in several important macro- and micro-nutrients and in DQ, favoring the BPM. These findings suggest the possibility for statistically and clinically significant variation in nutrient content and DQ of school lunches meeting National School Lunch Program (NSLP) nutrition standards. Building on that possibility for variation, and given schools report financial concerns as barriers to providing high DQ lunches, chapter 3 describes a cross-sectional content analysis to determine whether there were significant differences in nutrient content and DQ between middle school lunch menus from 85 Kansas school districts by socioeconomic status (SES) and rurality. The average DQ across all districts was 62.0±4.0 (Healthy Eating Index (HEI) score) out of 100, indicating a need for improvement. There were minimal differences in nutrient content and DQ by SES and rurality, suggesting efforts to improve DQ of Kansas school lunches should be applied equally across all SES and rurality categories. To determine best practices for improving DQ of school lunches, chapter 4 includes a critical review with the aim of developing school lunch best practices based on child DQ recommendations, and implementation techniques encouraging selection and consumption of healthier school lunches. Twenty-five articles were synthesized, creating a list of evidence-based school lunch best practices. Findings provide evidence that if implemented during menu and service planning, these best practices may help to improve school lunch DQ and increase

selection and consumption of higher DQ lunches by schoolchildren. With best practices determined, chapter 5 describes a randomized crossover trial that included 36 elementary school-aged participants for the purpose of investigating the acceptability and feasibility of best practice school lunches (BPSL, implementing best practices, HEI score=90–95/100) as compared to typical school lunches (TSL, meeting baseline NSLP nutrition standards, HEI score=70–75/100). Results showed minimal differences in acceptability (taste, plate waste, and hunger) and feasibility (cost, equipment, and skill to prepare meals). However, preparation time requirements for BPSL were significantly longer than for TSL (~four-fold). When BPSL and TSL were offered concurrently, participants selected TSL significantly more frequently than BPSL (TSL=83.3%, BPSL=16.7%). These findings suggest that BPSL may be as acceptable and feasible as TSL, but when served concurrently, schoolchildren will likely choose the TSL. Collectively, results from this dissertation provide evidence that there is a need for improvement in the DQ of school lunches across the state of KS, which is likely to be feasible and acceptable, challenging previously reported barriers. This improvement may be accomplished by implementing best practices for higher DQ school lunches across rurality and SES categories. Collectively, these results could inform key stakeholders in policy- and decision-making.

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Approved by:

Major Professor
Sara Rosenkranz, PhD

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A Priori Dietary Quality Score (APDQS)

Academy of Nutrition and Dietetics (AND)

Analysis of variance (ANOVA)

Baltic Sea Diet Score (BSDS)

Best Practice School Lunch (BPSL)

Best Practice School Lunch Menu (BPM)

Blood pressure (BP)

Body mass index (BMI)

C-reactive protein (CRP)

Calories (kcal)

Cardiovascular disease (CVD)

Child Nutrition Program (CNP)

DASH Diet Score (DASHDS)

Diet Quality Score (DQS)

Dietary Approaches to Stop Hypertension (DASH)

Dietary Quality (DQ)

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Identification (ID)

Institutional Review Board (IRB)

International Units (IU)

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Kilograms (kg)

Low Density Lipoprotein cholesterol (LDL)

Meal condition (MC)

Mediterranean Diet Quality Index for Kids (KIDMED)

Mediterranean Diet Score (MDS)

Meters (m)

Micrograms (mcg)

Milligrams (mg)

Millimeters of mercury (mmHg)

Monounsaturated fat/ fatty acids (MUFA)

National Center for Education Statistics (NCES)

National Health and Nutrition Examination Survey (NHANES)

National School Lunch Program (NSLP)

Ounce (oz)

Polyunsaturated fat/ fatty acids (PUFA)

Randomized Controlled Trial (RCT)

School Nutrition Dietary Assessment IV (SNDAIV)

Sigma Plus Statistical Software (SPSS)

Socioeconomic status (SES)

Standard deviation (SD)

Sugar-sweetened beverage (SSB)

Triglycerides (TG)

Typical School Lunch (TSL)

Typical School Lunch Menu (TM)

United Kingdom (UK)

United States (US)

United States Department of Agriculture (USDA)

USDA Center for Nutrition Policy and Promotion (CNPP)

USDA Food and Nutrition Service (FNS)

Waist-to-hip ratio (WHR)

Years old (yo)

Youth and Adolescent Food Frequency Questionnaire (YAQ)

Youth Healthy Eating Index (YHEI)

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cannot wait to translate what I learned to the school nutrition setting. Thank you also to Dr. Lotta Larson for agreeing to be on my committee and for your interest in health in the school setting. It is exciting, empowering, and a joy to share that passion with all of my committee members.

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To end, not only have we together gone far, but I can’t wait to see where we together go next.

# Dedication

Steve Jobs once said, “The people who are crazy enough to think they can change the world are the ones who do.” I am crazy enough to think that I can change the world, that I can change the future health of a nation through the dietary quality of school lunches. My parents instilled this lofty notion in me from a young age. They encouraged me to shoot for the stars because if I missed, they would catch me. What did I have to lose? I shoot for them still, but I no longer have just my parents to catch me. I now also have my husband to catch me and better yet to propel me even further towards my dreams. He has given up more to support my dreams than anyone could ever imagine. Thus, I dedicate this work to my parents and my husband, who allow me to take on the world and make it a better place through nutrition.

# Chapter 1 - Introduction

## Definition of Dietary Quality

Dietary quality (DQ) is an objective measure defining how healthful a meal or dietary pattern is by determining and scoring how closely food consumption follows scientifically- or government-established guidelines for a healthful diet.[1] Recently, nutrition science has shifted focus away from individual nutrients toward DQ, allowing researchers to investigate the effects of the whole diet, rather than a more reductionist view of individual dietary components.[1]

To measure DQ, there are at least 80 known scoring systems worldwide. Some of the most commonly used DQ scoring systems include the Healthy Eating Index (HEI), the Diet Quality Index (DQI), the Diet Quality Score (DQS), and several variations of each of these measures, as well as the Mediterranean Diet Score (MDS).[2] Dietary quality scoring systems include measures of nutritional adequacy, balance, moderation, and/or variety. Scores are usually out of 100 points, with higher scores signifying higher DQ, and thus greater compliance with guidelines for a healthful diet. Using the HEI as an example, which measures compliance with the Dietary Guidelines for Americans, higher scores can be obtained through consumption of greater quantities of total fruit, whole fruit, total vegetables, dark green and legume vegetables, whole grains, dairy, total protein foods, seafood and vegetarian proteins, and healthier fats (i.e., monounsaturated and polyunsaturated fats). Additionally, scores can be improved through consumption of lower amounts of refined grains, added sugar, sodium, and saturated fat.[3] According to the USDA Center for Nutrition Policy and Promotion (CNPP), a HEI score of 0–51 is considered “poor” DQ, 51–80 “needs improvement,” and 80–100 is considered “good” DQ.[4]

## Importance of Focusing on Dietary Quality

Focusing on DQ is important, as numerous studies have shown the association between DQ and health, psychosocial, and academic outcomes. Many of these outcomes will be discussed in much greater depth in later chapters. Overall, in terms of health outcomes, higher DQ has been shown to be associated with lower risk of overweight, obesity, and numerous chronic diseases, in children as well as adults.[2,5,6] Higher DQ has also been shown to be associated with improved learning, cognition, and behavioral functioning.[7-9] Thus, improving DQ could lead to a longer, healthier, more productive life.

## Impact of Dietary Quality in Childhood

Focusing on DQ is important, as noted above, but why focus on DQ in childhood? The obesity epidemic currently affects 36.5% of US adults and costs the US $147 billion annually in medical costs.[10] Effective interventions, including improving DQ of the American diet, are becoming increasingly important. This is especially true in child and adolescent populations, as future adult dietary behaviors are determined in childhood.[11] Thus, childhood is a key time for intervening to improve DQ of Americans.

## Primary Disease Prevention and Academic Promotion through Dietary Quality of School Lunches

Based on the evidence presented above, the National School Lunch Program (NSLP) seems to be an ideal vehicle for primary prevention of child and adult obesity and chronic disease, as well as promotion of academic performance and optimal behavioral functioning. The NSLP is a federally funded Child Nutrition Program (CNP) offered in public and non-profit private schools through the USDA Food and Nutrition Service (FNS).[12] The goal of the NSLP is to provide nutritionally-balanced meals to children that are low-cost or free, and available every school day.[12] According to the FNS, in 2017, 4.9 billion lunches were served through the NSLP, reaching 30.4 million US children.[13,14] With 53.7 million school-aged children in the US between the ages of 5–18 years,[15] the NSLP reaches approximately 57% of US school-aged children. Thus, the NSLP provides the opportunity for nutrition research and interventions to impact a large proportion of the US population.

In order for schools to qualify for reimbursement, or federal funding, for their school lunch program, they must meet NSLP nutrition requirements,[13] also commonly referred to as NSLP nutrition standards or guidelines. The requirements include minimum daily and weekly amounts of food components that must be offered.[16] For example, for 9–12th grades, school lunches must offer 1 cup of fruit, 1 cup of vegetable, 2oz equivalent of grains, 2oz equivalent of meat or meat alternate, and 1 cup of milk daily.[16] Within each of these food groups, there are additional specifications regarding what foods qualify for reimbursement. For example, grains must be whole grain rich.[16] These NSLP specifications help schools to ensure that they meet the individual nutrient requirements. For example, for 9–12th grades, school lunches must provide 750–850 calories, < 10% of calories from saturated fat, and < 1,420mg of sodium per day.[16-18]

## The Case for Further Improvement in Dietary Quality of School Lunches

The NSLP nutrition requirements were updated in January 2012, following the Healthy, Hunger-Free Kids Act, and in accordance with the then newly published 2010 Dietary Guidelines for Americans. The new nutrition requirements required schools to provide more fruits and vegetables, vary vegetable color and type, increase provision of whole grains, decrease added sugar and sodium, and lower saturated fat content.[16,19] These updates resulted in improved DQ of school lunches, as all changes increase HEI scores for total fruit, total vegetable, refined grain, added sugar, sodium, fatty acid ratio, and saturated fat subcomponents.

With implementation of, and meeting but not exceeding the 2012 NSLP nutrition requirements, DQ of school lunches receives a HEI score of 70–75 out of 100, based on the study presented in Chapter 2.[20] Despite this improvement, according to the USDA CNPP, the DQ of school lunches meeting baseline NSLP nutrition requirements still "needs improvement."[4,20] The HEI score needs to improve another 5–10 points in order to be considered "good" in terms of DQ.[4,20] Even though school lunches "need improvement," their DQ is significantly higher than that of the average US child's diet. According to the USDA CNPP, the average HEI score for the diet of US children, ages 2–17 years, is 55 out of 100, which is considered "poor."[21] Thus, the NSLP provides lunches of higher DQ than the average US child is receiving in general, but there is still room for improvement. Further improvement in DQ of school lunches could lead to further decreases in risk of overweight and obesity, numerous chronic diseases, as well as further improvement in learning, cognition, and behavioral functioning.

## Barriers to Improving Dietary Quality of School Lunches

Implementation of the 2012 NSLP nutrition requirement update has been slow, with only 14% of schools in compliance at the end of the first year.[22] School principals, foodservice directors, and foodservice workers claim that major barriers to implementation of higher DQ school lunches include concerns regarding acceptability and feasibility of resulting meals.[23-25] These barriers are reported as perceived barriers. There is minimal objective research regarding whether these barriers truly exist.

Following the 2012 NSLP update and major school lunch content changes, research has thoroughly evaluated plate waste differences,[26-32] minimally investigated cost differences,[27,32,33] and failed to determine taste test differences pre- and post-implementation. Thus, there is a lack of evidence regarding the true preferences of children for less healthful as compared to more healthful, higher DQ food options. There are also no studies evaluating important aspects of feasibility of improving school lunch DQ, such as employee skill needs, equipment needs, and time requirements to prepare meals. Without this valuable information, changes to school foodservice systems, in an attempt to improve DQ of lunches, will likely be ineffective, and the opportunity to improve child, and subsequently adult, eating behaviors will be missed.

Thus, the purpose of the studies within this dissertation was to better understand the implications of improvement in DQ of school lunches. In the first study (chapter 2), the purpose was to determine whether there were significant differences in nutrient content and DQ between a typical school lunch menu (TM) from an actual school district and a best practice school lunch menu (BPM) created to optimize nutrition regardless of feasibility through a cross-sectional content analysis of six weeks of each menu type. Based on the results of this study, the second study (chapter 3) was a cross-sectional content analysis comparing nutrient content and DQ of six weeks of 85 middle school lunch menus from Kansas to determine whether there were significant differences in nutrient content and DQ of middle school lunch menus meeting NSLP requirements by socioeconomic status (SES) and rurality. Based on evidence from the first two studies, the third study (chapter 4) aimed to critically review previous research on child DQ recommendations and implementation of healthy school lunches, and to develop healthy school lunch best practices based on the evidence from the review. With evidence from the first two studies and evidence-based school lunch best practices established, the fourth, and final, study was a randomized crossover trial investigating differences in acceptability by elementary schoolchildren and feasibility for school foodservice operations of best practice school lunches

(BPSL) with higher DQ and best practices implemented and typical school lunches (TSL) with average DQ and meeting baseline NSLP nutrition standards.

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# Chapter 2 - Variation in Nutritional Quality of School Lunches Meeting NSLP Guidelines

This is the accepted peer-reviewed version of the following article: Joyce JM, Rosenkranz RR, Rosenkranz SK. Variation in nutritional quality of school lunches with implementation of National School Lunch Program guidelines. *Journal of School Health*. 2018;88:636–643. 

## Abstract

**BACKGROUND:** School lunches must meet National School Lunch Program (NSLP) requirements to receive reimbursement. The purpose of this study was to determine whether there are significant differences in nutrient content and nutritional quality between two menus meeting NSLP requirements.

**METHODS:** A cross-sectional content analysis compared six weeks of a typical school lunch menu (TM) from an actual school district to a best practice school lunch menu (BPM) created by a Registered Dietitian based on Child and Adult Care Food Program (CACFP) best practices and Dietary Guidelines for Americans (DGA) healthy meal pattern recommendations. Daily nutrient content was determined using nutrient analysis software. Nutritional quality was computed using Healthy Eating Index 2010 (HEI).

**RESULTS:** For nutrients required for analysis, the BPM was lower in calories ($p = .001$), saturated fat ($p < .001$), and sodium ($p < .001$) and higher in protein ($p < .001$), carbohydrate ($p = .004$), and fiber ($p < .001$). For other nutrients of concern, the BPM was higher in vitamin A ($p < .001$), vitamin D ($p = .003$), phosphorus ($p < .001$), and magnesium ($p < .001$). The BPM had higher HEI scores for nutritional quality ($p < .001$).

**CONCLUSIONS:** Results indicate the possibility for significant variation in nutritional quality of NSLP-qualifying lunches. Using CACFP best practices and DGA recommendations may significantly impact school lunch dietary quality.



**Keywords:** Child nutrition sciences, adolescent nutrition sciences, food policy

# Introduction

The National School Lunch Program (NSLP) is a federally assisted meal program found in public and non-profit private schools and childcare institutions with the purpose to provide healthy food to children in order to combat hunger and obesity.[1,2] As a Child Nutrition Program (CNP), the NSLP is meant to provide lunches that are nutritionally balanced, low-cost or free, and available every school day.[2] In order to receive reimbursement for providing healthy food to children, institutions must meet required nutrition standards that are based on the most recent Dietary Guidelines for Americans (DGA).[1] The most recent iteration of these standards was released in January 2012. This update moved away from individual nutrient content requirements, to a meal pattern based on required daily or weekly amounts of specific food groups, with only four individual nutrient content specifications. There are also daily minimum food group requirements and weekly requirements for different colors and types of vegetables.[3] The four individual nutrient specifications include weekly average calories, sodium, saturated fat, and no trans fat, with different averages set for each grade group.[4]

Nutrition standards required for reimbursement are improving, but they leave open the possibility for significant variation in overall nutrition, which includes nutritional quality and nutrient content. For instance, according to recent National Nutrition and Health Examination Survey (NHANES) data, the top three nutrient deficiencies in the U.S. population are vitamin B6, iron, and vitamin D.[5] None of these nutrients is monitored for adequacy by NSLP standards. In addition to variation in individual nutrient content, there is the possibility for heterogeneity in overall nutritional quality. This heterogeneity may be due to the lack of specifications for quality of foods provided within food groups. For instance, different forms of fruit can count toward NSLP guidelines but vary widely in nutritional quality.

This possible variability in overall nutritional quality is worth noting. Several studies have shown that dietary quality is negatively associated with adiposity and cardiovascular and metabolic outcomes in children and adults.[6-9] Research has also identified behavioral and educational benefits associated with improving the quality of school lunches. Some of the benefits include 3.4 times increased on-task time,[10] higher reading fluency and comprehension,[11] improved test scores, 14% decrease in authorized absenteeism,[12] and prevention of long-term cognitive and behavioral problems.[13] There are also, however, many barriers to implementing optimal nutrition, so knowing whether significant improvements in nutritional quality can be made before making major investments in change is essential.

There are several existing programs that provide guidance to improving nutritional quality of meals. The Child and Adult Care Food Program (CACFP) is one of those programs. It is another CNP with requirements for reimbursement based on the DGA, but also includes numerous best practices that are highly encouraged. These best practices include making all grains whole grains; switching from canned fruits and vegetables to plain, frozen fruits and vegetables; ordering fresh fruits and vegetables that are in season and/or locally sourced to greatly decrease cost; limiting or ceasing serving processed meats and cheeses and pre-fried foods and instead, serve nuts, legumes, lean meats or fish, and only natural, low-fat or reduced-fat cheeses; and not serving non-creditable foods with added sugar.[14] These best practices are a step towards optimized nutritional quality.

The 2015 DGA also provides guidance on a healthy eating pattern, including increased consumption of fruits and vegetables, whole grains, fat-free or low-fat dairy, seafood, legumes, and nuts and decreased intake of meats, especially processed meats, sugar-sweetened foods, and refined grains. The most recent update in 2015, promotes a social-ecological model for improving nutrition of Americans that includes changes in school food policy, particularly increased food quality.[15]

A final guide for improving nutritional quality of meals is the USDA Center for Nutrition Policy and Promotion's Healthy Eating Index 2010 (HEI). This is an objective measure of overall nutritional quality of a diet, not individual nutrient content. The HEI provides a summary score out of 100, with a higher score meaning a healthier diet. In order to achieve a high score, the diet must include greater quantities of total and whole fruit, total vegetables, dark green and legume vegetables, whole grains, dairy, total protein foods, seafood and vegetarian proteins, and healthier fats in relation to saturated fat. Including lower amounts of refined grains, sodium, and empty calories also leads to a higher HEI score.[16]

Based on the possibility for variation in nutrition provided by and the benefits of high nutritional quality in school lunches, the purpose of the current study was to determine whether there would be a significant difference in nutrient content and nutritional quality between a typical school lunch menu and a best practice school lunch menu. Of particular focus were nutrients required for monitoring by the NSLP, major nutrients not required for monitoring by the NSLP, and HEI scores for overall nutritional quality. In addition, this paper reviews benefits of optimizing nutritional quality of school lunches, barriers to implementation of improvements in school lunch offerings, and guidance on improving school lunch quality.

# Methods

The current study used a cross-sectional content analysis design to compare a typical school lunch menu (TM) with a best practice school lunch menu (BPM) for overall nutrient content and nutritional quality. The TM was sourced from an actual school district's published menu. The BPM was created by the first author (JJ), a Registered Dietitian, with the goal of optimizing nutrition, regardless of feasibility.

## Procedure

For the TM, a convenience sample of six weeks of actual lunch menus was obtained from a local school district. Researchers completed an educational research assurances and certification process for the school district, to allow release of information on menus and food items to researchers for study purposes. Once approved, researchers met with the Foodservice Director to obtain detailed information regarding food items on the menu. These steps were taken to guide assumptions made about the TM during analysis including: that half of grains were whole grains, that fruit was canned in 100% fruit juice, that vegetables were frozen, that main entrees were pre-prepared, frozen products, and that rolls and plain vegetables had one teaspoon of butter for flavor. Because the school district provides an offer, as compared to serve, lunch program, two options were offered for vegetables daily. The vegetable option listed on the publicly available, online menu was the one chosen for analysis.

In order to optimize nutrition, the BPM was created to be seasonal, include whole fruits, incorporate vegetables into recipes when possible, include all whole-grain products, have minimal added fat or sugar, meet the lowest sodium requirement of 710mg/ lunch, be minimally processed and made from scratch, include fish and vegetarian meals, and include a variety of colors of fruits and vegetables. These factors incorporate optimal nutrition recommendations from the 2015 DGA healthy meal pattern,[14] CACFP best practices,[15] and 2010 HEI components mentioned previously.[16] CACFP best practices were used in this situation as the NSLP does not have such a document and as both are federally reimbursable meal programs for children with similar goals, food groups and qualifying food requirements. The BPM was created to optimize nutrition based on best practices and may not be currently feasible in all school foodservice environments. Additionally, the BPM was not created with meals as direct substitutes for TM meals, as this did not align with the goal to optimize nutrition.

Appropriate measures were taken to control for variance due to seasonality of foods and portion sizes. The TM was obtained for August and September, providing two weeks of summer and four weeks of fall menus. The BPM was developed to match seasonal timing of the TM. Thus, two weeks of summer and four weeks of fall were developed. All menus, TM and BPM, were portioned for the same age group, sixth to eighth grade, and used 2012 NSLP reimbursement requirements for meal components.[3] See Appendix B for TM and BPM samples.

Once menus were portioned, they were analyzed for overall nutritional quality consisting of two factors – nutrient content and objective nutritional quality. Daily nutrient content of all macro- and micro-nutrients was determined for each portioned menu system using Nutritionist Pro ™ Diet Analysis Software (Axxya Systems LLC, Woodinville, WA). Daily nutritional quality was computed for each menu system using the Healthy Eating Index (HEI) 2010.[16] HEI scoring components are based on a point scale out of 5 or 10 for the food component or nutrient amount in 1000 calories. Since NSLP-qualifying meals do not reach 1000 calories for the selected age group, proportions were used to determine what the nutrient or food component quantity would be if the meal had been 1000 calories. Once this number was computed, it was divided by the scoring component value for that food or nutrient and multiplied by 100 to give what percent of that value the menu met. This percentage was then transferred to a score of matching percent out of 5, 10, or 20. The 12 HEI scoring component values were totaled for each day to give a daily HEI score for objective nutritional quality. See Appendix C for sample calculations.

### Data Analysis

Because the TM had significantly higher average calorie provision as compared to the BPM and this difference could be the source of variation in other nutrients between the menu types, TM nutrients were standardized to BPM calories for the corresponding comparison day (ie, standardized TM protein = (original TM protein x corresponding day BPM calories) / TM calories for that day). Data presented in this paper are based on standardized TM nutrient content. Descriptive statistics included mean, standard deviation, and range, for each meal, week, and overall menu condition. Data were checked for normality and any non-normal data were transformed using $\log_{10}$ or inverse transformation. Independent *t*-tests of mean differences were used to determine significant differences between menu conditions for macro- and micro-nutrient content, as well as HEI score. The level of significance was set at $p < 0.05$. Adjustment for multiple comparisons was made using Bonferroni correction. Cohen's *d* was calculated for effect size determination for between menu condition differences. Statistical analysis was performed using SPSS analytic software (version 23, IBM Corporation, Armonk, NY).

## Results

### Nutrient Content of Nutrients Monitored by NSLP

The BPM met all NSLP requirements for food group components, calories (stayed within range of 600–700 calories), saturated fat (less than 10% of calories), trans fat (none, defined as

<0.5g by industry standards), and sodium (less than 710mg as proposed in 2012 guidelines). The TM met food group component requirements but, on average, exceeded limits for calories (5% over upper limit of range 600–700 calories), saturated fat (14% of calories, over limit of 10% of calories), and sodium (72% over limit of 710mg daily).

### Nutrient Content of Nutrients Required for Analysis by NSLP

Table 1 shows descriptive statistics and *p*-values for nutrients required for analysis by the NSLP. There were significant differences between menu conditions for nutrients required for analysis by the NSLP. The BPM was lower in calories by 13% (Cohen's $d=0.86$, $p=0.001$), saturated fat by 30% (Cohen's $d=0.90$, $p<0.001$), and sodium by 45% ($d=2.41$, $p<0.001$) and higher in protein by 21% ($d=-1.20$, $p<0.001$), carbohydrate by 14% ($d=-0.77$, $p=0.004$), and fiber by 148% ($d=-1.13$, $p<0.001$) than the TM.

### Nutrient Content of Other Macro- and Micro-nutrients of Concern

Table 2 shows descriptive statistics and *p*-values for other nutrients of concern not monitored by the NSLP. There were significant differences between menu conditions for nutrients of concern not required for analysis by the NSLP. The BPM was higher in vitamin A by 242% ($d=-0.95$, $p<0.001$), vitamin D by 17% (Cohen's $d=-0.74$, $p=0.003$), phosphorus by 25% ($d=-3.64$, $p<0.001$), and magnesium by 74% ($d=-2.54$, $p<0.001$) as compared to the TM.

### Overall Nutritional Quality

There was a significant difference in overall nutritional quality between menu conditions ($p<0.05$). Figure 1 represents weekly average HEI scores for each menu system. The BPM had significantly higher overall nutritional quality as evidenced by a 22% higher average HEI score as compared to the TM (BPM=91.8±5.1, TM=75.1±5.8, $p<0.001$). The difference in dietary quality between menu conditions was large ($d=-3.06$).

**Table 1. Comparison of Nutrient Content between Typical Menu and Best Practice Menu for Nutrients Monitored by the NSLP**

| Nutrient** | NSLP Standard | Typical Menu+ | | Best Practice Menu | | Mean Difference [1] | *p*-value [2] | Cohen's *d* |
|---|---|---|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation | | | |
| **Calories** | 600–700 | 733.7 | 154.3 | 637.6 | 31.1 | 96.1 | 0.001* | 0.86 |
| **Protein (g)** | 9–10oz per week | 29.6 | 3.67 | 35.6 | 6.09 | -6.1 | 0.000* | -1.20 |
| **Carbohydrate (g)** | 8–10oz per week | 76.6 | 16.2 | 87.4 | 11.3 | -10.9 | 0.004* | -0.77 |
| **Saturated Fat (g)** | <10% of calories (<6.7–7.8g) | 9.5 | 3.2 | 6.6 | 3.1 | 2.9 | 0.000* | 0.90 |
| **Trans fat (g)** | 0 | 0.3 | 0.3 | 0.2 | 0.3 | 0.1 | 0.131 | 0.40 |
| **Sodium (mg)** | <1420 | 1030.5 | 235.9 | 562.8 | 139.6 | 467.8 | 0.000* | 2.41 |
| **Fiber (g)** | 1/2 grains whole grain | 6.4 | 2.1 | 16.0 | 11.7 | -9.5 | 0.000* | -1.13 |

*Results considered significant if *p*-value < 0.007

**Monitored directly or indirectly by food component requirements

[1] Mean difference = TM – BPM

[2] *p*-value for independent *t*-test, two-tailed test

+TM standardized to BPM calorie level for corresponding day

**Table 2. Comparison of Nutrient Content between Typical Menu and Best Practice Menu for Major Nutrients Not Monitored by the NSLP**

| Nutrient | Typical Menu+ | | Best Practice Menu | | Mean Difference[1] | *p*-value[2] | Cohen's *d* |
|---|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Mean | Standard Deviation | | | |
| Total Fat (g) | 22.9 | 8.1 | 18.4 | 5.6 | 4.5 | 0.015 | 0.65 |
| Monounsaturated Fat (g) | 7.5 | 2.2 | 6.2 | 2.8 | 1.3 | 0.051 | 0.52 |
| Polyunsaturated Fat (g) | 4.8 | 2.3 | 3.2 | 2.1 | 1.6 | 0.007 | 0.72 |
| Cholesterol (mg) | 72.5 | 19.0 | 78.9 | 40.7 | 6.5 | 0.746 | -0.20 |
| Sugar (g) | 35.0 | 16.0 | 37.1 | 8.1 | -2.2 | 0.148 | -0.17 |
| Vitamin A (IU) | 1949.6 | 1618.0 | 6674.7 | 6867.8 | -4725.1 | 0.000* | -0.95 |
| Vitamin C (mg) | 43.5 | 24.0 | 81.8 | 91.6 | -38.3 | 0.046 | -0.57 |
| Vitamin D (IU) | 121.0 | 21.8 | 142.1 | 33.7 | -21.1 | 0.003* | -0.74 |
| Folate (mcg) | 111.7 | 33.4 | 132.4 | 76.6 | -20.7 | 0.181 | -0.35 |
| Vitamin B12 (mcg) | 1.8 | 0.7 | 2.1 | 0.8 | -0.3 | 0.128 | -0.40 |
| Iron (mg) | 4.1 | 0.8 | 4.6 | 1.3 | -0.5 | 0.054 | -0.51 |
| Calcium (mg) | 488.4 | 82.7 | 534.0 | 153.6 | -45.6 | 0.175 | -0.37 |
| Phosphorus (mg) | 524.2 | 80.0 | 855.6 | 100.7 | -131.4 | 0.000* | -3.64 |
| Magnesium (mg) | 88.7 | 17.3 | 154.4 | 32.2 | -65.7 | 0.000* | -2.54 |
| Zinc (mg) | 3.8 | 1.3 | 4.0 | 1.2 | -0.2 | 0.541 | -0.13 |

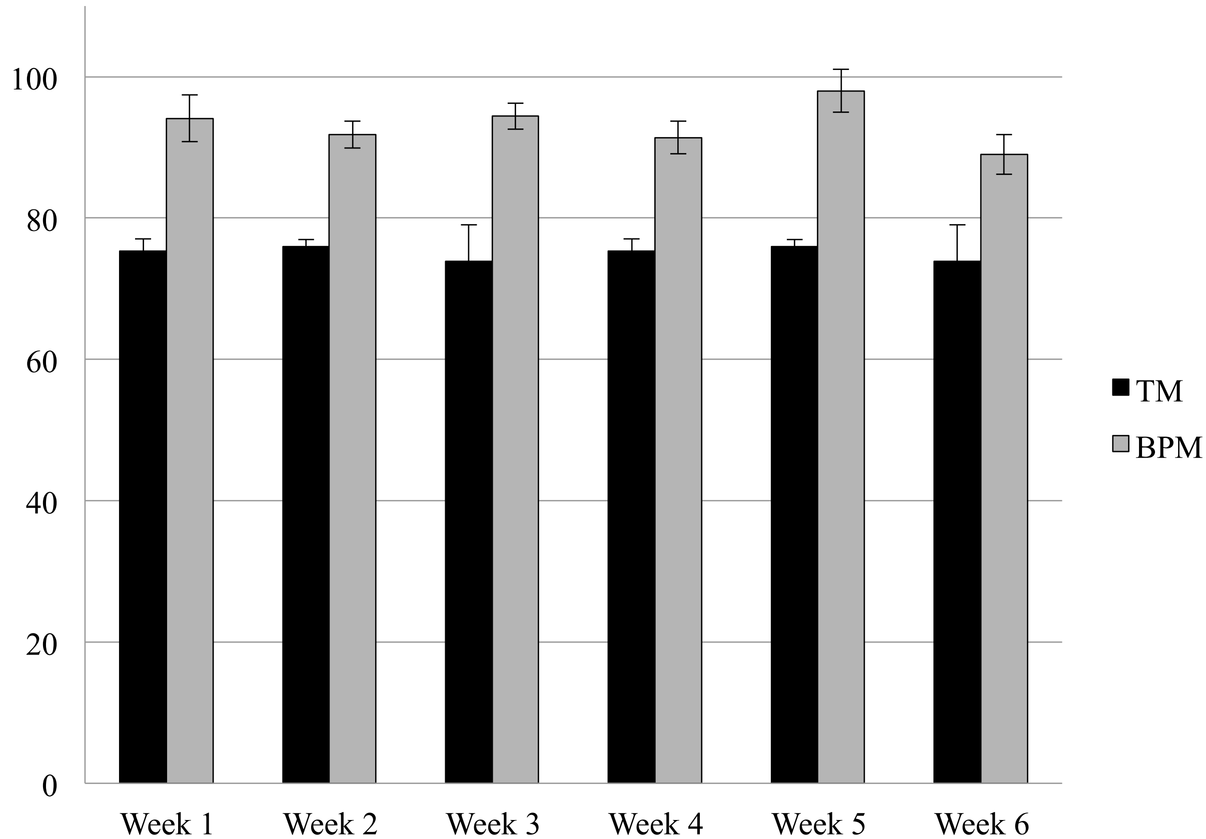
*Results considered significant if $p$-value < 0.003

[1]Mean difference = TM – BPM

[2]$p$-value for independent $t$-test, two-tailed test

+TM standardized to BPM calorie level for corresponding day

**Figure 1. Weekly Average HEI Scores for Typical Menu and Best Practice Menu Overall Nutritional Quality**




*Error bars represent standard deviation.

## Discussion

The purpose of this study was to determine whether there were significant differences in nutrient content and nutritional quality between a typical and a best practice school lunch menu. Significant differences were found between menu conditions in nutrient content and nutritional quality favoring the BPM. There were significant differences between TM and BPM for nutrients required for monitoring by the NSLP. These differences remained significant despite standardizing TM nutrients to BPM calorie level, which effectively equalized the caloric opportunity for nutrient provision. Effect sizes indicated that these were large differences for calories, protein, carbohydrate, saturated fat, sodium, and fiber. For other macro- and micro-nutrients of concern, four nutrients were significantly higher for BPM as compared to TM. Large differences were observed for vitamin A, vitamin D, phosphorus, and magnesium. Overall nutritional quality was significantly different between the BPM and the TM, where BPM nutritional quality was approximately 22% higher, as compared to TM, with a large effect size. Total calories also differed between TM and BPM; interestingly, the TM ended up being outside of the NSLP calorie requirements. The assumptions that were made with regard to selection of products used for TM may have created an overestimate of the actual calories provided by TM. It is important to note that the BPM had a significantly higher HEI score despite having significantly lower calories. Overall results show that a school lunch menu created with the goal of optimizing nutrition could provide significantly higher nutritional quality to schoolchildren.

### Implications of Improved School Lunch Nutrition Quality

There are many benefits to improving quality of school lunches. First, diet quality has been shown in several studies to be negatively associated with child and adult adiposity and cardiovascular and metabolic diseases.[6-9] Educationally, cross-sectional and intervention studies evaluating effects of high nutritional quality school lunches on child behavioral and cognitive function found that high quality lunches resulted in 3.4 times improved on-task time, increased alertness,[10] higher scores in reading fluency and comprehension,[11] 14% decrease in authorized absenteeism,[12] optimized child cognitive and behavioral function, and prevention of long-term cognitive and behavioral problems in children, especially with poor diet quality or of low socioeconomic status.[13]

Although benefits of optimizing nutritional quality of school lunches are evident, there are also many barriers. Perceptions of school principals and school foodservice workers pose potential barriers in schools. Nollen at al (2007) interviewed school principals and foodservice personnel from four urban and four rural schools, finding that principals and foodservice staff felt that obesity was not a problem within their school, that health was not the school's top priority, and that they must prepare students for the real world. Additionally, perceptions are that school lunch participation rates must remain high, and that proper resources are inadequate for implementation of wellness initiatives.[19] Barriers among school foodservice directors to improving the school food environment include lack of time; lack of nutrition education for students, staff, community, and parents; high costs of fruits and vegetables, pressure to serve what is liked instead of what is healthy; and financial pressures.[20] Thus, numerous barriers to implementation of higher nutritional quality lunches within schools exist. As the aim of the current study was to determine whether there were potential differences in nutritional quality when using best practices, overcoming these barriers may be worth pursuing as a next step in the process to improving nutritional quality of school lunches.

## Changes in Dietary Quality with New NSLP Guidelines and Resources

The NSLP guidelines have changed in recent years. Research suggests that they are improving.[16,6] The 2012 guidelines vary greatly from previous requirements (2000), which allowed for a slightly higher calorie allowance; stipulated less than 30% of calories from fat and less than 10% of calories from saturated fat; and required at least one-third of the Recommended Dietary Allowance (RDA) for protein, iron, calcium, and vitamins A and C; with no food group specifications.[15] In addition to moving from nutrient content to food group content, 2012 NSLP nutrition standards include additional requirements that all grains be whole-grain rich, that sodium be limited, and that milk be low-fat or fat-free.[3] These changes move toward focusing on higher quality foods and on food groups, rather than individual nutrients. Such a move is supported by current research evidence. The evidence-based HEI scoring system focuses on food components for evaluating nutritional quality.[16] Additionally, a review by Mozaffarian (2017) addressing whether all calories are created equal, found that low nutrition quality foods can lead to weight gain, while iso-caloric amounts of high nutrition quality foods can lead to weight loss. Thus, there is a need to shift from total calories, total fat, and individual nutrient counting, to considering overall diet quality and food patterns to decrease disease risk and improve health.[6]

In addition to NSLP guideline improvements, there is evidence that schools are making great efforts to improve nutritional quality of foods offered, and to get students involved in making healthier choices. Terry-McElrath and colleagues (2015) found that with implementation of the new standards, the number of schools reporting no candy or regular-fat snacks, no higher fat milks, no French fries, non-fat milk, fruit or vegetables, and whole grains increased.[21] The School Nutrition Association conducted a national survey from 2014 to 2016 of almost 1,000 school meal program operators that showed that there were increased efforts to promote healthier choices by students.[22] These initiatives to market and increase appeal of healthier food choices have been seen in more schools since 2014, when the majority of the latest NSLP standards went into effect. The survey showed that 66% of schools offered a salad bar, 57% offered locally sourced produce, and a growing number of districts implemented Farm-to-School programs, involved student taste testers, offered sampling, had partnerships with a chef, were undergoing recipe development, or were considering or planning such initiatives. Johnson and colleagues found that implementation of the Healthy Hunger-Free Kids Act was associated with improvements in nutritional quality of student food choices, with negligible differences in meal participation.[23] These studies indicate that new NSLP guidelines have improved upon previous guidelines, and that their implementation is leading to beneficial changes in schools.

The above-listed programs may be realistic steps that schools can take to improve nutritional quality of lunches. Along with the 2010 HEI and 2015 DGA, the CACFP is also a good resource that offers several best practices for improving nutrition quality of school lunches and is the most similar to the NSLP. These best practices include: making all grains whole grains; switching from canned fruits and vegetables to plain, frozen fruits and vegetables; ordering fresh fruits and vegetables that are in season and/or locally sourced to greatly decrease cost; limiting or ceasing serving processed meats and cheeses and pre-fried foods and instead, serve nuts, legumes, lean meats or fish, and only natural, low-fat or reduced-fat cheeses; not serving non-creditable foods with added sugar.[14] These are small steps that impact and improve nutrient content and nutritional quality of daily school lunches.

## Strengths

The current study has several strengths that warrant mentioning. Researchers obtained as much information as possible from the school district to make nutrient analysis as accurate as possible. All assumptions are clearly stated, and were made conservatively, favoring higher nutritional quality of the TM. Menus were chosen from the same season to account for variations in nutritional quality by changes in seasonal foods. Six weeks, or 30 days, of each menu style were used for comparison.

### Limitations

As with any study, there are also limitations that should be considered when interpreting findings of the current study. Researchers were unable to obtain exact product information, which would have provided the most accurate analysis. The BPM was created without regard for feasibility, and although that determination was made *a priori*, we realize that it does not solve implementation issues. There were only two menu systems compared, however, person-hours and effort required for these two menu systems was substantial and precluded adding additional menu systems for the current study.

### Conclusions

The current study sought to answer a primary question regarding decisions around improvement of nutritional quality of school lunches. Could changes in school lunch menus that reflect best practices, as compared to real-life typical menus, make a significant difference in nutritional quality of lunches, when both menus met NSLP requirements? Based on the findings from the current study, the answer to that question would be yes. Previous evidence indicates that such improvement in school lunch nutritional quality is associated with positive health, behavioral and educational outcomes. Although there are substantive benefits to making improvements, there are also many barriers, as presented in this paper. Despite these barriers, NSLP requirements have been improving, and there are examples of schools successfully implementing healthy changes. Implementing some of the CACFP best practices, DGA healthy meal pattern recommendations, or other small changes suggested in this paper may provide a realistic first step to providing future generations of schoolchildren with significantly higher nutrition quality. Future research should include analysis of the impact of individual small changes based on best practices to help schools prioritize changes that may be feasible to implement. Further, cost-benefit analysis may be particularly helpful in making important resource and budgetary decisions for implementation.

## Implications for School Health

Based on this study, implementing a few small changes could result in significant improvements to nutritional quality of school lunches. These include:[14,15]

- Making all grains whole grains.
- Switching from canned fruits and vegetables to plain, frozen fruits and vegetables.
- Ordering fresh fruits and vegetables that are in season and/or locally sourced to greatly decrease cost.
- Limiting or ceasing serving processed meats and cheeses and pre-fried foods and instead, serving nuts, legumes, lean meats or fish, and only natural, low-fat or reduced-fat cheeses.
- Not serving non-creditable foods with added sugar.
- Serving only fat-free or low-fat, plain dairy products.

These are small, feasible, easily implemented changes that could individually increase HEI scores for nutritional quality. For example, merely switching from canned to fresh fruit could increase HEI scores by 7%, or 5 points out of 100. If several changes are made similar to those of the BPM presented in this paper, HEI scores could increase by as much as 22%, or 17 points out of 100. These are large, significant changes considering that the average US child's diet has an overall HEI score of 47-50 out of a possible 100,[25] and thus could greatly improve health and academic outcomes associated with improved diet quality for schoolchildren involved. Such changes could also be suggested to and made by any foodservice organization serving children and adolescents.

A negative perception of healthier school lunch offerings is a major barrier to implementing the suggestions above.[19,20] Buy-in will need to be obtained from all levels of stakeholders for optimal implementation of these changes, including the school foodservice department staff, teaching staff, school administrative staff, school district administrators, parents, students, and community members. Having support from the state child nutrition program will also optimize implementation of such changes.

There are several successful techniques that can improve acceptance and consumption of healthier food items offered through the changes suggested above. These include:[26-28]

- Using small prizes and emoticon stickers to encourage healthy food choices.
- Promoting nutrition goals via posters, handouts, and display items.
- Increasing lunch period to at least 35 minutes.
- Incorporating one or more Smarter Lunchroom intervention.

## Human Subjects Approval Statement

This study was determined to be exempt from IRB review according to the U.S. Department of Health and Human Services' Office for Human Research Projects Human Subject Regulations Decision Chart, as it does not involve research about human subjects.[24] Researchers completed an educational research assurances and certification process for the school district, which was approved, to allow release of information on menus and food items to researchers for study purposes.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# Chapter 3 - Evaluation of Variations in Nutritional Quality of School Lunches Meeting National School Lunch Program Guidelines by Socioeconomic Status and Rurality

## Abstract

**Background:** The National School Lunch Program (NSLP) is a federal food assistance program eliminating child nutrition disparities by providing nutritionally balanced, low-cost/free meals every school day. A recent study showed that there is the possibility for significant variation in nutrient content and dietary quality (DQ) of school lunches meeting NSLP requirements. Possible drivers of variation include socioeconomic status (SES) and rurality. The purpose of this study was to determine if there was variation in nutrient content and DQ of middle school lunch menus meeting NSLP requirements by SES and rurality.

**Methods:** A cross-sectional study was performed comparing a random sample of Kansas middle school lunch menus for nutrient content and DQ by SES and rurality. Forty-five menus each from low and from high SES strata were obtained from websites of randomly selected Kansas school districts. Thirty days of each menu were analyzed for nutrient content using ESHA Food Processor. Daily Healthy Eating Index (HEI) 2015 scores were calculated for DQ. Rurality was determined for each school district by National Center for Education Statistics (NCES) locales.

**Results:** Eighty-five menus were analyzed. Significant differences were found in added sugar ($p<0.001$) and calcium ($p=0.001$) favoring high SES menus, and sodium ($p=0.001$) favoring low SES menus. No significant differences were found in nutrient content between city, suburban, town, or rural locales. An interaction effect between SES and rurality was found for calcium

($p$=0.001). HEI score were not different by SES or rurality ($p$>0.05), with mean score and standard deviation 62.0±4.0 across all schools.

**Discussion and Conclusions:** Nutrient content and DQ of middle school lunch menus in Kansas do not vary by SES or rurality. Efforts to improve the DQ of school lunches should focus on all school foodservice operations, not specifically low SES or rural schools, though these schools may have other foodservice needs that are outside of the scope of the current study.

# Introduction

According to the USDA Food and Nutrition Service (FNS), there is agreement among public health practitioners that food insecurity and poor nutrition are major issues with a need to treat these problems through providing adequate and nutritious food to underprivileged populations.[1] Federal food assistance programs are part of their solution.[1] The National School Lunch Program (NSLP), especially the free and reduced-price lunch benefit, is one such federal food assistance program seeking to decrease disparities in nutrition among children, by providing nutritionally-balanced meals at a low cost, or free, available every school day.[2,3] Despite the NSLP's goal of treating nutrition disparities, a recent study from our lab group found that there is the *possibility* for significant variation in nutrient content and DQ of school lunches, while meeting NSLP nutrition standards.[4] This cross-sectional study compared six weeks of a typical school lunch menu, obtained from an actual school district that was meeting baseline NSLP nutrition standards, with six weeks of a best practice school lunch menu, which was created by a Registered Dietitian with the goal of optimizing nutrition regardless of feasibility and thus greatly exceeding baseline NSLP nutrition standards. Results from the study revealed several large, statistically and clinically significant differences in nutrient content and DQ.[4] These results presented more questions – does this variation *actually* exist outside of just one school district, and if so, what are the possible drivers of this variation?

There has been some research regarding perceived barriers to improving DQ of school lunches, which could provide insight into potential sources of variation. Studies by Nollen et al (2007), Brouse et al (2009), and Fulkerson et al (2002) investigated perceived barriers to improving DQ of school lunches, and found two common themes, including that 1) schools are doing the best they can with available resources, and 2) that there are financial pressures and concerns.[5-7] With these themes in mind, socioeconomic status (SES) of school districts presents as a possible driver of variation in nutrition provided by school lunches, if variation does exist.

Elsewhere in public health, SES, or income level and wealth, has been shown to be a source of disparity in child and adolescent nutrition. A narrative review by Hanson et al (2007) was performed to determine associations between SES and five health behaviors during adolescence, including diet and nutrition.[8] Twenty-five of the 31 articles included in this review indicated that there were associations between low SES and inadequate fruit and vegetable intake, as well as higher fat and refined grain intake in adolescence.[8] The overall evidence indicated a disparity in general adolescent diet by SES. When considering school-aged children specifically, a cross-sectional study by Fahlman et al (2010) investigated differences in the overall diet of 7–12th graders from low SES, urban and high SES, suburban Michigan schools in a health education class.[9] The results showed that lower SES students were more likely to consume higher meat, fried foods, and empty calories; less likely to consume fruits and vegetables, dairy products, and grains; had lower self-efficacy to make healthy diet choices or changes; and had less overall diet knowledge than their higher SES counterparts.[9] These differences showed a large disparity in dietary behaviors, knowledge, and self-efficacy of schoolchildren by SES. Narrowing in on the school food environment, Delva et al (2007) performed a large cross-sectional study with a nationally representative sample of American schools, investigating ethnic and SES differences in availability of healthful food choices.[10] Parent education was the proxy measure utilized to determine student SES. Results revealed a negative linear relationship between SES and schools offering breakfast, and the percentage of students participating in NSLP and Team Nutrition programs. There was a non-significant, positive trend for an association between SES and number of more-healthful foods available.

Lower SES schools also had a significantly higher number of days with fast-food items for lunch, lower number of more-healthful food items available a la carte, and lower ratio of more-to-less healthy foods available to students (i.e., a less-healthful mix of available options).[10] These results showed variation in DQ of the overall school food environment by SES. Together, these studies suggest that SES may be an important driver of DQ variation in child and adolescent overall diet, schoolchild overall diet, and overall school food environment. However, no known studies have investigated the potential variation in nutrition provided by NSLP-qualifying lunches, a food environment which has broad reach in adolescence and where efforts to improve DQ may have great impact.

Related to SES, rurality has also been shown to play a significant role in many health disparities, including nutrition-related issues. A cross-sectional study by Davis et al. (2011) evaluated overweight, obesity, and related health behaviors in rural and urban children using NHANES data. The results of the study indicated that urban and rural areas were significantly different in most demographics including SES, with urban residents being of higher SES than rural residents.[11] There were no differences in dietary intake between urban and rural participants in this study; however, there was a significant difference in obesity prevalence, with rural children significantly more likely to be obese than urban children, 22% vs. 17%, respectively. There were also significant differences in predictors of obesity between urban and rural participants. Rural obesity was predicted by race, physical activity level, and screen time, while urban obesity was predicted by race, age, SES, and dietary intake.[11] Another study supporting rurality as a possible driver was a cross-sectional study by Befort et al (2012) investigating differences in obesity and behavioral determinants of obesity of adults by residence using NHANES data.[12] This study found that rural residents reported lower income levels than urban residents. Rural residents had significantly higher consumption of calories from fat than urban residents. Rural residents also had significantly higher obesity prevalence than urban residents. SES modified the strength of these relationships found between rural and urban residents.[12] Additional studies showed associations between rurality and risk factors for disease, disease prevalence, and mortality.[13-15] These studies show the importance of investigating potential differences between low and high SES, and rural and urban school districts with regard to the DQ of school lunches to determine potential disparities that may indicate a need for intervention.

With this in mind and the questions presented above, the purpose of the current study was to determine whether there are differences in DQ provided in middle school lunches, across the state of Kansas, in high versus low SES and in rural versus urban school districts. We hypothesized that there would be significant differences in nutrient content and DQ of middle school lunch menus, favoring higher SES, less rural school districts.

## Methods

The current study was a cross-sectional content analysis, comparing middle school lunch menus in Kansas by SES and rurality.

### Socioeconomic Status

Socioeconomic status of school districts was determined using the percentage of schoolchildren in the district receiving free or reduced-price lunches (FRPL). Researchers obtained a list of all school districts in Kansas and the percentage of the students receiving FRPL from the Kansas Department of Education K–12 Report Generator.[16] Data were grouped by district/organization totals for all schools during the school year of 2015–2016, and then used for district SES stratification and assignment. Districts were ranked from lowest to highest percent

FRPL. Given the best fit for the data, districts with >50% FRPL were assigned to the low SES strata and districts with <50% FRPL were assigned to the high SES strata. The low SES strata contained 153 districts (53.5% of total), and the high SES strata contained 130 districts (45.6% of total). Three districts had 50.0% FRPL and were excluded from analyses. Researchers were blinded to SES and school district stratification in order to reduce potential bias.

## Rurality

Rurality was determined using the locale reported for each school district in the US by the National Center for Education Statistics (NCES).[17,18] The school district name from the Report Generator was entered into the NCES "Search for Public School Districts" search engine.[17] Once the school district was found using the search engine, the locale was obtained from the district's directory profile. Locales include city, suburb, town, and rurality, and were developed by NCES based on proximity to metropolitan areas, population size, and population density.[18] The NCES created locale codes for research and data reporting related to schools. These codes have not been validated, but they do use similar base information to determine designations as other coding systems.[18] Locales were mutually exclusive and coded 0 for city, 1 for suburb, 2 for town, and 3 for rural.

## Sample

Once the strata were created including all Kansas school districts, school district USD identification numbers were randomized for each strata. The first 68 randomized school districts were selected, with a goal of 90 total school districts with complete and usable data for analysis to obtain a representative sample. Menus were obtained for school districts' middle schools from their publicly available websites. Publicly available menus were used to obtain food item information, as it would not be feasible to obtain detailed production records and purchased product information from all school districts in such a large sample. An example of two weeks of a publicly available menu can be found in Figure 2. All menus were obtained for the first six weeks of the 2016–2017 school year, to control for variations in seasonality of menus. School districts were excluded if they did not have menu information available on their website and if the information on the menu obtained was not complete enough for analysis (i.e., food items listed too generally, only one week available, unable to pull information from the website, etc.). School districts were also excluded if the publicly available menu was not current.

**Figure 2. Two-week Sample of a Publicly Available Middle School Lunch Menu**

| MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY |
|---|---|---|---|---|
| Choice of fat-free (unflavored or flavored) and unflavored low-fat milk offered DAILY! | FARM TO SCHOOL. Opaa! is proud to provide farm fresh, locally-grown products whenever they are available. Partnering with us in this endeavor are the following Hamra Farms Farhmeier Farms Rasa Orchard Value Added Products | HealthierUS School Challenge. Opaa! designs elementary menus to meet the nutrition targets for HealthierUS School Challenge! | 1 • Soft Tacos • Chicken & Cheese Quesadilla Fresh Garden Salad, Cowboy Beans , Fresh Fruit, Applesauce • Taco Salad , Cowboy Beans , Fresh Fruit, Applesauce, Cornbread , Cowboy Beans | 2 • Pepperoni Pizza • Peanut Butter & Jelly w/ Yogurt Baby Carrots w/ Dip, Fresh Garden Salad, Fresh Fruit, Strawberry Banana Mix • Popcorn Chicken Salad , Baby Carrots w/ Dip, Fresh Fruit, Strawberry Banana Mix, Fruit Streusel Muffin , Baby Carrots w/ Dip |
| 5 No School | 6 • Super Nachos • Beef Enchiladas Refried Beans, Fresh Garden Salad, Mandarin Oranges, Fresh Fruit • Taco Salad , Refried Beans, Mandarin Oranges, Fresh Fruit, Cornbread | 7 • Chicken Patty • Roasted Pork Mashed Potatoes w/ Gravy, Green Beans, Pineapple, Fresh Fruit, Hot Roll • Strawberry Chicken Salad, Mashed Potatoes w/ Gravy, Pineapple, Fresh Fruit, Hot Roll | 8 • Hot Dog • Chili w/ Cinnamon Roll Fresh Garden Salad, French Fries, Fresh Fruit, Pears • Cobb Salad , Fresh Fruit, Pears, Fruit Streusel Muffin | 9 • Tony's Pizza • Parmesan Chicken Sandwich Fresh Garden Salad, Roasted Vegetables , Tropical Fruit, Fresh Fruit • Popcorn Chicken Salad , Roasted Vegetables , Tropical Fruit, Fresh Fruit, Fruit Streusel Muffin |

## Nutrient Content

The first six weeks (30 days) of each school district menu were portioned per NSLP nutrition standards for the middle school age group.[19] An example of a week of portioned menus can be seen in Figure 3. Because there was not access to specific product information, a system of assumptions about food items was created. Assumptions about foods served were made based on common types of foods and other information available on menus and in favor of the school districts, such that there would be more favorable nutrient content and higher DQ following analysis. A comprehensive list of assumptions made during portioning of menus can be found in

Appendix D. Multiple researchers completed menu portioning. To maximize inter-rater reliability, the principal investigator trained all researchers, was present during all portioning work time, maintained a list of assumptions on-hand for reference, and reviewed all completed portioned menus.

**Figure 3. One Week Sample of a Portioned Middle School Lunch Menu**

6 Weeks of Portioned Lunches Code 102

| Meal Pattern Wk 1 | Tuesday 9/13 | Thursday 9/22 | Wednesday 8/24 | Thursday 8/25 | Friday 8/26 |
|---|---|---|---|---|---|
| Fruit (1/2c/d) | ½ c mandarin oranges(canned) | ½ c applesauce(canned) | ½ c peaches (canned) | ½ c banana orange mix(canned) | ½ c pineapple (canned) |
| Total Veg (3/4c/d) | ¾ c tator tots | 1 c salad with 1 T Italian dressing | ¾ c glazed carrots | ¾ c tator tots | ¾ c broccoli with 2 T ranch dip |
| Grain (2oz or 30g/d) | 2 oz bun (wg) | 2 oz sub | 2 oz hot roll with 1 tsp butter (wg) | 2 oz bun (wg) | 30 g corn dog |
| Meat/Meat Altern. (2oz or 14g/d) | 2 oz bbq rib | .5 oz mozzarella cheese, 1 oz pepperoni, .5 oz salami | 2 oz fish patty (breading counts toward 30g carbs) | 1.5 oz ground beef, .5 oz cheddar cheese | 14 g corn dog |
| Milk (1c/d) | 1 c low fat milk | 1 c low fat milk | 1 c low fat milk | 1 c low fat milk | 1 c low fat milk |

Once all menus were portioned per NSLP middle school age group nutrition standards, portioned menus were entered into ESHA Food Processor Nutrient Analysis Software (ESHA Research, version 4.1.1255, Salem, OR) to determine nutrient content of all major macro- and micro-nutrients. Because specific food item information was not available, assumptions had to be made during nutrient analysis as well, based on expert opinion of the principal investigator regarding foods typically and realistically served in schools, and such that school districts had more favorable nutrient content and DQ. Because foods can be searched for in ESHA using ESHA codes, one code was selected for each common food item used in nutrient analysis. These codes were then used to input portioned food items into the Food Processor. This maximized inter-rater reliability and minimized variation due to different forms of the same food item being analyzed (i.e., one ESHA code for steamed broccoli as opposed to several different forms of steamed broccoli being used). A list of ESHA codes used can be found in Appendix E. To further increase inter-rater reliability, the principal investigator again trained all researchers on nutrient analysis methods, checked data input during training and periodically throughout analysis, was present during all analysis sessions, and spot checked nutrient analysis during dietary quality and further data analysis.

### Dietary Quality

Dietary quality was calculated following menu portioning and nutrient analysis using the HEI 2015.[20] An Excel calculator was created to calculate HEI 2015 scores. A list of HEI calculation equations and instructions for DQ analysis used in the current study can be found in Appendix F. The HEI is a valid and reliable measure of dietary quality, or compliance with Dietary Guidelines for Americans recommendations for a healthy diet.[21]

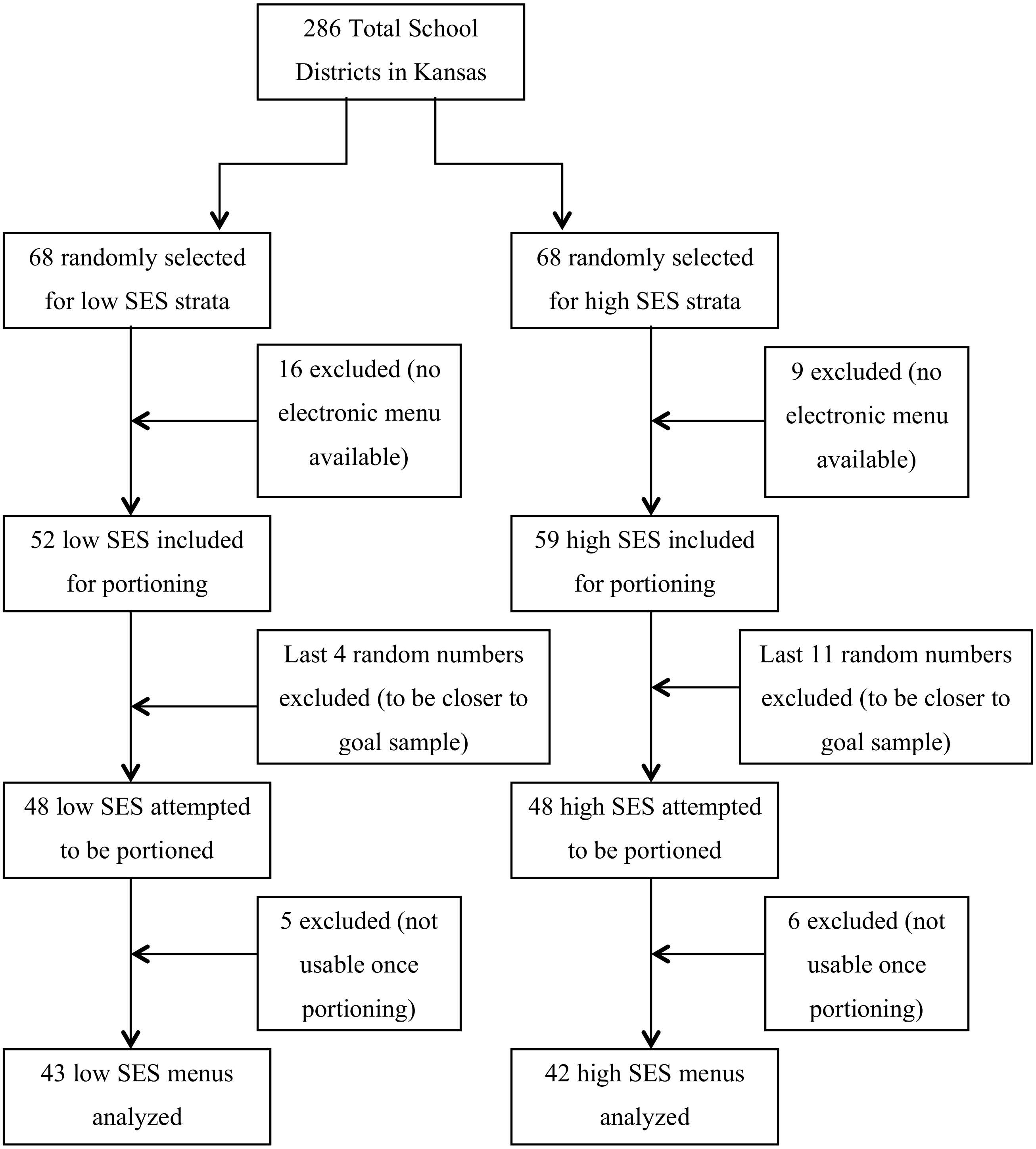
### Statistical Analysis

Statistical analysis was completed using SPSS Statistical Software (IBM Analytics, version 23, Armonk, NY). Descriptive statistics were determined for SES and rurality groups including averages and standard deviations of nutrient content and HEI score, and parametric assumptions were checked. Two-way ANOVA was used to determine main and interaction effects of SES and rurality on nutrient content and DQ. Chi-squared was used to determine differences in characteristics of menus, including distribution of SES and rurality groups. Effect size was calculated using Cohen's *d* and partial eta squared. Bonferroni correction was used for multiple comparisons.

## Results

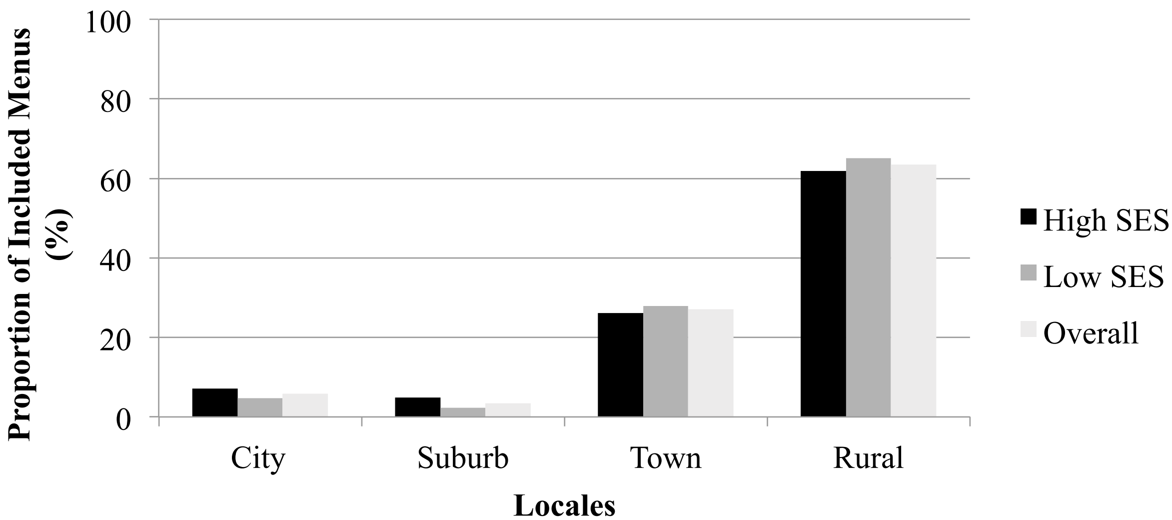
Initially, 68 school districts were randomly selected from the low- and the high-SES strata, 136 districts in total, with the goal of including 45 menus from each strata in the final analysis. Of these 136 total initial school districts sampled, 25 school districts' publicly available menus did not have adequate detail for analyses, 16 low SES and nine high SES. Thus, 111 school districts produced menus that appeared to be initially usable from their publicly available websites, 52 low SES and 59 high SES. With the goal of 90 menus, the last additional random numbers on each strata's list, four low SES and 11 high SES menus, were not included, leaving 48 menus from each strata for portioning with three menus per strata remaining for oversampling. Once portioning began, due to lack of specific or usable information, five low SES and six high SES menus were not able to be portioned and thus analyzed, resulting in a total of 85 menus portioned (43 low SES and 42 high SES). With 30 days of lunches analyzed per menu, this analysis included 2,550 lunches. A flow chart of final sample selection and inclusion can be found in Figure 4.

**Figure 4. Flow Chart of Final Sample Selection and Inclusion**



Of the 85 menus included in analyses, 50.6% were low SES and 49.4% were high SES. The high SES strata had mean (±SD) percent FRPL of 32.3±10.2% (range: 8.3–48.8%). The low SES strata had mean (±SD) percent FRPL of 58.4±6.8% (range: 50.3–78.7%). The proportions of menus in each strata and overall by locale can be found in Figure 5. There were no significant differences in proportions of school district SES or in proportions of rurality between all, low SES, or high SES menus.

**Figure 5. Proportion of Included Menus by Locale**




*There were no significant differences between strata or overall in proportion of menus by locale (*ps*>0.05).

Low and high SES overall means and standards deviations for nutrient content and DQ can be found in Table 3. There were several small to moderate, significant differences by SES. Menus were significantly different in nutrient content by SES, including added sugar (difference (high–low) = -0.4g or -80%, $d = 0.777$, $p < 0.001$), calcium (difference (high–low) = 5.3mg or 1%, $d = -0.223$, $p = 0.001$), and sodium (difference (high–low) = 54.1mg or 48%, $d = -0.657$ $p =$

0.001). Differences were such that the high SES menus had lower added sugar, higher calcium, and higher sodium content. There was no significant difference in HEI score, or DQ, between low and high SES menus.

**Table 3. Comparison of Nutrient Content and DQ by SES**

| Nutrient | Low SES (mean ± SD) | High SES (mean ± SD) | *p*-value | Cohen's *d* |
|---|---|---|---|---|
| **Calories** | 611 ± 22 | 615 ± 22 | 0.304 | -0.182 |
| **Protein (g)** | 30.4 ± 0.8 | 30.5 ± 0.8 | 0.245 | -0.125 |
| **Carbohydrate (g)** | 74.9 ± 4.0 | 74.8 ± 3.3 | 0.189 | 0.027 |
| **Total Fiber (g)** | 7.7 ± 0.5 | 7.6 ± 0.5 | 0.853 | 0.200 |
| **Sugar (g)** | 32.1 ± 2.2 | 31.7 ± 2.1 | 0.198 | 0.186 |
| **Added Sugar (g)** | 0.5 ± 0.7 | 0.1 ± 0.2 | 0.000* | 0.777 |
| **Total Fat (g)** | 22.1 ± 1.3 | 22.4 ± 1.4 | 0.898 | -0.222 |
| **Saturated Fat (g)** | 8.1 ± 0.4 | 8.2 ± 0.6 | 0.781 | -0.196 |
| **MUFA (g)** | 5.7 ± 0.6 | 5.7 ± 0.6 | 0.819 | 0 |
| **PUFA (g)** | 3.4 ± 0.5 | 3.4 ± 0.4 | 0.638 | 0 |
| **Trans Fat (g)** | 0.6 ± 0.1 | 0.6 ± 0.2 | 0.110 | 0 |
| **Cholesterol (mg)** | 66.5 ± 5.7 | 67.6 ± 6.2 | 0.709 | -0.185 |

| | | | | |
|---|---|---|---|---|
| **Vitamin A (IU)** | 3480.9 ± 980.5 | 3314.0 ± 1088.8 | 0.115 | 0.161 |
| **Thiamin (mg)** | 0.38 ± 0.03 | 0.38 ± 0.03 | 0.822 | 0 |
| **Riboflavin (mg)** | 0.74 ± 0.04 | 0.73 ± 0.03 | 0.613 | 0.283 |
| **Niacin (mg)** | 5.44 ± 0.58 | 5.47 ± 0.60 | 0.520 | -0.051 |
| **Vitamin B6 (mg)** | 0.51 ± 0.05 | 0.51 ± 0.04 | 0.912 | 0 |
| **Vitamin B12 (mcg)** | 1.87 ± 0.12 | 1.88 ± 0.11 | 0.255 | -0.087 |
| **Biotin (mcg)** | 1.70 ± 0.60 | 1.89 ± 0.78 | 0.036 | -0.273 |
| **Pantothenic Acid (mg)** | 1.78 ± 0.10 | 1.80 ± 0.11 | 0.124 | -0.190 |
| **Folate (mcg)** | 77.56 ± 9.15 | 76.02 ± 7.88 | 0.144 | 0.180 |
| **Vitamin C (mg)** | 26.75 ± 6.04 | 27.88 ± 6.31 | 0.391 | -0.183 |
| **Vitamin D (IU)** | 8.11 ± 2.75 | 9.93 ± 4.18 | 0.028 | -0.514 |
| **Vitamin E (mg)** | 1.51 ± 0.19 | 1.52 ± 0.25 | 0.610 | -0.045 |
| **Vitamin K (mcg)** | 29.94 ± 7.34 | 29.95 ± 9.10 | 0.656 | -0.001 |
| **Calcium (mg)** | 494.9 ± 22.0 | 500.2 ± 25.5 | 0.001* | -0.223 |

| | | | | |
|---|---|---|---|---|
| **Fluoride (mg)** | 0.02 ± 0.00 | 0.02 ± 0.00 | 0.060 | 0 |
| **Iron (mg)** | 3.58 ± 0.24 | 3.56 ± 0.22 | 0.992 | 0.087 |
| **Magnesium (mg)** | 92.88 ± 5.62 | 92.62 ± 4.85 | 0.440 | 0.050 |
| **Phosphorus (mg)** | 515.72 ± 24.40 | 518.59 ± 23.85 | 0.381 | -0.119 |
| **Potassium (mg)** | 1019.0 ± 63.6 | 1023.5 ± 38.5 | 0.291 | -0.086 |
| **Sodium (mg)** | 1064.9 ± 82.5 | 1119.0 ± 82.2 | 0.001* | -0.657 |
| **Zinc (mg)** | 3.69 ± 0.31 | 3.73 ± 0.25 | 0.523 | -0.142 |
| **HEI^** | 62.4 ± 2.5 | 61.6 ± 2.7 | 0.097 | 0.307 |

*Results were significant for *p*<0.001.

^HEI score out of 100 points

Rurality locale overall means and standard deviations for nutrient content and DQ can be found in Table 4. There were no significant differences in nutrient content or HEI scores for DQ by rurality.

**Table 4. Comparison of Nutrient Content and DQ by Rurality**

| **Nutrient** | **City (mean±SD)** | **Suburb (mean±SD)** | **Town (mean±SD)** | **Rural (mean±SD)** | ***p*-value** | **Partial eta squared** |
|---|---|---|---|---|---|---|
| **Calories** | 620 ± 18 | 624 ±18 | 615 ± 23 | 610 ±23 | 0.473 | 0.032 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Protein (g)** | 30.5 ± 0.4 | 30.0 ± 1.4 | 30.4 ± 0.7 | 30.5 ± 0.8 | 0.855 | 0.010 |
| **Carbohydrate (g)** | 76.4 ± 1.6 | 75.8 ± 4.3 | 74.5 ± 3.2 | 74.8 ± 4.1 | 0.584 | 0.025 |
| **Total Fiber (g)** | 8.0 ± 1.0 | 7.2 ± 0.4 | 7.7 ± 0.5 | 7.6 ± 0.5 | 0.539 | 0.028 |
| **Sugar (g)** | 33.8 ± 1.6 | 33.9 ± 2.0 | 31.4 ± 1.8 | 31.8 ± 2.2 | 0.025 | 0.113 |
| **Added Sugar (g)** | 0.6 ± 0.7 | 1.6 ± 1.6 | 0.2 ± 0.4 | 0.2 ± 0.4 | 0.002 | 0.171 |
| **Total Fat (g)** | 22.7 ± 1.6 | 23.3 ± 1.4 | 22.6 ± 1.6 | 21.9 ± 1.2 | 0.114 | 0.074 |
| **Saturated Fat (g)** | 8.0 ± 0.3 | 8.1 ± 0.3 | 8.3 ± 0.7 | 8.1 ± 0.5 | 0.311 | 0.045 |
| **MUFA (g)** | 5.5 ± 1.2 | 6.2 ± 0.3 | 5.7 ± 0.6 | 5.6 ± 0.5 | 0.405 | 0.037 |
| **PUFA (g)** | 3.7 ± 1.0 | 4.0 ± 0.1 | 3.5 ± 0.5 | 3.3 ± 0.4 | 0.081 | 0.083 |
| **Trans Fat (g)** | 0.5 ± 0.2 | 0.6 ± 0.1 | 0.6 ± 0.2 | 0.6 ± 0.1 | 0.768 | 0.015 |
| **Cholesterol (mg)** | 61.9 ± 5.4 | 66.5 ± 3.1 | 69.0 ± 7.5 | 66.7 ± 5.3 | 0.101 | 0.077 |
| **Vitamin A (IU)** | 3838.1 ± 1270.4 | 3149.3 ± 1525.3 | 3403.5 ± 1090.0 | 3366.3 ± 1004.6 | 0.785 | 0.014 |
| **Thiamin (mg)** | 0.37 ± 0.04 | 0.40 ± 0.01 | 0.37 ± 0.03 | 0.38 ± 0.03 | 0.486 | 0.031 |
| **Riboflavin (mg)** | 0.74 ± 0.03 | 0.77 ± 0.02 | 0.73 ± 0.04 | 0.74 ± 0.03 | 0.511 | 0.029 |
| **Niacin (mg)** | 5.32 ± 1.10 | 5.48 ± 0.49 | 5.49 ± 0.66 | 5.45 ± 0.53 | 0.917 | 0.007 |
| **Vitamin B6** | 0.52 ± 0.06 | 0.49 ± 0.02 | 0.51 ± 0.05 | 0.50 ± 0.04 | 0.731 | 0.017 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **(mg)** | | | | | | |
| **Vitamin B12 (mcg)** | 1.77 ± 0.15 | 1.90 ± 0.12 | 1.86 ± 0.13 | 1.89 ± 0.10 | 0.224 | 0.055 |
| **Biotin (mcg)** | 1.78 ± 0.70 | 1.91 ± 1.33 | 1.76 ± 0.69 | 1.80 ± 0.71 | 0.746 | 0.016 |
| **Pantothenic Acid (mg)** | 1.84 ± 0.18 | 1.82 ± 0.12 | 1.78 ± 0.10 | 1.79 ± 0.10 | 0.560 | 0.026 |
| **Folate (mcg)** | 85.34 ± 15.20 | 87.53 ± 5.44 | 75.44 ± 8.11 | 75.96 ± 7.55 | 0.046 | 0.098 |
| **Vitamin C (mg)** | 29.69 ± 7.26 | 27.58 ± 2.00 | 26.48 ± 7.21 | 27.44 ± 5.93 | 0.657 | 0.021 |
| **Vitamin D (IU)** | 10.33 ± 3.09 | 10.52 ± 5.45 | 9.29 ± 3.78 | 8.72 ± 3.65 | 0.378 | 0.039 |
| **Vitamin E (mg)** | 1.61 ± 0.43 | 1.61 ± 0.28 | 1.49 ± 0.24 | 1.52 ± 0.19 | 0.582 | 0.025 |
| **Vitamin K (mcg)** | 37.53 ± 12.90 | 31.82 ± 9.09 | 26.84 ± 7.45 | 30.46 ± 7.82 | 0.036 | 0.104 |
| **Calcium (mg)** | 517.7 ± 47.6 | 497.5 ± 23.6 | 497.5 ± 17.3 | 495.7 ± 23.7 | 0.057 | 0.092 |
| **Fluoride (mg)** | 0.02 ± 0.00 | 0.02 ± 0.00 | 0.02 ± 0.00 | 0.02 ± 0.00 | 0.355 | 0.041 |
| **Iron (mg)** | 3.44 ± 0.19 | 3.59 ± 0.17 | 3.57 ± 0.20 | 3.58 ± 0.25 | 0.511 | 0.029 |
| **Magnesium (mg)** | 97.00 ± 7.00 | 88.82 ± 6.74 | 92.23 ± 4.74 | 92.79 ± 5.17 | 0.367 | 0.040 |
| **Phosphorus** | 532.5 ± | 519.8 ± | 514.7 ± | 516.7 ± | 0.450 | 0.034 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **(mg)** | 34.0 | 10.2 | 22.3 | 24.8 | | |
| **Potassium (mg)** | 1024.6 ± 46.8 | 990.3 ± 43.6 | 1019.4 ± 43.7 | 1023.5 ± 57.7 | 0.929 | 0.006 |
| **Sodium (mg)** | 1125.6 ± 119.1 | 1082.6 ± 80.6 | 1089.9 ± 89.8 | 1090.8 ± 85.3 | 0.536 | 0.028 |
| **Zinc (mg)** | 3.64 ± 0.30 | 3.48 ± 0.36 | 3.63 ± 0.25 | 3.77 ± 0.29 | 0.153 | 0.066 |
| **HEI**^ | 61.5 ± 2.6 | 61.5 ± 1.3 | 62.6 ± 3.5 | 61.8 ± 2.3 | 0.571 | 0.026 |

*Results were significant for $p<0.001$.

^HEI score out of 100 points

There was a significant interaction effect between rurality and SES for nutrient content, but not for HEI score. A significant interaction effect was seen for calcium ($p=0.001$). This interaction was such that the difference in calcium favoring high SES menus diminished as the menu became more rural (difference (high SES – low SES): city=69mg, suburban=41mg, town=19mg, rural=-7mg) and reversed for the rural menus, such that the low SES menus had higher calcium content than the high SES menus by 7mg.

In addition to statistical analysis, several general/overall observations were made while calculating HEI scores for DQ. HEI scoring components consist of total fruit, whole fruit, total vegetable, dark green vegetable and legumes, whole grains, dairy, total protein foods, seafood and plant proteins, fat ratio, refined grains, sodium, added sugar, and saturated fat. Most menus received a maximum score for total fruit and total vegetable (overall mean HEI component score ± standard deviation: total fruit 4.8 ± 0.1 out of 5, total vegetable 4.9 ± 0.1 out of 5) in meeting NSLP nutrition requirements, unless the menu greatly exceeded NSLP allowable calorie amounts, as HEI scores are standardized to calorie amounts. The majority of menus received a score of zero, or mostly scores of zero, for the whole fruit component (overall mean HEI component score ± standard deviation: 2.1 ± 1.4 out of 5), as canned fruit tended to be the fruit option of choice. Most menus received the maximum score for dark greens and legumes on two days per week, as dark green vegetables and legumes are two required varieties of the vegetable meal component that must be provided over the course of the week (overall mean HEI component score ± standard deviation: 1.9 ± 0.3 out of 5). Most menus received a score of zero for the whole grain component (overall mean HEI component score ± standard deviation: 2.1 ± 1.9 out of 10), as most menus provide whole grain-rich grains and not whole grains. The exception to this observation was that many menus included corn grain products, which were often whole grain (i.e., corn chips, hard taco shells, cornbread, corndogs). Most menus received the maximum score for dairy and total protein foods in meeting NSLP nutrition requirements (overall mean HEI component score ± standard deviation: dairy 10.0 ± 0.1 out of 10, total protein foods 5.0 ± 0.0 out of 5), unless the menu greatly exceeded NSLP allowable calorie amounts, as HEI scores are standardized to calorie amounts. The majority of menus received a score of zero for the seafood and plant protein component (overall mean HEI component score ± standard deviation: 0.1 ± 0.2 out of 5), as few menus included these items as a meat/meat alternate food item. If seafood or plant proteins were included, they generally consisted of bean burrito, fish sticks or fish patty sandwich, peanut butter, hummus, or tuna salad. With regard to fatty acid ratio, saturated fat, and sodium components, most menus received a wide range of scores, generally on the lower/less favorable end of the range (overall mean HEI component score ± standard deviation: fatty acid ratio 2.0 ± 0.6 out of 10, saturated fat 5.1 ± 0.6 out of 10, sodium 3.9 ± 0.8 out of 10). Because of assumptions made, all menus received the maximum score for the refined grain component and for the added sugar component (overall mean HEI component score ± standard deviation: refined grain 10.0 ± 0.0 out of 10, added sugar 10.0 ± 0.0 out of 10).

## Discussion

This cross-sectional study included analysis of the nutrient content and DQ of 85 randomly selected school districts' middle school lunch menus, or 2,550 school lunches, in Kansas. Menus were compared to determine whether there were differences in DQ provided in middle school lunches in high versus low SES and in rural versus urban school districts. Across all schools, the overall mean HEI score was 62, which according to the USDA CNPP, needs improvement.[22] Results showed that there were no significant differences by SES or by rurality in DQ. Results also showed that there were few main or interaction effects on nutrient content by SES and rurality. Menus differed in added sugar, calcium, and sodium by SES. The differences in added sugar and calcium favored the high SES menus, while the difference in sodium favored the low SES menus. Menus did not differ by rurality alone. There was, however, one difference due to the interaction of SES and rurality, in calcium content, such that as the school district became more rural, the difference in calcium content diminished to the point that in the most rural districts lower SES menu calcium content exceeded higher SES menu calcium content. Overall, it does not appear that middle school lunch menus in Kansas differ significantly in nutrient content or DQ by SES or rurality. However, there is room for improvement in DQ across SES and rurality in the state.

Several previous studies have indicated that there are significant differences in dietary behavior, dietary knowledge, and self-efficacy to consume a healthy diet, in schoolchildren and also in the overall school food environment, by SES.[9,10] The current study differs significantly from these other studies, however, in that the current study focuses on the reimbursable meal, not overall schoolchild diet or overall school food environment. This is likely the reason for the difference in results as the reimbursable lunch investigated here is well regulated, while overall child diets are not regulated (directly) and competitive school foods are much less regulated. This is the first known study to investigate associations between school nutrition and rurality. There have been other, more general population studies that have found significant differences in nutrition, disease prevalence, weight status, and other health behaviors by locale.[11-15] With these studies indicating the possibility for variation in nutrition by rurality,[11-15] in conjunction with previous research by our lab group indicating the possibility for significant variation in DQ of school lunches meeting NSLP nutrition standards,[4] it was important to investigate differences in school nutrition associated with rurality, especially as federal food assistance programs, including the NSLP, seek to eliminate disparities in nutrition.[1] Again, the lack of significant differences in DQ by rurality in the current study is likely due to the fact that the NSLP regulates the nutrition provided by participating schools' lunches. The NSLP guidelines provide a DQ score of about 75 as a baseline just for meeting the requirements.[4] The DQ score provided by meals analyzed in the present study was 62, which is lower than 75 provided by meeting baseline NSLP requirements. This difference could be due to schools not meeting NSLP requirements, or potentially due to assumptions made by the researchers. Further, more in-depth investigations would be needed for each individual menu to clarify the reason for the lower DQ score.

There were several strengths to the current study. First, there was a large sample size, 85 total menus and 2,550 school lunches, randomly selected from Kansas school districts. Second, assumptions were made in favor of better nutrition in schools' lunches, and thus, significant differences were less likely to be found and, if found, were more likely to be due to the foods served, and not due to error in assumptions. Third, there were numerous quality control measures taken to eliminate sources of bias and error due to researchers and methodology. The principal investigator trained and monitored all researchers on all aspects of data analysis to increase inter-rater reliability. Lists of assumptions for portioning and of ESHA food codes increased inter-rater reliability, favored higher DQ in school lunches, and provided methodological consistency and transparency. Checking all portion records and spot-checking of nutrient analysis while completing, during data formatting in Excel, and during HEI calculations also increased inter-rater reliability.

There are also several limitations to the current study. Numerous assumptions had to be made throughout data analysis due to lack of specific school food item information. It was not realistic to obtain this information for the sample size included. This limitation was minimized by consistent and documented assumptions, however, giving the schools the benefit of the doubt may have also masked any true differences or disparities by SES or rurality that do exist. Another limitation was that there were multiple researchers performing data analysis. Again, numerous control measures were taken to ensure optimal consistency in analysis by researchers. An additional limitation was the use of percentage of students receiving FRPL as a proxy for SES of school districts. However, according to the NCES, percentage of FRPL is reported to be the best and most commonly used proxy.[23] There is a strong correlation between the percentage of FRPL and school district SES, as they are both determined by family income level. Percentage of FRPL provides information on relative SES.[23] According to a report by Cruise and Powers (2006), looking at the relation between FRPL eligibility counts by the NCES and poverty estimates by the 2000 Census, percentage of FRPL may be the most current, reliable, and direct measure of sub-county, low-income status for children and school districts, as FRPL provides information on an even smaller area than the Census, which does not look smaller than the county level.[24] Additionally, according to a cross-sectional study examining associations between percent of students receiving FRPL and other community-based SES measures, percent FRPL was significantly, strongly, and consistently associated with percent of families in poverty, percent of households in poverty, and median household income.[25] Thus, percentage of students receiving FRPL was used to measure SES of school districts in this study. Finally, there was relatively small separation between the high and low SES strata in terms of percentage of students receiving FRPL. This was unavoidable due to the nature of the FRPL distribution for the state of Kansas, and in order to obtain an adequate sample size for comparison.

The DQ observations provide valuable information moving forward. Scoring components that could use improvement include whole fruit, whole grains, seafood and plant proteins, added sugar, sodium, saturated fat, healthy to unhealthy fat ratio, and ensuring that calories remain within NSLP nutrition standards. Changes to one or two of these scoring components could raise the average HEI score by five, 10, 15, or even 20 points. Based on the average HEI score overall of approximately 62, Kansas school lunch DQ "needs improvement" according to the USDA CNPP.[22] With changes to two or three of the HEI scoring components in need of improvement, school lunches could receive a HEI score at or above 80 points and be considered "good," while also setting the national standard.

Future research is needed in several areas. There is limited research investigating the DQ of school lunches and the overall school food environment. There is also limited research on how to improve DQ of school lunches. As mentioned above, there are some areas where improvements can be made with small changes to current menus. Additionally, valid and reliable measures of school district SES and rurality are needed.

## Conclusions

Overall, there do not appear to be meaningful differences in nutrient content or DQ of Kansas middle school lunch menus by SES or rurality. These are positive results, as this indicates that the NSLP as a public health nutrition program to eliminate disparities appears to be working, and it appears that children of all SES and regional locales in Kansas are likely receiving similar nutrition via school lunches. This also indicates that initiatives to improve school lunch DQ should focus on all schools equally, but may be particularly important in areas where opportunities for high DQ outside of the school food environment may be limited.

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# Chapter 4 - Development of Evidence-based School Lunch Best Practices: A critical review


## Abstract

**Introduction:** School lunches meeting National School Lunch Program nutrition standards may vary significantly in dietary quality (DQ). Overall DQ is associated with child and adult weight status and chronic disease risk, and academic performance. Thus, the purpose of the current study was to: 1) review available research on child DQ recommendations and healthy school lunch implementation, and 2) develop evidence-based best practices for healthy school lunches.

**Methods:** We performed a critical review that systematically identified relevant studies in PubMed and Scopus. Search strategies were determined *a priori* with professional librarian assistance. Two independent reviewers assessed methodological quality. Results were synthesized to develop healthy school lunch best practices.

**Results:** Twenty-five articles met inclusion criteria. Best practices to improve school lunch DQ included increasing dairy, fruit, non-starchy vegetables, nuts, seeds, whole grains, lean meat/poultry, eggs, and fish, and decreasing/minimizing red/processed meat, total fat, saturated fat, salt, refined grains, and pre-fried/fried foods. Implementation techniques that improved selection and consumption of healthy foods included: using nudge strategies and Smarter Lunchrooms interventions; increasing normativeness, convenience, and attractiveness; including students in planning and implementation; and marketing healthy foods to schoolchildren.

**Discussion:** This review resulted in the determination of evidence-based best practices, including implementation techniques, for healthy school lunches.

**Implications for Research and Practice:** Used during menu and service planning, these best practices may improve school lunch DQ and selection and consumption of resulting lunches.

# Introduction

Dietary quality (DQ) refers to how closely an individual's diet, or food pattern, follows established guidelines for a healthy diet.[1] There are at least 80 known scoring systems to objectively define DQ.[2] Some of the most common DQ measures reported in research include the Healthy Eating Index (HEI), Diet Quality Index (DQI), Mediterranean Diet Score (MDS), Baltic Sea Diet Score (BSDS), Diet Quality Score (DQS), and Healthy Diet Indicator (HDI). Generally, these measures score DQ based on food groups, nutrient content, variety, balance, moderation, and/or adequacy.[2]

Dietary quality has become a recent focus in nutrition research as it allows for investigation of associations between dietary intake and various health, psychosocial, and academic performance outcomes. DQ allows researchers and practitioners to look beyond individual nutrients to the whole diet.[1] This approach is more practical and realistic, as we do not consume individual nutrients, for the most part, but instead whole foods in an entire dietary pattern.

Dietary quality is important, as high DQ has been shown to be associated with more favorable outcomes related to child and adult weight status, chronic disease risk, and academic performance.[1-8] It is particularly important to focus on DQ in childhood, as eating habits in childhood determine adult eating habits and predict adult disease risk.[2] According to the USDA Center for Nutrition Policy and Promotion (CNPP), using the HEI, the average overall DQ for US children, ages 2–17 years, was 55 out of a maximum score of 100.[9] A cross-sectional study evaluating the possibility for variations in nutritional quality of school lunches showed meeting baseline NSLP nutrition standards results in an average HEI score for DQ of 75 out of 100.[10] The CNPP considers HEI scores of 50 or less to be "poor," 51–80 "need improvement," and greater than 80 "good."[11] Thus, children are receiving higher DQ meals at school than outside of school, but improvement could still be made in DQ of school lunches.

As an example of suggestions for improvements in DQ, the Child and Adult Care Food Program (CACFP), a comparable federally assisted meal program in childcare settings, encourages institutions to go above and beyond the baseline nutrition standards with a published list of recommended best practices.[12] These best practices encourage even higher DQ of meals served than is already provided by baseline nutrition standards for reimbursement of meals. With the need for improvement in school lunch DQ even when meeting current NSLP nutrition standards, the creation of best practices for the NSLP could be beneficial. In addition to food group recommendations to improve DQ, best practices should include suggestions for implementation to encourage selection and consumption of resulting higher DQ food items/meals offered. Implementation is important to consider, particularly given that previous research has shown that acceptability and feasibility of higher DQ school lunches are major barriers to their implementation.[13]

Therefore, the purpose of the current study was to review previous research on child DQ recommendations and implementation of healthy school lunches, and to develop healthy school lunch best practices based on the evidence from the review. In doing so, the following research questions will be answered: 1) what are the DQ recommendations for school-aged children [5–18 years old (yo)], and 2) what are effective techniques to encourage healthy food selection and consumption in the school lunchroom?

# Methods

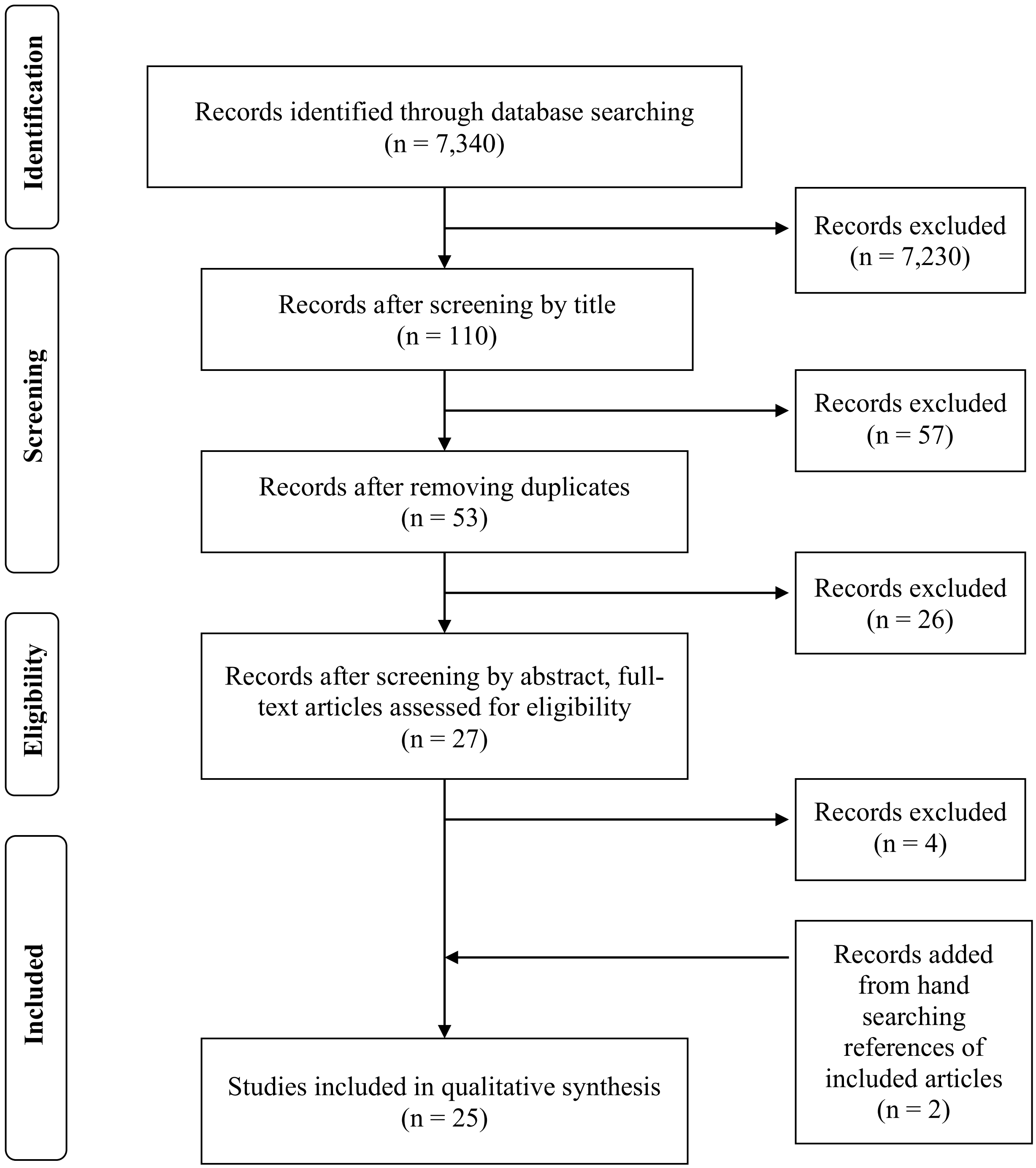
## Search Strategy

Relevant studies were identified by performing literature searches in PubMed and SCOPUS electronic databases. Filters for searches included full text, published in the last 10 years, humans, English, child: 6–12 years, adolescent: 13–18 years, and peer-reviewed. Search terms, used alone and in various combinations, included child*, adolescen*, diet quality, academic, cognition, performance, health, health promotion, optimal health, weight, healthy weight, ideal weight, nutrition* quality, school lunch, nutrition, quality, healthy eating, smarter lunchroom, child nutrition behavioral economics, lunchroom environment, school food environment, healthy, lunch, child eating behavior, and interventions.

Inclusion and exclusion criteria were established *a priori*. Studies were included if they involved child or adolescent subjects (ages 5–18yo/ K–12th grade); involved human subjects; had a cross-sectional, case-control, cohort, intervention/ experimental, randomized controlled trial (RCT), or review (any type) study design; were in the English language; showed relevance to the research question; involved a US population; were peer-reviewed; had full-text article available; and were published within the last 10 years (2007–2017). Relevance to the first research question was established if articles included dietary quality or overall eating patterns as the exposure, as opposed to individual nutrients, and included health, academic, cognitive, or behavioral outcomes. Relevance to the second research question was established if articles included school lunchroom techniques as the exposure and selection and/or consumption of targeted, healthy foods or meals as the outcome. Articles were excluded if they involved cell and animal model studies, ecological and case studies, young children (infants to 4yo/ pre-K), or adults (older than 18yo). A few exceptions to the inclusion criteria were determined once the search began due to limited results. Some studies were also included if they involved non-US populations or if they involved both school-aged children and infants. In studies with both school-aged children and infants, only results from school-aged children were considered for this review. Several studies were also hand-selected from review study results and references if they met inclusion criteria.

One hundred ten titles were selected from initial searches with the above search terms based on relevance as indicated by search term inclusion, inclusion criteria, exclusion criteria, and relevance to research questions. Fifty-seven duplicate titles were then removed. From this list of 53 remaining titles, the abstracts were reviewed based on inclusion and exclusion criteria and relevance to research questions. Twenty-six abstracts were removed at this stage. From the 27 included abstracts, full-text articles were retrieved and assessed based on inclusion and exclusion criteria and relevance to research questions. Four full-text articles did not meet inclusion criteria and were removed. The 23 remaining full-text articles were read, summarized, and assessed for quality. During this process, 34 articles were hand selected from references of included review studies. Of these 34 hand-selected articles, two articles met inclusion criteria. Thus, in total, 25 full-text articles were read, summarized, and assessed for quality. A flowchart of the article selection process can be found in Figure 2.

**Figure 6. Flow Diagram for Review of Literature**



### Summarizing Results and Quality Assessment

Information was extracted from each included article and summarized. The extracted information included purpose/research question, study design, data collection method, sample, response/retention rate, and main outcomes. In addition, articles were assessed for quality using the Academy of Nutrition and Dietetics Evidence Analysis Library (AND EAL) Quality Criteria Checklists for Primary Research and Review Articles.[14] Quality assessment was completed independently by two reviewers (JJ and BC). The reviewers reached 100% agreement on all quality assessments, and thus, no disagreement reconciliation process was needed.

## Results

A total of 7,340 articles were identified in the initial search. After screening titles and removing duplicates, 7,287 articles were excluded, leaving 53 abstracts. Of the 53 abstracts, 27 full-text articles remained for review after determining eligibility against relevance and inclusion and exclusion criteria. Four additional articles were excluded during full-text review. Thirty-four additional articles were hand-selected from the references of included review articles and compared to inclusion criteria. Of these 34 hand-selected articles, two met inclusion criteria and were thus included for full review. In the end, 25 articles were included, summarized, and assessed for quality in this review.

Of the articles included for review, 11 articles were from the US, while international articles included three each from Canada and Australia, two from the United Kingdom (UK), and one each from Finland, England, Taiwan, Mexico, and Europe. The majority of study designs were cross-sectional (n=10) or prospective cohort studies (n=4). There were also several experimental designs (i.e., one randomized controlled, two cluster randomized controlled, one pilot, one efficacy, and two intervention trials) and review studies (i.e., two narrative reviews and two systematic reviews). Multi-day food recalls or records and food frequency questionnaires were the most common method of dietary assessment. Outcome measures varied widely depending on the research question. Overall, sample sizes varied widely, with a range of 146 to 7,752 participants/ observations. Response and retention rates also widely varied, from 46% to over 90%, when reported. Based on the AND EAL Quality Criteria Checklist, the overall quality of articles was neutral with 17 studies receiving this rating. Eight articles were rated positively, and no articles received a negative rating. Article summaries can be found in Appendix G.

### What are the DQ recommendations for school-aged children (5–18 years old)?

Sixteen of the included studies were related to DQ. The results of these studies were summarized and synthesized qualitatively to establish several recommendations related to DQ and weight, chronic disease risk, and academic performance. Recommendations were based on associations between individual nutrients or food components and outcomes, and also between overall DQ or dietary patterns and outcomes.

The first recommendation synthesized from this critical review was that schools should consider decreasing sodium, total fat, and saturated fat content of meals, while increasing monounsaturated (MUFA) and polyunsaturated (PUFA) fat content. According to a meta-analysis investigating the impact of salt on child blood pressure, a 40–50% reduction in salt intake led to a significant decrease in systolic (-1.17mmHg), diastolic (-1.29mmHg), and overall blood pressure in children.[21,40] It should be noted that this meta-analysis did not meet inclusion criteria during hand searching of references of a larger included narrative review, due to its focus on one individual nutrient and not dietary quality or overall eating patterns. It was included to further support the recommendation for lower sodium content of meals, which is a component of high DQ diets investigated by studies reported later in the results section on overall DQ. The recommended sodium level for 5–18 year-olds is 1,200–1,500mg/d.[41] The current NSLP sodium standard for a reimbursable school lunch is ≤1,230mg (82–103% daily recommendation) for grades K–5, ≤1,360mg (91–113% of daily recommendation) for grades 6–8, and ≤1,420mg (95–118% of daily recommendation) for grades 9–12.[42-45]

Several clinical, observational, and review studies investigated the relationship between childhood fat intake and health and academic outcomes. In reviews and cross-sectional studies completed in the US, Australia, and Taiwan, healthy diets of higher DQ, including higher amounts of PUFA and MUFA and lower amounts of saturated fat, were associated with better mental health outcomes,[16] higher executive functioning,[18] and improved academic performance.[17,20] Additionally, unhealthy added fats were associated with higher triglycerides (2.7% increase in triglycerides with 1% increase in added fats) in a cross-sectional study involving Mexican, school-aged children.[30] This is further supported by studies that did not meet inclusion criteria while hand searching references, but were reported in a narrative review that was included. In these studies, higher fat intake was positively associated with childhood obesity and total cholesterol. Total and saturated fats were positively associated with incidence of type 2 diabetes in childhood.[21,46] Additionally, positive associations were found between childhood fast food intake, often a source of total and saturated fats and low DQ, and overweight (three times increased risk),[21,47] obesity (1.23 times increased odds), and BMI (1% increase from 12% increase in fast food intake).[21,48] Thus, it is recommended that schools decrease total and saturated fats and increase poly- and monounsaturated fats. The current NSLP standards only include direct requirements for saturated fat (less than 10% of calories) and trans fat (none permitted).[42,43]

A second recommendation based on aggregate results from included studies was for schools to consider including dairy products. A positive association between dairy intake and HDL was reported by a cross-sectional study looking at energy sources and cardiovascular disease (CVD) indicators in Mexican, school-aged children.[30] Additionally, a cross-sectional study investigating associations between food group intake and serum C-reactive protein (CRP) levels found that dairy intake was associated with low CRP levels in children.[31] Further supporting this recommendation, numerous studies of the health impacts in childhood of dairy consumption reported in an included narrative review, but that themselves did not meet inclusion criteria upon hand searching references, found that higher dairy consumption was associated with 26–43% lower risk of overweight and excess body fat,[21,49,50] lower blood pressure (1.74mmHg lower systolic and 0.87mmHg lower diastolic blood pressure with ≥2 servings dairy per day),[21,51] improved insulin resistance and sensitivity, decreased blood glucose levels, and decreased diagnosis of type 2 diabetes.[21,52,53] Another study that did not meet inclusion criteria reported in the included narrative review showed that vitamin D, of which dairy products are a good source, was associated with decreased total cholesterol (r=-0.086), LDL (r=-0.025), and triglycerides (r=-0.135) and with increased HDL.[21,54] Current NSLP nutrition standards require one cup of fluid milk be offered.[42,43] The product offered may be fat-free or low-fat plain or flavored milk.[42,43,45] This is the only required dairy. Dairy, such as cheese and yogurt, may be included as meat alternates.[42,43]

The third recommendation arising from the current review was for schools to consider increasing fruits and vegetables, fiber-containing foods, and whole grains. Several included studies showed beneficial associations between fruits and vegetables, high-fiber foods, and whole grains and health and academic outcomes. A cross-sectional study of the associations between food group intake and CRP levels in children found that children in the low CRP classification consumed significantly more grains, fruits, and vegetables, especially citrus, melons, and berries, than children in the average and high CRP classifications.[31] A narrative review reported that higher whole grain intake was associated with lower homocysteine levels, C-peptide levels, fasting insulin, and waist circumference and higher folate levels.[21] Results from three additional included reviews, completed in the US and Australia, found that fruits and vegetables, fiber-containing foods, and whole grains were also associated with better mental health outcomes,[16] higher executive functioning,[18] and increased academic performance[16,17] when included in a healthy diet of high DQ. In particular, higher consumption of fruits and vegetables was associated with higher math and reading scores, such that a 3.5% increase in vegetable consumption was associated with a 1% increase in math and reading scores and a 29% increase in fruit consumption was associated with a 1% increase in math scores on the Western Australian Literacy and Numeracy Assessment.[29] Consuming <8.57g/d of green leafy vegetables and <201.3g/d of fresh fruit was associated with poorer cognitive performance related to reaction time and number of errors in Australian adolescents.[28] Higher whole grain intake was associated with higher reading scores, such that a 10% increase in whole grain intake resulted in a 1% increase in reading scores in Australian schoolchildren.[29] Lower fruit and fruit juice consumption (<30g/d) was also associated with lower non-verbal reasoning in Finnish children.[23] This recommendation is further supported by studies within an included narrative review that themselves did not meet inclusion criteria upon hand searching references. These studies showed that higher fruit and vegetable intake, generally considered to be >3 servings per day, was associated with lower BMI,[21,55] 37% lower odds of becoming overweight,[21,56] and lower central adiposity.[21,57,58] Higher fiber intake was associated with lower risk of metabolic syndrome,[21,59] CRP levels ($r$=-0.230 to -0.308),[21,60] waist circumference (1% lower with 16% higher fiber intake),[2159] and abdominal obesity ($r$=-0.224 to -0.272).[21,60] Currently, the NSLP standards require offering a minimum amount for each age group of fruit, vegetable, and whole-grain rich grains. Whole grains are not required.[42,43]

A fourth recommendation was for schools to consider decreasing inclusion of refined grains and foods with added sugar. A cross-sectional study investigating CVD indicators in Mexican, school-aged children found that sugar-sweetened beverage (SSB) intake, a major source of added sugar, was positively associated with diastolic blood pressure and fasting glucose levels.[30] Consumption of refined grains and foods with added sugar was also associated with poorer mental health outcomes[16] and executive functioning[18] when included in an unhealthy diet of low DQ in Australian and US children and adolescents. Lower consumption of SSB and other sweets was associated with improved academic performance in Australian, Taiwanese, and Canadian children and adolescents.[16,20,27] Consuming even one SSB per day was positively associated with poor academic performance,[27] specifically lower math and reading scores, compared to consuming no SSB in Canadian children.[29] Studies, that did not meet inclusion criteria but were reported in an included narrative review, further support this recommendation. These studies reported positive associations between SSB intake and cardiometabolic risk (3.2 times increased odds for highest tertile intake as compared to lowest tertile intake), triglyceride levels, blood pressure (6.01% increase with 1% increase in SSB intake), glucose levels (7.10% increase with 1% increase in SSB intake), BMI, waist circumference, overweight, and general and abdominal obesity. Additionally, SSB intake was negatively associated with HDL levels.[21,61] The current NSLP nutrition standards indirectly restrict added sugar by allowing certain foods to be creditable, but not others high in added sugar.[42,43] However, there is room for improvement.

For example, two 2-oz grain-based desserts may be served per week.[42,43] Flavored milk may be served,[42-45] providing 16g of added sugar per cup.[62] Canned fruit may be served in syrup,[42,43] providing 4g of added sugar more per half cup than fruit canned in 100% fruit juice[63] and 9g more sugar per half cup than fresh fruit.[64]

The fifth recommendation was for schools to consider increasing poultry, fish, eggs, and legumes as protein sources, while decreasing red and processed meats. Healthy diets of higher DQ, including higher amounts of lean protein, protein high in PUFA and MUFA, and lower amounts of red and processed meats, were associated with better mental health outcomes[16] and higher executive functioning,[18] in an Australian systematic review to evaluate the effects of dietary intake on academic achievement and in a US systematic review to investigate the impact of dietary consumption on executive functioning in children and adolescents, respectively. In a cross-sectional study to determine associations between DQ and academic performance in Australian adolescence, processed meats, in particular, were associated with lower reading scores in adolescence, such that 1% increase in processed meat intake was associated with a 3-point decrease in reading score on the Western Australia Literacy and Numeracy Assessment.[29] In another cross-sectional study investigating the associations between the Baltic Sea Diet score and the DASH Diet score in Finnish children, higher red meat and sausage consumption, ≥104g or 3.5oz per day, was associated with lower non-verbal reasoning.[23] Finally, in a prospective cohort to determine associations between dietary patterns and cognitive performance of Australian adolescents, consuming >60.3g/d of red meat was associated with poorer performance with fewer correct responses.[28] Legumes will be discussed later in this section.

These recommendations are further supported by included studies that investigated overall dietary patterns. In the Australian cross-sectional study mentioned previously to determine associations between DQ and academic performance in adolescence, a healthier dietary pattern was described as being high in fruits, vegetables, whole grains, legumes, and fish.[29] A Western dietary pattern was described as being high in take-out, red and processed meats, SSB, refined grains, and fried foods.[29] The lowest quartile score for the healthy dietary pattern was associated with a 9-point decrease in math score, a 28-point decrease in reading score, and a 42-point decrease in writing score compared to the highest quartile score for the healthy dietary pattern. The highest quartile score for the Western dietary pattern was associated with a 46-point decrease in math score, a 59-point decrease in reading score, and a 57-point decrease in writing score compared to the lowest quartile score for the Western dietary pattern.[29] In a similar prospective cohort study from Australia, higher consumption of a Western dietary pattern by one standard deviation in z-score was associated with significantly lower cognitive performance in terms of longer reaction times, higher number of errors, and fewer correct responses. Higher consumption of a healthy dietary pattern by one standard deviation in z-score was associated with significantly lower number of errors. Being in the 99th percentile for Western dietary pattern and first percentile for healthy dietary pattern resulted in a difference of 44 milliseconds in reaction time, such that the healthier diet had a faster reaction time. Clinically, this was a substantial difference in cognitive performance.[28]

In a narrative review of the role of childhood diet in development of cardiometabolic risk factors, a healthy dietary pattern was defined as being higher in plant-based foods and fish and a Western dietary pattern as high in red meat, meat derivatives, sweets, pastries, fast food, SSB, fried foods, and snacks.[21] In this study, the Western dietary pattern was associated with obesity, increased triglycerides, higher general and abdominal adiposity, insulin resistance, and increased risk of metabolic syndrome. The healthy dietary pattern was associated with a healthier cardiovascular profile and improved glucose and lipid metabolism.[21] A similar healthy dietary pattern, including ≥2 servings of fruits and non-starchy vegetables, ≥2 servings of dairy, ≥0.75 servings of whole grains, and lean meat, poultry, and fish daily, was associated with a 30–50% reduction in adolescent lipid levels.[15] The Mediterranean diet, similar to the healthy dietary pattern, was also associated with lower prevalence of metabolic syndrome, lower HDL, lower risk of overweight and obesity, lower body fat percentage[21] and higher academic performance.[16] When considering the nutrient-density of foods, a cross-sectional study, examining associations between unhealthful eating patterns and unfavorable academic performance in Taiwanese elementary schoolchildren, showed that children with low intake of high-nutrient density foods and high intake of sweets and fried foods were 1.6 times more likely to have unfavorable overall academic performance.[20] In addition, in an intervention in England where healthier school lunches were implemented including the recommendations stated above, schoolchildren had 3.4 times improved teacher-pupil on-task time and overall general trends for increased alertness.[22]

Further support was provided for the above recommendations in the results of included studies investigating the associations between overall DQ and health and academic outcomes. DQ was quantified using several scoring systems, including the Healthy Eating Index (HEI), Dietary Quality Index (DQI), Dietary Quality Index for Adolescents (DQI-A), Healthy Diet Index (HDI), A Priori Dietary Quality Score (APDQS), Dietary Quality Index – International (DQII), DASH Diet Score (DASHDS), Baltic Sea Diet Score (BSDS), Mediterranean Diet Quality Index for Kids (KIDMED), and Youth Healthy Eating Index (YHEI). Canadian children and adolescents within the highest tertile for DQ, as measured by the DQI and HEI, were 31% less likely to fail in school as compared to the lowest tertile.[19] Lower DQ, as measured by DASHDS and BSDS, was also associated with lower non-verbal reasoning in Finnish children.[23]

Low DQI and YHEI scores were associated with poor academic performance in Canadian children.[27] DQI and HDI were inversely associated with weight, BMI, waist-to-hip ratio, waist circumference, and percent body fat for children in the United Kingdom.[26] An 8-unit increase in DQII was associated with 1kg/$m^2$ lower central fat mass and 1.8% lower percent body fat in Canadian children.[32] Adolescents at age 15 years with APDQS above the median score experienced 2.2–5.7kg less weight gain than those below the median.[25] Dietary quality, as measured by HEI, DQI, and KIDMED, was also found to be inversely associated with blood pressure, lipid levels, inflammatory markers, BMI, body fat, and waist circumference.[21] One of the components within DQ scoring systems, diet adequacy, was associated with all body fat indices, such that a 1-unit improvement in adequacy was significantly associated with smaller gain in fat mass, central fat mass, body fat percentage, and percent central body fat in Canadian children.[32] Additionally, in a study using the DQI-A and the DASHDS to investigate associations between DQ and attention capacity in European adolescents, there were significant positive associations between DQI-A and DASHDS and attention capacity, such that a 1-point increase in DQ score was associated with a 0.15–0.16 point increase in attention capacity.[24]

### What are effective techniques to encourage healthy food selection and consumption in the school lunchroom?

It is not only important to look at ways to improve DQ of meals offered to children, but also to look at ways to ensure that those resulting healthier meals are selected and consumed. Seven of the studies included were related to effective implementation techniques to encourage selection and consumption of higher DQ food items in the school lunchroom. The results of these studies were summarized and combined qualitatively to establish several recommended techniques for implementation.

The first technique involved nudge strategies. Nudge strategies include observing how students make choices as they go through the cafeteria, and then placing, arranging, labeling, and presenting healthier food items such that they are preferentially selected.[33] Some examples of nudge strategies include prefilled trays, posters and window sticker promotions, packaging sticker promotions on products, end-of-shelf labels, fruit display stands with individual pieces of fruit, prominent positioning, and placing larger numbers of promoted items on display.[33] In a school cafeteria intervention study where nudge strategies were employed in the United Kingdom, students were 2.5, 3, and 7.5 times more likely to select promoted plant-based food items, fruit/ vegetable/ salad, and salad, respectively, compared to baseline.[33]

The second technique involved sticker labeling and prizes for selection of promoted healthy food items. In another school cafeteria intervention study utilizing these techniques, the labeling stickers were green emoticon, or smiley, stickers placed on healthy food items being promoted. Prizes for selecting promoted healthy food items included stickers, temporary tattoos, Frisbees, bracelets, and mini beach balls. Prizes were only given on pre-determined prize days, not every school day. Selection of promoted healthy foods was significantly increased from 4.5–49.4%, a 1100% increase.[38]

A third technique was cafeteria modifications. In a school cafeteria modification intervention study, modifications were to serve five fruits and vegetables daily, <30% total calories from fat per meal, <10% total calories from saturated fat per meal, and 20–30g fiber per meal; to modify recipes to include more whole grains, low-fat cheese, and leaner ground beef; to purchase healthier versions of items, shift purchasing with less money allocated to unhealthy foods and more allocated to healthy foods, and to request fewer unhealthy commodities; to bring portion sizes back to NSLP recommendations; and to promote nutrition goals via posters, handouts, and display items.[39] There was a significant decrease in selection of calories (-137kcal), total fat (-60 to -78kcal), saturated fat (-22 to -24kcal), carbohydrate (-56kcal), and protein (-20kcal) and a significant decrease in intake of calories (-103kcal), total fat (-41 to -58kcal), saturated fat (-16 to -18kcal), and carbohydrate (-41kcal) after the intervention compared to baseline. At 28 months following implementation of the cafeteria modification program, there were significantly higher HEI scores, by 3.9 points for intake and 5.3 points for selection for the intervention school, and significantly lower HEI scores, by 6.2 points for intake and 5.6 points for selection for the control school with no modifications.[39]

A fourth technique involved increasing normativeness, attractiveness, and convenience of healthy food items, often known as Smarter Lunchroom techniques or child behavioral economics.[35] In an intervention study focusing on increasing normativeness, attractiveness and convenience of fruit, methods included placing fruit first in the serving line, offering two or more fruits in two or more locations, displaying fruit attractively at student eye level, labeling fruit on the service line and on all menus with creative names generated by students, displaying fruit factoids on dry-erase boards at student eye level, and holding one-hour long training sessions on such techniques with kitchen staff, followed by continued training and support as needed by cooperative extension.[35] This intervention resulted in significantly increased selection of fruit in treatment schools and 22% decreased selection in control schools with no intervention. Fruit consumption increased in treatment schools by 14% and decreased in control schools by 16%. This intervention also resulted in a non-significant positive effect on vegetable selection, but not consumption, in treatment schools. There was also a significant 10% increase in milk selection, but not consumption, in treatment schools. An additional finding was that this type of intervention was determined feasible by school staff.[35]

In another school cafeteria intervention study designed to increase normativeness, attractiveness, and convenience of fruits and vegetables, similar results were observed. Students were 13.4% and 23% more likely to take fruit and vegetables, respectively. Fruit and vegetable consumption increased 18% and 25%. Students were also 16% and 10% more likely to consume the entire fruit and vegetable serving. These results were observed while a wide range of less-healthy options were simultaneously available. On average, changes took three hours to implement and cost under $50.[37]

An additional cross-sectional study, investigating factors in school lunch environments that predict adolescent fruit and vegetable consumption, found similar results regarding the attractiveness of healthy food items. The odds of students eating fruit were 44% higher if the fruit quality was good or excellent, as opposed to fair or poor. The odds of students eating vegetables were 48% higher if a salad bar was present.[34]

Another technique was to increase the length of the lunch period. In the study mentioned above, investigating factors in the school lunchroom environment that impact selection and consumption of healthy food items, the odds of eating fruits and vegetables at school were 40% and 54% higher, respectively, if the lunch period was 34 minutes or longer.[34] Thus, the recommendation from this review was to ensure that the lunch period is at least 35 minutes long.

A final technique included student involvement in cafeteria initiatives. In an aforementioned study investigating factors in the school lunchroom environment, student involvement in cafeteria health initiatives was associated with 34% higher odds of eating vegetables.[34] In an intervention study with student involvement in healthy lunchroom initiatives, similar results were noted. There were three levels of student involvement. In the participation only intervention, students drew vegetables on posters, but posters were not printed for marketing. In the marketing only intervention, vegetable posters were printed and hung above the salad bar, but students did not draw them. In the participation and marketing intervention, students drew vegetables on posters, and then vegetable posters were printed and hung above the salad bar. During the design phase, in which students were or were not involved in drawing and printing posters, there was a significant increase in selection of vegetables by one-third of a serving. During the promotion phase, in which the posters designed by students or pre-designed were displayed, there were significant increases in vegetable selection by one full serving and in consumption of vegetables by 100%. At two months follow-up, students consumed significantly more vegetables by almost a half serving from pre-intervention.[36] Thus, the recommendation from the authors of this review was to involve students in all levels of planning and preparing healthy food promotions.

These recommendations based on results of included studies were synthesized to create a list of evidence-based school lunch best practices. These best practices can be found in Table 5.

**Table 5. Evidence-based School Lunch Best Practices**

| **Child Dietary Quality Recommendations** | **Implementation Techniques to Improve Selection and Consumption of Healthier Food Items** |
|---|---|
| Decrease sodium, total fat, and saturated fat content of meals, especially fried foods. | Use nudge strategies.<br>Examples: prefilled trays, posters and window sticker promotions, packaging sticker promotions on products, end of shelf labels, fruit display stands with individual pieces of fruit, prominent positioning, and placing larger |

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| | numbers of promoted items on display. |
| Increase monounsaturated (MUFA) and polyunsaturated (PUFA) fat content of meals. | Use labeling stickers, such as green emoticon or smiley stickers, placed on promoted healthy food items. Provide prizes for selecting promoted healthy food items, such as stickers, temporary tattoos, Frisbees, bracelets, and mini beach balls. Give prizes on pre-determined prize days, not every school day. |
| Include low fat, unflavored diary products. | Implement a cafeteria modifications program. Example program: serve five fruits and vegetables daily, <30% total calories from fat per meal, <10% total calories from saturated fat per meal, and 20-30g fiber per meal; modify recipes to include more whole grains, low fat cheese, and leaner ground beef; purchase healthier versions of items, shift purchasing with less money allocated to unhealthy foods and more allocated to healthy foods and to request fewer unhealthy commodities; bring portion sizes back to NSLP recommendations; promote nutrition goals via posters, handouts, and display items. |
| Increase provision of fruits and vegetables, | Increase normativeness, attractiveness and |

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| fiber-containing foods, and whole grains in meals. | convenience of healthy food items. Examples (with fruit): placing fruit first in the serving line, offering two or more fruits in two or more locations, displaying fruit attractively at student eye level, labeling fruit on the service line and on all menus with creative names generated by students, displaying fruit factoids on dry-erase boards at student eye level, holding one-hour long training sessions on such techniques with kitchen staff, following with continued training and support as needed, and providing good to excellent quality of fruit. |
| Decrease provision of refined grains and foods/ beverages with added sugar in meals. | Ensure that the lunch period is at least 35 minutes long. |
| Increase provision of poultry, fish, eggs, and legumes as protein sources. | Involve students in cafeteria initiatives. Examples of initiatives: naming healthy food items, creating marketing materials for healthy food items. |
| Decrease provision of red and processed meats as protein sources. | |

## Discussion

The current study critically reviewed the currently available literature using two electronic databases to assimilate the most up-to-date, high quality, and unbiased evidence with regard to child DQ recommendations and effective implementation techniques for healthy school lunches. The results of the included articles were summarized, critically appraised, and synthesized to create evidence-based school lunch best practices.

There are several similarities and differences between these best practices and the current NSLP guidelines. Similarities include increasing provision of fruits and vegetables, decreasing saturated fat content of meals, decreasing fried foods, including dairy products, decreasing refined grains and added sugar, and increasing fiber-containing foods and whole grains to an extent. These similarities would be stronger if pre-fried foods, flavored milk, and grain-based desserts were not permitted and if whole grains were required as compared to the current whole-grain rich requirement for grains. Differences include decreasing sodium, decreasing total fat, increasing MUFAs and PUFAs, decreasing red and processed meat as protein sources, and increasing poultry, fish, eggs, and legumes as protein sources. An additional difference is the inclusion of techniques to improve selection and consumption of resulting higher dietary quality food items/ meals. Sodium content was to be decreased to 640–740mg per lunch, but this gradual decrease has been halted to 1,240–1,420mg by the November 2017 Interim Final Rule allowing Child Nutrition Program flexibilities.[42-45] There is only an indirect attempt to decrease total fat, via qualifying food restrictions. There are no requirements encouraging increasing MUFA and PUFA, decreasing red and processed meat, or increasing leaner, unprocessed protein sources. There are also no implementation technique suggestions.[42,43] Thus, these best practices would make a good complement to the NSLP nutrition standards, similar to the CACFP nutrition standards and their best practices.

To our knowledge, this is the first critical review to investigate overall DQ recommendations for children, specifically for use within the school foodservice environment. The current study is also the first known review of implementation techniques that encourage schoolchildren to select and consume healthier food options in the school cafeteria. Two narrative and two systematic reviews related to child DQ and health, psychosocial, and academic outcomes were included in this critical review.[16-18,21] Each of these reviews focuses on dietary intake and a single type of outcome – health, psychosocial, or academic. No studies were identified that investigate overall DQ and multiple outcomes, especially that compile results to form recommendations. Additionally, there were several strengths to this critical review. The search process was systematic. Search terms, strategies, and inclusion and exclusion criteria were determined *a priori* with professional librarian assistance. More than one database was used to find relevant studies. The databases used were appropriate, large, and encompassing. Two independent reviewers critically appraised included studies using AND EAL quality criteria checklists.

There were also limitations to this review. It was a critical review, which was rigorous, but not a systematic review. The search process was determined *a priori*. Some inclusion and exclusion criteria were modified to include non-US populations, due to limited search results returned. These studies may not have been as relevant to US-based NSLP guidelines as compared to other included studies. Additionally, studies cited from included reviews did not all meet inclusion criteria, themselves, but were discussed in the results section of this review, as they were an important and meaningful part of an included review paper. Finally, two search databases were utilized for this critical review. These databases were determined with professional librarian assistance, however, adding a third database may have yielded additional articles for inclusion.

There are several opportunities for future research. The search strategy used for the current review revealed an abundance of cross-sectional studies related to adult DQ (not included) and significantly fewer related to child DQ. There were only a few prospective cohort or intervention studies, of stronger methodological rigor, related to child DQ. Thus, there is a need for more prospective cohort and intervention studies related to child DQ and various outcomes of interest. Related to lunchroom techniques, there were several intervention studies, but they were short in duration. There is a need for longer interventions, one to three years in length to determine the sustainability of such interventions. Interventions were also noted to be limited in reach and to be lacking in detailed discussion of feasibility. Thus, future interventions could benefit from the use of the RE-AIM framework to determine generalizability and translatability. The RE-AIM framework defines the reach (what participants were included demographically), effectiveness (effect of the intervention), adoption (what are the systems-level demographics), implementation (fidelity to the intervention protocol), and maintenance (long-term adoption of the intervention at the individual and systems levels) achieved by the study.[66-68] The overall quality of studies included was neutral (67% of studies), so there is also a need for more rigorous, high-quality research in regards to child DQ and lunchroom techniques.

## Implications for Research and Practice

The resulting evidence-based school lunch best practices from this critical review could be used in several ways. First, these best practices could be used to inform policy regarding

NSLP guidelines. It is important to note that the CACFP has a published best practices document to accompany its nutrition standards, whereas the NSLP currently has no such document. Recommendations from the current study could be used to inform the creation of such a document for the NSLP. These best practices could also be provided to state departments of education for distribution to their school lunch programs and used in the planning of healthier menus and service. Additionally, these best practices could be utilized to support continuing with the current NSLP nutrition standards or moving further forward in terms of DQ of these standards, as opposed to relaxing the current standards and reversing DQ advances. Finally, these best practices provide evidence-based healthy eating guidelines for nutrition professionals working with parents looking to improve their child's DQ.

If implemented, these evidence-based school lunch best practices could result in large improvements in school lunch DQ. Possible improvements in school lunch DQ with implementation of the child DQ best practices have been quantified utilizing the HEI 2015 in Table 6.

**Table 6. Improvements in School Lunch DQ with Implementation of Child DQ Evidence-based School Lunch Best Practices**

| Child Dietary Quality Recommendations | Improvement to HEI 2015[9] School Lunch Score* |
|---|---|
| Decrease sodium, total fat, and saturated fat content of meals, especially fried foods. | Decreasing sodium content of meals from current NSLP sodium target to final NSLP target (9–12th grade 1420mg to 740mg): + 8 points<br>Decreasing saturated fat to ensure in compliance with NSLP standards: + 0–6 points |

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| Increase monounsaturated (MUFA) and polyunsaturated (PUFA) fat content of meals. | Increasing MUFA and PUFA: + 0–10 points |
| Include low fat, unflavored dairy products. | Including dairy: schools receive full credit (10 points), unless over NSLP calorie limit |
| Increase provision of fruits and vegetables, fiber-containing foods, and whole grains in meals. | Increasing total fruit: schools receive full credit (10 points), unless over NSLP calorie limit<br>Including whole fruit: + 0–5 points<br>Increasing vegetable: schools receive full credit (10 points), unless over NSLP calorie limit<br>Including whole grains, not whole grain-rich products: + 10 points |
| Decrease provision of refined grains and foods/ beverages with added sugar in meals. | Decreasing refined grains, not using white products: + 10 points<br>Decreasing added sugar from grain-based desserts, flavored milk, or canned fruit: + 0–5 points |
| Increase provision of poultry, fish, eggs, and legumes as protein sources. | Including lean, non-red meat protein sources: + 4 points<br>Including fish and legumes as protein sources: + 5 points |
| Decrease provision of red and processed meats as protein sources. | Decreasing red meat as protein source: + 4 points |

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| | Decreasing processed meat as protein source: + 8 points |
| All child DQ recommendations (total) | + 35–71 points |

*Ranges represent possibility for schools to vary in score by meeting (larger possible improvement in DQ) versus exceeding (smaller possible improvement in DQ) NSLP baseline nutrition standards.

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# Chapter 5 - Acceptability and Feasibility of Best Practice School Lunches: A randomized crossover trial


## Abstract

**Background and Purpose:** National School Lunch Program (NSLP) nutrition standards have improved school lunch dietary quality (DQ), however, previous research has suggested that acceptability and feasibility of higher DQ lunches may pose significant barriers to implementation. Thus, the purpose of this study was to determine the acceptability and feasibility of best practice school lunches (BPSL), optimizing DQ, as compared with typical school lunches (TSL), meeting minimum NSLP standards.

**Methods:** Forty elementary school-aged participants (grades K–5) were recruited for a randomized crossover trial. Participants attended three meal conditions choosing one of two meal types within each condition – 1) two BPSL, 2) two TSL, 3) one BPSL and one TSL. Acceptability was assessed using taste test surveys, weighted plate waste assessments, and hunger scales. Feasibility included meal cost, time, and skill and equipment needed to prepare meals.

**Results:** For acceptability, there were no significant differences in total taste test score, average total plate waste, or change in hunger (*ps*>0.017) before or after adjusting for all covariates, when comparing overall BPSL and TSL or when comparing BPSL served in meal condition 1 (alone) and BPSL served in meal condition 3 (with TSL). After adjusting for BMI percentile alone, there was a significant difference in average total plate waste between overall BPSL and TSL ($p$=0.006) and in total taste test score between BPSL in meal condition 1 and BPSL in meal condition 3 ($p$=0.015). There was a significant difference in selection of meal type in meal

condition 3 with the TSL selected more often (TSL=83.3%, BPSL=16.7%, $p$=0.001). For feasibility, meal cost ($p$=0.783) and skill and equipment requirements were not significantly different between meal types. BPSL required significantly longer time to prepare than TSL (TSL=60±25minutes, BPSL=267±101minutes, $p$=0.026).

**Conclusions:** Results indicate few differences in acceptability and feasibility between BPSL and TSL. Higher DQ lunches took significantly greater preparation time, potentially posing a significant barrier under current school foodservice conditions. When served concurrently, less healthful, competitive foods were selected more frequently than higher DQ options, however, when offered alongside another high DQ option, BPSL meals were acceptable to participating children. This study could inform decision and policy-makers seeking to improve school lunch DQ and student acceptance of high DQ meals.

# Introduction

The Healthy, Hunger-Free Kids Act led to substantive changes to the National School Lunch Program (NSLP) in January of 2012, which improved the dietary quality (DQ) of school lunches. These changes required schools participating in the NSLP to provide more fruits and vegetables, vary vegetable color and type, increase provision of whole grains, decrease added sugar and sodium, and lower saturated fat content.[1,2] These changes represent a shift in the focus of the NSLP nutrition standards toward food groups and DQ, and away from individual nutrients. The shifting of focus toward DQ is supported by recent changes in other government nutrition entities. The Healthy Eating Index (HEI), created by the USDA Center for Nutrition Policy and Promotion (CNPP) and the National Cancer Institute of the National Institutes of Health, focuses mainly on food components, similar to the NSLP changes, for evaluating DQ, not individual nutrient content.[3] The 2015 Dietary Guidelines for Americans healthy meal pattern recommendations, and the 2016 Child and Adult Care Food Program best practices, also support focusing on food groups and DQ, as compared to individual nutrients.[4,5]

The aforementioned changes in the NSLP are also supported by previous research, as many studies have shown the benefits of improved DQ through changes in dietary patterns and school lunches. The health benefits of improving DQ in childhood include a lower risk of overweight, obesity, and numerous chronic diseases, in childhood and adulthood.[6-8] The academic benefits of higher DQ school lunches include improved on-task time and increased alertness during the school day,[9] as well as higher scores in reading fluency and comprehension,[10] decreased authorized absenteeism,[11] and optimized child cognitive and behavioral function.[12]

Implementation and adoption of these new standards has been slow, and there are now also efforts to reverse DQ advances made in the new standards (i.e., higher target sodium levels, allowing low-fat flavored milk, and providing waivers allowing exemption from the whole grain-rich requirement).[13] The School Nutrition Dietary Assessment IV (SNDAIV) is a report which evaluates the nutrient content of average school meals and competitive foods using a representative sample of US schools, comparing them to school meal standards and selected aspects of the Dietary Guidelines for Americans. The most recent report showed that implementation of the NSLP updates was poor, with only 14% of schools in compliance at the end of the first year.[14] Slow adoption, and now relaxation of the improved standards, is reportedly due to barriers to implementing higher DQ school lunches.[13,14]

Several studies have examined the perceived barriers to implementation of higher DQ school lunches from the perspective of principals, school foodservice directors, and school foodservice personnel.[15-17] A large observational study by Nollen et al (2007) investigated the perceptions of high school personnel regarding the relationship between the school food environment and obesity.[15] Related to feasibility, the study found that school personnel felt that they were doing the best they could with available resources, that barriers to offering healthier food items included cost and waste, and that wellness plans would be better implemented if they were given the proper resources, including money. Related to acceptability, school personnel felt a need to maintain high participation rates, were concerned about waste, and wanted to be liked and appreciated.[15] Another cross-sectional survey by Brouse et al (2009) used a random sample of 259 school foodservice directors and investigated perceptions of barriers to improving the nutrition status of schoolchildren.[16] Perceived barriers to serving healthier food items included lack of time, the high cost of fruits and vegetables, pressure to serve foods that schoolchildren liked as compared to healthful foods, and financial concerns regarding healthy food offerings.[16] A cross-sectional study by Fulkerson et al (2002) surveyed 235 urban school foodservice personnel in Michigan regarding perceptions of interactions with students, barriers to suggesting healthful foods to students, and perceptions of student nutrition.[17] Perceived barriers to suggesting healthful food items included lack of time, and students having already made their decisions regarding less healthful items. Additionally, school foodservice personnel felt that reasons for students not choosing healthful food items included general dislike of those types of foods.[17] A recurring theme was concern over lower acceptability and feasibility of school lunch menus offering more healthful food items. These barriers were reported as perceived, but the extent to which these perceived barriers are real, is uncertain.

There has been some previous research that has investigated the existence of these barriers following changes to school foodservice as a result of implementation of the updated NSLP nutrition standards, and thus higher DQ school lunches. Following the January 2012 update and subsequent major school lunch content changes, several studies evaluated plate waste differences,[18-23] few studies investigated cost differences,[24-26] and no known studies determined taste differences or additional feasibility differences (i.e., staffing, preparation time, and equipment needs) pre- and post-implementation. Additionally, current data may not be accurate regarding acceptability and feasibility, as only 14% of schools in 2013 were fully compliant with updated NSLP guidelines, when most of these studies occured.[14] Further, studies of children thus far, have neglected to look at true preferences for less healthful, lower DQ foods as compared to healthier, higher DQ food options. Thus, there is a critical gap in current research on the acceptability and feasibility of providing higher DQ school lunches.

The purpose of the current study was to fill this critical gap in research knowledge by assessing the acceptability and feasibility of lunches that are high in DQ. The aims were to determine: (1) whether there were differences in the acceptability of best practice school lunches as compared with typical school lunches; (2) whether there were differences in the feasibility of best practice school lunches as compared with typical school lunches; and (3) whether the presence of both meal types in one meal setting (choice) influenced the acceptability of the best practice school lunches. With these questions answered, this study could provide important information to decision- and policy-makers with regard to the need for, and practicality of, providing high DQ school lunches.

## Methods

### Participants

The population of interest for this randomized crossover trial was elementary school-aged children in grades kindergarten through fifth (K–5). We recruited children from four local school districts using informational flyers that were emailed to parents via school wellness committees and posted on Facebook for public sharing. Information was also disseminated to Kansas State University faculty and staff via internal communication. Interested parents contacted the principal investigator to express interest, and participants were screened via email for inclusion and exclusion criteria. Inclusion criteria included attendance at a school receiving NSLP reimbursement, and parent/guardian willingness to transport the participant to all meal sessions. Exclusion criteria included having food allergies, currently receiving nutrition therapy, being home schooled or attending a school not participating in the NSLP, and not being available to participate in all three meal sessions. Eligible children were randomly assigned to one of three groups by random number generator and invited to come to Kansas State University for full screening and baseline assessment, explained in detail later in this section. Participants completing the study received a $25 gift card for a local grocery store, a printed cookbook with copies of BPSL recipes, and a certificate of participation. Participating schools were provided with all best practice meal recipes standardized and large-scale for school foodservice, and a corresponding production and recipe-scaling calculator. IRB approval was obtained from Kansas State University Committee on Research Involving Human Subjects (proposal #8938).

## Sample Size and Power Calculations

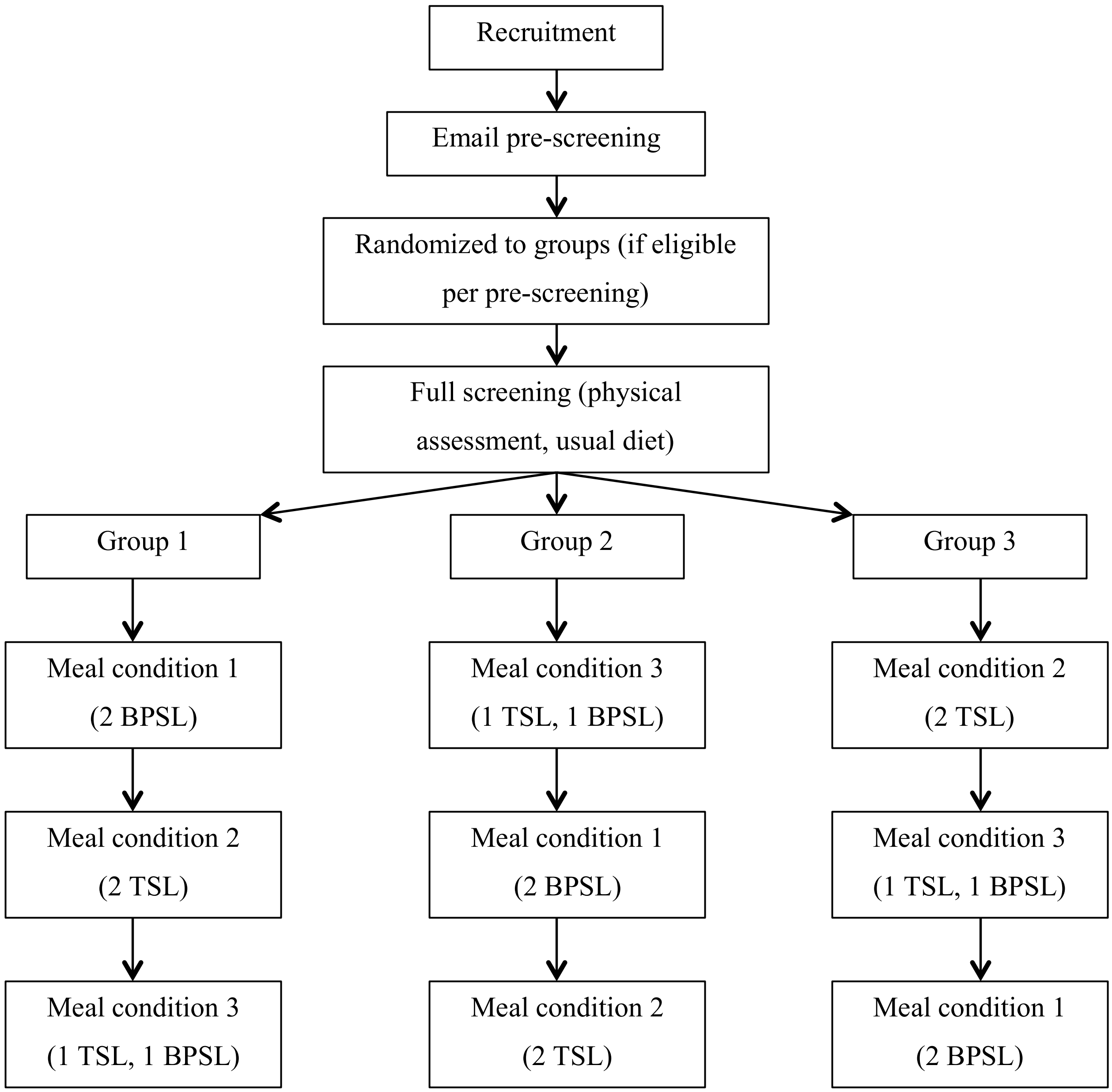
With type 1 error rate set at 0.05 and power at 0.8, a sample size of four participants per group (i.e., 12 total participants) was needed for adequate power based on plate waste differences from a study by Marlette et al (2005) that evaluated school lunch plate waste differences between students who did and did not purchase competitive foods.[19] The current study aimed for 40 participants with anticipation of a 20–25% dropout rate and also allowing for adequate power to conduct multiple-comparisons across several dependent variables.

## Study Design

This study was a randomized crossover trial, where participants were randomized to one of three groups, and each group was assigned to receive three meal conditions comprised of different meal types in a specific order, to control for an order or carryover effect. Meal conditions were provided such that each group attended one session every three weeks. A flow chart of the overall study design can be found in Figure 6. Randomized participants attended a physical assessment and full screening before beginning any meal conditions.

Each meal condition consisted of a particular meal type based on DQ with two levels, (1) typical school lunch (TSL) and (2) best practice school lunch (BPSL). The TSL consisted of meals similar to those found in typical school lunches that were accessed on local school foodservice websites (i.e., chicken tenders, hamburger, pizza, etc.). Each TSL met minimum NSLP nutrition standards, with average DQ (HEI score of 70–75/100). The BPSL consisted of meals that incorporated Child and Adult Care Food Program best practices,[12] 2015 Dietary Guidelines for Americans healthy meal pattern recommendations,[11] HEI 2015 positive scoring components,[10] and evidence-based school lunch best practices that were determined in a critical review by authors of the current study.[27] Each BPSL had optimal DQ (HEI score of 90–95/100). All meals were created equally, aside from DQ, meeting all NSLP nutrition standards for the K–5th grade age group. At each meal session, acceptability (taste test survey, plate waste assessment, change in hunger) and feasibility (meal cost, preparation time, skill and equipment needs) of the meals were determined.

**Figure 7. Study Design Flow Chart**



Levels of the meal type were utilized to create three different lunch conditions. Meal condition one consisted of a choice between two BPSL options. Meal condition two consisted of two TSL options. Meal condition three consisted of a choice between one BPSL option and one TSL option. The meals served for each meal condition can be found in Table 7.

**Table 7. Meals Served for Each Meal Condition**

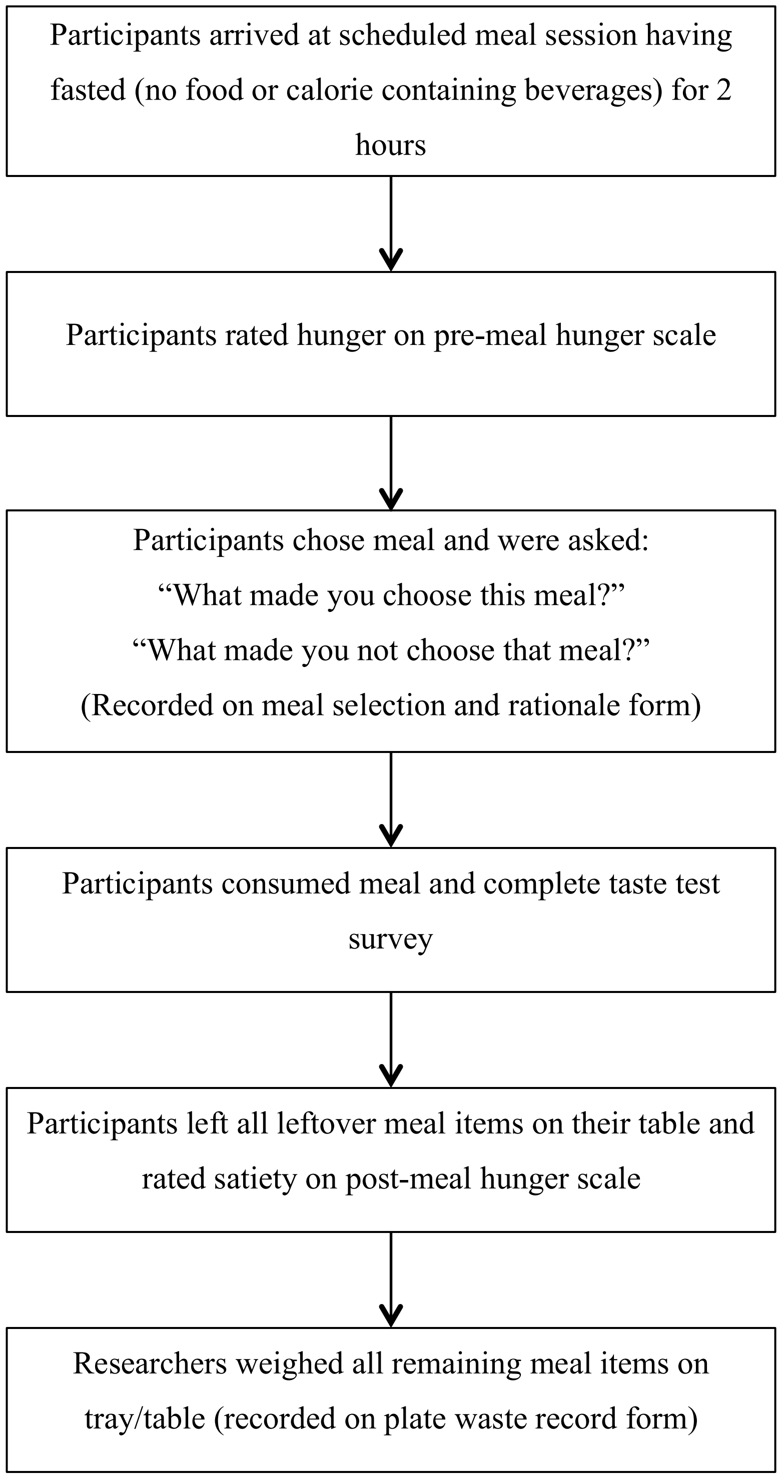
| **NSLP Meal Component** | **Meal Condition 1** | | **Meal Condition 2** | | **Meal Condition 3** | |
|---|---|---|---|---|---|---|
| | BPSL 1 | BPSL 2 | TSL 1 | TSL 2 | BPSL | TSL |
| **Meat/ Meat Alternate** | Oven fried chicken* | Homemade cheese pizza* | Frozen chicken nuggets | Frozen cheese pizza | BBQ pulled pork* | Beef hot dog |
| **Grain** | Whole grain cornbread* | Whole grain crust* | White roll | (crust) | Whole grain slider buns | White hot dog bun |
| **Vegetable** | Broccoli salad* | Mixed greens salad with carrots, tomato, cucumber | Broccoli with cheese sauce | Carrots with ranch dip | Asian coleslaw* | Frozen French fries |
| **Fruit** | Grapes | Clementine | Pineapple fruit cup in 100% | Mandarin orange fruit cup | Apple slices | Peach fruit cup in 100% |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | fruit juice | in 100% fruit juice | | fruit juice |
| **Milk** | 1% low fat milk, plain | 1% low fat milk, plain | 1% low fat milk, plain | 1% low fat milk, plain | 1% low fat milk, plain | 1% low fat milk, plain |

*Recipes can be found in Appendix H

Following completion of the nine scheduled meal sessions, make-up sessions were offered in order by meal condition (i.e., meal condition one first, meal condition two second, meal condition three third). Each meal session followed the same general procedure, which was designed to be similar to a typical school cafeteria, and lasted approximately 20–30 minutes. A flow chart of the meal sessions can be found in Figure 7.

**Figure 8. Meal Session Flow Chart**



## Data Collection

At the pre-screening and initial assessment appointment, informed consent, both written parental consent and written and oral child assent was obtained. Height, weight, and waist circumference measurements were obtained by two trained researchers. Detailed protocols for obtaining these measurements can be found in an article by Guagliano and Rosenkranz (2012).[28] Two measurements were averaged for each anthropometric characteristic and the average value was used for analysis. Body mass index (BMI) percentile was determined using the Centers for Disease Control and Prevention (CDC) BMI percentile calculator for children and teens.[29] Usual diet was determined via 24-hour dietary recall using the Automated Self-Administered 24-hour (ASA24) Dietary Assessment Tool by the National Cancer Institute (version 2016, US Department of Health and Human Services, Washington, D.C.).[30] Parents completed the dietary recall with participant assistance. Basic medical history was obtained from the parent consisting of information about any known drug nutrient interactions, food allergies, nutrition therapy utilization, and conditions influencing diet but not receiving nutrition therapy. Ethnicity, age, and grade level were also obtained during the initial assessment.

**Acceptability.** ***Meal selection*** was assessed at meal condition 3, which included one BPSL and one TSL. As participants moved through the service line, their meal choice was recorded, and they were also asked why they chose what they did, and why they did not choose the other meal option (see Appendix I). The meal selected, and selection rationale, were recorded along with tray ID number.

***Taste test evaluation*** was performed at each of the three meal sessions using a modified version of the USDA, Food and Nutrition Services, Child Nutrition Programs, Team Nutrition try-day taste-testing ballot.[31,32] An example of the survey can be found in Appendix J. The form was provided with each tray and coded to match the tray ID number. Participants were asked to complete the form either during or after the meal, but before leaving the testing area. Smiley faces represented a 5-point Likert scale for responses to each question. These were coded for analysis (i.e., full frown/ really dislike = 1; half frown/ somewhat dislike = 2; flat face/ neutral feelings = 3; half smile/ somewhat like = 4; full smile/ really like = 5). Scores for appearance, smell, taste, and desire to serve at school were recorded individually and also totaled to create a total taste test score. Researchers were present in the room during meal sessions to ensure that no food was discarded, and that all forms were completed and remained with the trays.

***Plate waste assessment*** was determined at each meal session using a modified method from several prior research studies investigating plate waste in school and adult care food program settings[33-35] and validated by the Rutgers Department of Nutritional Science and Extension Specialists.[36] Trays were numbered by trained researchers with a unique ID code for each tray, or tray ID number. Trashcans were removed from the serving area. Food items within each NSLP meal/food component (i.e., grain, meat/ meat alternate, fruit, vegetable, and milk) were weighed on food scales (OXO Good Grips Stainless Steel Food Scale with Pullout Display, 11-pound) individually, prior to service, and recorded as initial weights. Participants were instructed to leave trays with remaining food on the table when finished. Researchers closely monitored the eating area during consumption. Upon exit of all participants, researchers collected trays and weighed each individual food item/meal component remaining. This weight was recorded (see form in Appendix K) and compared to the initial serving weight measured before service, which resulted in waste as a percentage of initial serving. The plate waste of each meal subcomponent (i.e., grain, protein, fruit, vegetable, milk) was recorded and also averaged across all subcomponents to create an average total plate waste value. Two scales of the same brand were used to decrease instrumentation error, and one scale was used for measuring food items after service. Photos of plate waste were also taken for additional verification of results, if needed.

***Change in hunger*** from pre- to post-meal was used to determine level of satiety. Hunger was measured using the 5-point Likert scale, found in Appendix L.[37] This is a common scale used in mindful eating techniques, eating disorder nutrition therapy, and diabetes nutrition therapy. The scale was developed by Harvard Medical School for their Joslin Diabetes Center.[31] The hunger scale was completed using a single question asked by trained researchers twice at each of the three meal sessions, first, before leaving the food service area and consuming the meal, and a second time after consuming the meal, but before leaving the testing area. Change in hunger was determined by subtracting pre-meal hunger from post-meal hunger.

**Feasibility.** ***Meal cost*** was determined by first dividing the cost of a full package of a food item or ingredient from grocery store receipts, by the number of servings in that package, to determine the cost of one serving of each ingredient or food item purchased. The cost of one serving of each ingredient was then multiplied by the number of servings of that ingredient used to prepare each recipe, to determine the cost of the ingredient in the recipe. The cost of each ingredient in each recipe was totaled to obtain a recipe cost, which was then divided by the number of portions prepared by that recipe. With the cost of each food item and each recipe portion determined, these were totaled for each food item and recipe portion making up a meal, to determine the meal cost.

***Preparation time*** was determined using the start and end time of each step of the preparation process of a food item or a recipe. The time to perform each preparation step was totaled for each food item or recipe, to determine the total time to prepare each food item or recipe, which was then totaled for each meal, resulting in the final meal preparation time.

***Skill and equipment*** needed to prepare meals was determined by an experienced school foodservice director and Registered Dietitian (KH), based on experience with job descriptions and duties of staff and with equipment for large-scale cooking in a school foodservice environment. The researcher evaluated each recipe and food item within a meal to determine the skills and the types of equipment, small and large, required to prepare each meal.

## Statistical Analysis

Statistical analyses were performed using SPSS analytic software (version 25, IBM Corporation, Armonk, NY). Descriptive statistics included means and standard deviations, and proportions for baseline characteristics and acceptability and feasibility measures. One-way ANOVA and chi-squared tests were used to determine differences in baseline characteristics between groups. Presence of an order effect was investigated using one-way ANOVA for differences in acceptability (overall taste test survey scores, average total plate waste percentage, change in hunger) between groups. Cronbach's alpha, with a cut-point of 0.6, was used to ensure that taste test survey and plate waste assessment subcomponents were consistently measuring the same construct. Milk percentage plate waste was excluded from total average plate waste percentage, as it had a Cronbach's alpha<0.6, and was not consistent with the other measures of plate waste. For acceptability comparisons, one-way ANOVA was used to determine significant differences in total taste test score, total average plate waste percentage, and change in hunger between overall BPSL and overall TSL and also between BPSL in meal condition 1, as compared to meal condition 3. Analyses were repeated using ANCOVA to adjust for possible confounders, including sex, grade level, BMI percentile, and group. Binary logistic regression, with entry method, was used to determine whether any participant characteristics predicted selection of the BPSL in meal condition 3. Characteristics in the regression analysis included sex (two groups: male or female), grade level (three groups: K+1st, 2nd+3rd, 4th+5th), BMI percentile (three groups: healthy weight <85th percentile, overweight 85–95th percentiles, obese >95th percentile), fruit consumption (two groups: <1 serving/ day, >1 serving/ day), vegetable consumption (three groups: <0.5 servings/ day, 0.5–1 serving/ day, >1 serving/ day), and added sugar consumption (three groups: 0–8g/d, 8–16g/d, 16–27g/d). For feasibility comparison, one-way ANOVA was used to determine differences in preparation time and cost of meals between overall BPSL and overall TSL. Follow-up analyses were performed to determine whether there were any significant differences in taste test survey subcomponents (taste, smell, appearance, and service recommendation) and meal component plate waste assessment (fruit, vegetable, grain, protein, and milk). Level of significance was set at 0.05, with Bonferroni correction used for multiple comparisons. Parametric assumptions were checked for normality and equality of variance using Levene's test and Browne-Forsythe test. Variance inflation factors, with cut-point <5, were checked for all variables before performing regression analysis.

## Results

### Participant Characteristics

Forty-three participants expressed interest in the current study, with thirty-six (84%) completing all three meal sessions. During screening, five participants were excluded due to food allergy, inability to make scheduled initial assessment appointment times, and unwillingness to undergo a physical assessment. Of the 38 remaining interested participants, two started, but did not complete the study (5% dropout rate). Dropouts were due to new diagnosis of food intolerance and scheduling communication issues. Thirty-six participants completed the study. Twenty-four participants attended all three meal sessions as scheduled, while twelve participants attended at least one make-up session.

Participant characteristics of those completing the study can be found in Table 8. There were no significant between group differences for baseline characteristics including gender, age, grade level, or ethnicity. There was a significant difference between groups for weight ($p$=0.003), where group 2 was heavier than groups 1 and 3. There were no other significant anthropometric differences between groups.

**Table 8. Participant Characteristics, All Participants and by Group**

| Characteristic | | All Participants | Group 1 (n=11) | Group 2 (n=11) | Group 3 (n-14) |
|---|---|---|---|---|---|
| | | Proportion (%) | | | |
| Grade Level | Kindergarten | 16.2% | 18.1% | 0 | 28.6% |
| | 1st | 16.2% | 18.1% | 9.1% | 21.4% |
| | 2nd | 16.2% | 9.1% | 9.1% | 21.4% |
| | 3rd | 24.3% | 36.4% | 36.4% | 7.1% |
| | 4th | 16.2% | 9.1% | 36.4% | 7.1% |
| | 5th | 10.8% | 9.1% | 9.1% | 14.3% |
| Sex | Female | 59.5% | 54.5% | 81.8% | 50.0% |
| | Male | 40.5% | 45.5% | 18.2% | 50.0% |
| Ethnicity | Caucasian | 78.4% | 81.8% | 63.6% | 85.7% |
| | Hispanic | 2.7% | 0 | 9.1% | 0 |
| | African | 5.4% | 0 | 0 | 14.3 |

| | | | | | |
|---|---|---|---|---|---|
| | **American** | | | | |
| | **Native American** | 0 | 0 | 0 | 0 |
| | **Asian/ Pacific Islander** | 5.4% | 9.1% | 9.1% | 0 |
| | **Other** | 8.1% | 9.1% | 18.2% | 0 |
| **BMI Percentile Category** | **<85th, Healthy** | 69.4% | 81.8% | 45.5% | 78.6% |
| | **85th-95th, Overweight** | 13.9% | 18.2% | 18.2% | 7.1% |
| | **>95th, Obese** | 16.7% | 0 | 36.4% | 14.3% |
| **Mean ± Standard Deviation** | | | | | |
| **Age (years)** | | 7.7±1.7 | 7.5±1.7 | 8.3±1.1 | 7.3±2.1 |
| **Height (cm)** | | 130.2±10.5 | 127.1±10.4 | 136.7±5.8 | 127.6±11.7 |
| **Weight (kg)** | | 30.2±8.3 | 26.1±6.2 | 36.7±7.6* | 28.2±7.6 |
| **BMI Percentile** | | 61.4±30.2 | 43.4±32.6 | 77.5±22.0 | 63.0±27.7 |
| **Waist Circumference (cm)** | | 56.1±11.7 | 49.3±16.5 | 61.6±8.5 | 57.0±6.2 |

*Indicates a statistically significant difference between groups ($p$<0.004).

## Differences in Acceptability between BPSL and TSL

**Taste Test Evaluation.** Taste test results are summarized in Appendix M and can be visualized in Figure 8. There were no significant differences in total taste test score ($p$=0.420) between overall BPSL and overall TSL before controlling for confounders. Following adjustment for sex, grade level, BMI percentile, and group, total taste test score differences remained non-significant ($p$=0.226). Post-hoc analysis of individual taste test scoring subcomponents revealed no significant differences between overall BPSL and overall TSL for taste, smell, appearance, or service recommendations, before or after adjusting for covariates (*p*s>0.013).

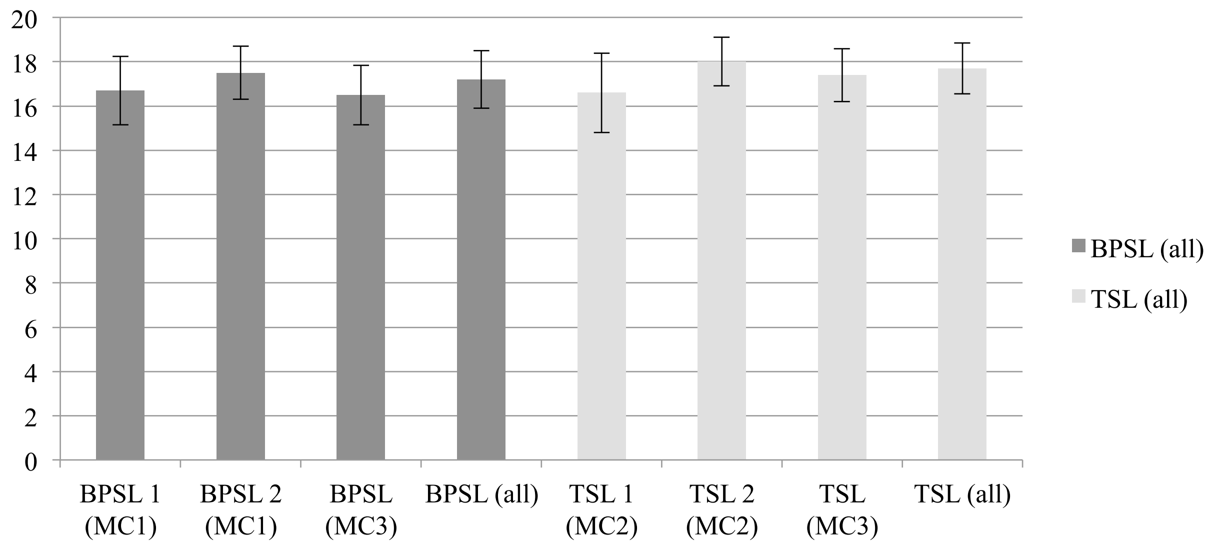
**Plate Waste Assessment.** Plate waste results are summarized in Appendix N and can be visualized in Figure 8. There was no significant difference in average total plate waste ($p$=0.582), before controlling for confounders. There were also no significant differences after adjusting for sex, grade level, and group individually or all covariates collectively. When controlling for BMI percentile alone, there was a significant difference in average total plate waste, such that the obese participants wasted the least of BPSL, followed by the healthy weight participants and then the overweight participants (adjusted mean=50.4±2.0%, $p$=0.006). Post-hoc analysis of individual meal component waste revealed no significant differences between overall BPSL and overall TSL in fruit, vegetable, grain, protein, or milk waste, before or after adjusting for covariates (*p*s>0.01).

**Change in Hunger.** Changes in hunger can be visualized in Figure 8. There was no significant difference in change in hunger between overall BPSL and overall TSL ($p$=0.197) before controlling for confounders. There was also no significant difference after adjusting for sex, grade level, BMI percentile, and group individually and collectively (*p*s>0.05).

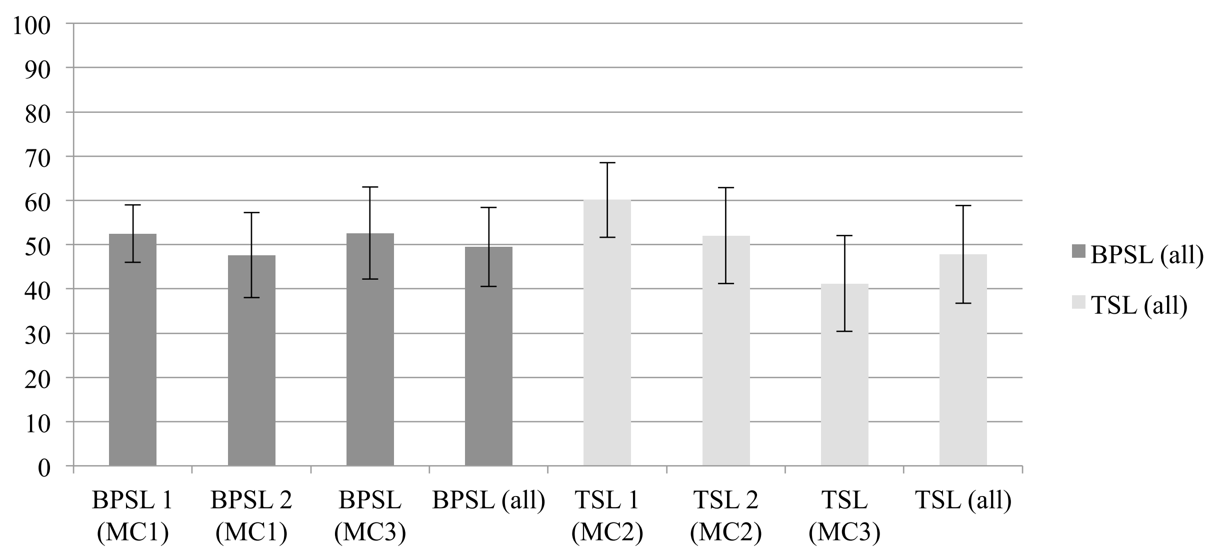
**Differences by Group.** There was a significant difference in acceptability by group, suggesting an order effect. Total taste test score was significantly different, such that Group 2, which completed the two meal conditions including BPSL first before completing the meal condition with only TSL, had higher total taste test scores for BPSL than Groups 1 and 3 ($p$=0.003, Group 1: 16.5±2.0, Group 2: 18.7±1.9, Group 3: 18.0±2.2). Change in hunger ($p$=0.647) and average total plate waste ($p$=0.034) were not significantly different between groups. Because these results indicate a possible order effect, group was included as a covariate in subsequent analyses.

**Figure 9. Comparison of Acceptability by Meal Type**

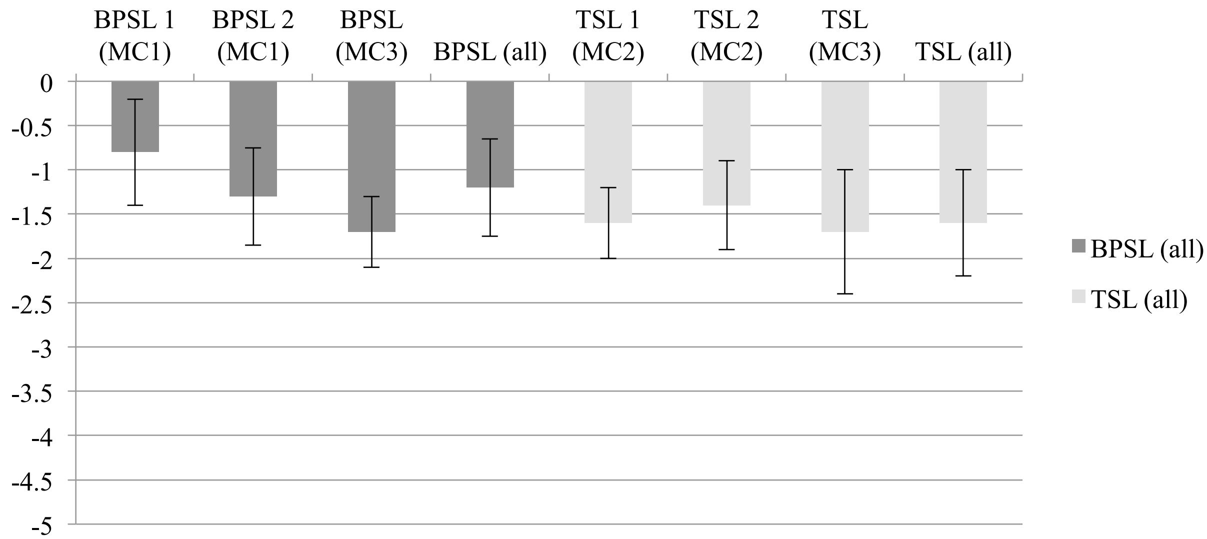
**A. Total Taste Test Score**




**B. Average Total Plate Waste**




**C. Change in Hunger**




*There were no significant differences between meal types for total taste test score, average total plate waste, and changes in hunger after adjusting for sex, grade level, BMI percentile, and group (*ps*>0.017)

^MC = meal condition

+Max scores: total taste test score = 20 points, average total plate waste = 100%, change in hunger = 5 points from pre- to post-meal consumption

++Error bars = standard deviation

### Influence of Presence of Competitive Foods on Acceptability

Aim three was to investigate whether offering BPSL alongside less healthful, competitive foods (TSL) influenced acceptability of the BPSL. To investigate this matter, results from meal selection, taste test, plate waste, and hunger scale for BPSL served in meal condition 1 with only BPSL meals served (BPSL1 and BPSL2) were compared to results for BPSL served in meal condition 3 alongside TSL. These data are presented in Appendix M, Appendix N, and Figure 2.

**Meal Selection.** Meal selection for meal condition 3 was also investigated. There was a significant difference in meal type selection in meal condition 3. The TSL meal option was selected significantly more than the BPSL meal option (TSL = 83.3%, BPSL = 16.7%, $p$=0.001).

Regression analysis was performed to determine whether any participant characteristics predicted selection of BPSL over TSL in meal conditions 3. Sex, grade level, BMI percentile, fruit consumption, vegetable consumption, and added sugar consumption were included in models. Neither model, forcing all variables together or step-wise with dietary factors first, followed by participant characteristics, showed significant predictors for selecting BPSL over TSL in meal condition 3 (model with all variables at once: sex $p$=0.781, grade level $p$=0.460, BMI percentile $p$=0.979, fruit consumption $p$=0.152, vegetable consumption $p$=0.441, and added sugar consumption $p$=0.300). Table 9 presents a regression table with odds of participants selecting the BPSL in meal condition 3 by baseline characteristic. Participants were not more likely to choose BPSL in meal condition 3 by any of the investigated characteristics.

**Table 9. Odds of Selecting BPSL as Opposed to TSL in Meal Condition 3 by Baseline Characteristic**

| Baseline Characteristic | Odds Ratio+ (95% Confidence Interval) |
|---|---|
| **Sex** | |
| Male* | 1.00 |
| Female | 0.58 (0.10–3.38) |
| **Grade Level** | |
| K & 1st* | 1.00 |
| 2nd & 3rd | 0.50 (0.07–3.65) |
| 4th & 5th | 0.33 (0.03–3.84) |

| | |
|---|---|
| **BMI Percentile** | |
| Healthy (<85th)* | 1.00 |
| Overweight (85th–95th) | 0.34 (0.02–7.11) |
| Obese (>95th) | 0.80 (0.08–8.47) |
| **Fruit Consumption** | |
| Low (<1 serving/d)* | 1.00 |
| High (>1 servings/d) | 0.21 (0.02–2.04) |
| **Vegetable Consumption** | |
| Low (<0.5 serving/d)* | 1.00 |
| Moderate (0.5-1 serving/d) | 0.12 (0.01–2.60) |
| High (>1 serving/d) | 1.25 (0.20–7.96) |
| **Added Sugar Consumption** | |
| Low (0-8g/d)* | 1.00 |
| Moderate (8-16g/d) | 0.14 (0.01–3.28) |
| High (>16g/d) | 2.26 (0.32–15.76) |

*Reference category

$^{+}$Unadjusted odds ratio

**Taste Test Evaluation.** There were no significant differences in total taste test scores when comparing BPSL served in meal condition 1 and BPSL served in meal condition 3 ($ps>0.017$), before or after controlling for all confounders collectively. When controlling for BMI percentile alone, there was a significant difference in total taste test score, due to overweight participants not selecting the BPSL over the TSL in meal condition 3 (adjusted mean=17.1±0.6, $p=0.015$). Post-hoc analysis of individual taste test scoring components revealed no significant difference in individual taste, smell, appearance, or service recommendation before or after controlling for all confounders collectively. Again, when controlling post-hoc analysis for BMI percentile alone, there was a significant difference in survey score for smell ($p$=0.005).

**Plate Waste Assessment.** There was no significant difference in average total plate waste ($p$=0.760), before or after controlling for confounders, between BPSL in meal condition 1 and BPSL in meal condition 3. Post-hoc analysis of individual meal component plate waste revealed no significant difference in fruit, vegetable, grain, protein, or milk waste before or after controlling for all confounders collectively. When controlling post-hoc analysis for BMI percentile alone, there was a significant difference in protein waste ($p$=0.001).

**Change in Hunger.** There were no significant differences in change in hunger between BPSL in meal condition 1 and BPSL in meal condition 3 ($p$=0.308) before controlling for confounders. There were also no significant differences after adjusting for sex, grade level, BMI percentile, and group individually and collectively.

## Qualitative Results regarding Acceptability

Several questions were asked in an open-answer format to gather qualitative data regarding acceptability of meals. A record of all comments and responses can be found in Appendices O and P. The first question was upon selection of the meal regarding what reason the participant had for choosing that meal and what reason they had for not choosing the other meal option. The majority of responses, found in Appendix O, point to favoring or disliking one specific food item. Some food preferences also became apparent. The participants highly favored hot dogs and pizza over most other foods, while disliking both forms of broccoli provided. The rest of the likes and dislikes as rationale for selection were widely varied.

The second question was whether the participants had any comments at the end of their taste test survey. Recorded comments can be found in Appendix P. There were no common themes to the comments recorded. Comments were mainly children practicing use of sensory descriptors for foods (i.e., bread is soft, chicken is crunchy) and stating likes or dislikes, which were documented quantitatively in selection, consumption, and taste test score data.

## Differences in Feasibility between BPSL and TSL

**Meal Cost.** Cost data are presented in Table 10. Overall average BPSL cost was \$0.12 more per meal than TSL, which is a 3% difference, however, this was not a significant difference ($p$=0.783).

**Preparation Time.** Preparation time data can also be found in Table 10. BPSL, overall, required significantly longer preparation time than TSL (BPSL: 267 minutes, TSL: 60 minutes, $p$=0.026).

**Table 10. Comparison of Preparation Time and Cost for Meal Types**

| Meal | Food Items | Food Item Preparation Time (min) | Food Item Cost per Serving | Number of Servings Prepared | Total Meal Preparation Time (min) | Total Meal Cost per Serving |
|---|---|---|---|---|---|---|
| **BPSL1 (MC1)** | Chicken nuggets | 177 (Start prep 11, marinade 105, finish prep 26, bake 35) | \$0.50 | 18 | 379 | \$3.83 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Broccoli salad | 120 (Prep 72, marinade 48) | $0.98 | | | |
| | Cornbread | 56 (Prep 18, preheat 14, bake 24) | $0.29 | | | |
| | Grapes | 26 | $0.44 | | | |
| | Milk | 0 | $1.62 | | | |
| **BPSL2 (MC1)** | Pizza Crust | 135 (Prep 43, set 92) | $0.10 | 18 | 239 | $3.37 |
| | Pizza Sauce | 30 (Prep 15, cook 15) | $0.63 (sauce + cheese) | | | |
| | Pizza | 61 (Prep 15, preheat 20, bake 26) | $0.73 (crust + sauce + cheese) | | | |
| | Salad | 13 | $0.84 | | | |
| | Clementine | 0 | $0.18 | | | |
| | Milk | 0 | $1.62 | | | |
| **BPSL** | Pulled pork | 117 | $1.21 | 12 | 183 | $4.20 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **(MC3)** | | (Preheat 12, prep 10, bake 75, pull 20) | (+ BBQ sauce) | | | |
| | Slider buns | 0 | $0.18 | | | |
| | Apples | 9 | $0.40 | | | |
| | Coleslaw | 57 (Prep 55, set 2) | $0.79 | | | |
| | Milk | 0 | $1.62 | | | |
| **Overall BPSL** | | | | | 267 | $3.80 |
| **TSL1 (MC2)** | Roll (frozen) | 28 (Preheat 13, bake 15) | $0.51 (+ butter) | 13 | 86 | $4.36 |
| | Broccoli (frozen) with cheese sauce (prepared) | 12 (Prep 2, steam 9, mix with cheese sauce 1) | $0.57 | | | |
| | Chicken nuggets (frozen) | 46 (Preheat 14, bake 32) | $1.04 (+ ketchup) | | | |
| | Fruit cup | 0 | $0.62 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (canned) | | | | | |
| | Milk | 0 | $1.62 | | | |
| **TSL2 (MC2)** | Pizza (frozen) | 37 (Preheat 17, bake 20) | $0.87 | 13 | 37 | $3.39 |
| | Carrots with dip | 0 | $0.28 (+ ranch dip) | | | |
| | Fruit cup (canned) | 0 | $0.62 | | | |
| | Milk | 0 | $1.62 | | | |
| **TSL (MC3)** | Hot dog | 31 (Boil water 21, cook 10) | $0.69 | 12 | 56 | $3.28 |
| | Hot dog bun | 0 | $0.45 | | | |
| | French fries (frozen) | 37 (Preheat 12, bake 25) | $0.21 (+ ketchup) | | | |
| | Fruit cup (canned) | 0 | $0.31 | | | |
| | Milk | 0 | $1.62 | | | |
| **Overall TSL** | | | | | 60 | $3.68 |

**Skill.** A breakdown of skills needed to prepare each meal and meal item can be found in Appendix Q. There were two skills found to be common to both BPSL and TSL. There were four additional skills needed by school foodservice staff to prepare BPSL. These additional skills are common skills and may not greatly increase training needs or skill level of applicants/employees.

**Equipment.** A breakdown of large kitchen equipment and smaller kitchenware needed to prepare each meal and meal item can also be found in Appendix R. There were three pieces of larger kitchen equipment and four pieces of smaller kitchen equipment common to both BPSL and TSL preparation. BPSL required six additional pieces of larger equipment and four additional pieces of smaller equipment. These additional pieces of equipment are commonly found in most school foodservice environments and may not greatly increase equipment needs.

## Discussion

The primary purpose of this study was to compare acceptability and feasibility of BPSL, of high DQ, to TSL, of moderate DQ. Overall, our results suggest that high DQ school lunches are acceptable to children in grades K–5, particularly when offered alongside a second high DQ meal choice. The results also suggest that high DQ school lunches are equally acceptable to elementary schoolchildren when served alongside a lower DQ meal choice, but will be selected much less often than the lower DQ option. Additionally, there was evidence suggesting that weight status may impact acceptability of high DQ school lunches, however, when adjusting for other potential confounders in addition to weight status, this difference was no longer significant. Additionally, there was a significant order effect, such that the group of participants, who completed the two meal conditions including BPSL first, followed by the TSL only condition, had higher total taste test scores for BPSL than those of groups exposed to TSL earlier in the meal condition order. These results suggest that being exposed to higher DQ school lunches before less healthful, competitive foods may improve acceptability of the higher DQ options.

The third aim of the current study, related to acceptability, was to investigate whether the presence of both meal types in one meal setting (choice) influenced the acceptability of the best practice school lunches. The results suggest that high DQ school lunches are equally acceptable to elementary schoolchildren when served alongside a lower DQ meal choice, in terms of taste preference and plate waste, but will be selected much less often than the lower DQ option. Again, there was evidence that weight status may impact acceptability of high DQ school lunches when served alongside competitive foods of lower DQ. These differences were also no longer significant after adjusting for other potential confounders in addition to weight status. To supplement this quantitative data on acceptability, results are corroborated and even explained by selection and taste test survey comments. Based on these comments, the participants did not appear to notice any difference in or favor any particular meal type when served separately. However, when BPSL and TSL were served simultaneously, a useful theme became apparent that less healthful, competitive foods would consistently be chosen over more healthful options, but that more healthful options were very appealing and would have happily been chosen had the less healthful, competitive option not been present.

In terms of feasibility, this study adds to the current body of research on cost comparisons, and to our knowledge, is the first to compare time, skill and equipment needed to prepare high DQ school lunches. With a 3% higher meal cost, the BPSL was not significantly more expensive than the TSL, contrary to common perceptions. In contrast, commonly reported time requirements for high DQ lunches were confirmed by the current study, as BPSL took significantly longer to prepare as compared to TSL. Caution should be taken, however, when interpreting this difference for several reasons. The total times calculated include every minute of preparation, whether multiple tasks were done simultaneously (multi-tasking) or not. Also, food was prepared by undergraduate and graduate students, who are not experienced cooks. Additionally, food was prepared using small, dated, home-style kitchens with no use of large scale cooking equipment or space (i.e., Robot Coupe, double ovens, steam kettles, etc.). It should also be noted that ample, and even excess time was set aside to prepare each meal, and thus efficiency was not a priority, instead focusing on accuracy. And finally, recipes chosen for the BPSL were such that BPSL meals were minimally processed and utilized very few value-added, convenience products. Value-added product purchase (i.e., pre-chopped fresh broccoli) and use of large scale cooking equipment (i.e., Robot Coupe) would reduce time required to prepare BPSL meals. Thus, the time difference presented here is likely exaggerated in comparison to that which a school foodservice operation would actually experience. There were a few additional skills and large and small pieces of kitchen equipment needed to prepare BPSL as compared to TSL, however the additional equipment needs are for equipment commonly found in school foodservice operations and would likely not require major acquisitions of additional equipment. Similarly, additional skills needed to prepare BPSL would not be such that they greatly impact training or hiring practices. Caution should be taken when interpreting feasibility results, as scaling these results from a small-scale, lab-style operation to a large-scale, multi-unit school foodservice operation is unlikely to be clear and linear.

To our knowledge, this is the first study to extensively investigate differences in the acceptability and feasibility of best practice as compared to typical school lunches. Plate waste percentages were similar in the current study to those of previous studies by Marlette et al

(2005),[19] Smith and Cunningham-Sabo (2013),[18] Cohen et al (2014),[20] Byker et al (2014),[21] and Gase et al (2014).[23] Marlette et al (2005) investigated the influence of food preparation methods and competitive foods on school lunch plate waste of sixth graders in three Kentucky middle schools. Results of this study showed that competitive food purchases significantly affected plate waste of fruit, grain, meat, and mixed dishes and that plate waste was highest for those purchasing competitive foods. Additionally, results showed the impact of competitive food purchases was the greatest on waste of fruits and vegetables.[19] Similarly, Smith and Cunningham-Sabo (2013) investigated impact of the offer service style, where students can refuse some reimbursable meal components, and saw greater waste of higher DQ fruits and vegetables than those of lower DQ.[18] Byker et al (2014) and Gase et al (2014) measured what meal components and foods students wasted in general, within an actual lunchroom setting with reimbursable and competitive foods available, and found higher fruit and vegetable component waste.[21,23] An additional study looking at impact of competitive foods by Cluss et al (2014) found that children consumed more healthful food items in the lunchroom when less healthful options were removed.[25] Collectively, the current results, corroborate previous results, suggesting that competitive foods impact healthier food acceptability. In the same children, under different conditions in the current study, the BPSL was acceptable, yet only 17% selected the BPSL when TSL was also offered. However, in the current study, there were no other acceptability differences between healthier lunches and less healthful, competitive lunches. This could be due to the smaller amount of options available, serve style of meals as compared to offer, and age groups investigated. Additionally, there were no significant differences in plate waste, before or after adjusting for all covariates, between BPSL and TSL in the current study. These results also supports results of a study by Cohen et al (2014) investigating differences in selection and consumption of meal components following implementation of the new NSLP nutrition standards.[20] Cohen and colleagues found increased consumption of vegetables and no other significant differences in meal component consumption with school lunches meeting the new 2012 NSLP nutrition standards as compared to meals meeting previous standards. Thus, no significant increase in waste was seen with higher DQ school lunches.[20] The current study additionally extended these results by investigating not just plate waste, but also taste test preference and change in hunger, with higher DQ school lunches.

The results of the current study also support and extend the existing body of literature on the feasibility of higher DQ school lunches. A study by Trevino et al (2012) investigated the impact of improving the DQ of school lunches in a 3-year randomized cluster, primary prevention trial, in 42 middle schools over five states, on revenues and expenses.[26] Authors reported that there was no significant difference in revenues or expenses, and that there was a trend for intervention schools with higher DQ lunches, to have higher excess revenue over expense ($3.5 million) than control schools ($2.5 million) over the 3-year intervention.[26] A study by Cohen et al (2016) looked at a sample from the NOURISH study to examine changes in school food revenue and participation rates with implementation of school lunch guidelines that were more strict than the NSLP (i.e., decrease in less healthful, competitive food options available and overall higher DQ school lunches).[24] Results indicated that there was an initial small loss of overall revenue in year one due to loss of revenue from competitive foods, but overall revenue returned to baseline year two due to increase in school meal revenue. There was no decline in participation rates.[24] These results are supported by the current study indicating that there are no statistically significant cost differences between meal types in addition to no significant overall differences in the acceptability of meal types. A study by Cluss et al (2014) investigating the impact of offering healthier foods in the lunchroom, found that food costs increased by about 15% and that participation decreased by 5–6% over five years during the intervention.[25] The current study challenges these reported cost differences, although the current study is a short-term analysis, whereas the Cluss et al (2014) study was a long-term analysis. This difference in results could be due to numerous factors within the school food environment studied, including quality of food, presentation style, characteristics of the student population, and perceptions of school foodservice and teaching staff, to name a few.

There were several strengths of the current study. The randomized crossover trial study design allowed for control for a potential order effect on acceptability. The study design also allowed us to determine the impact of choice on the acceptability of the high DQ school lunch options, which provides important context for determining acceptability in an offer setting and in a lunchroom with competitive foods available. A variety of measures were utilized for determining acceptability and feasibility. There was a conscious effort to eliminate bias and to ensure a lack of behavioral techniques in service of lunches that could impact selection, preference, or consumption. All researchers were trained by the principal investigator in survey methods and on appropriate professionalism during interactions with participants, specifically not to influence choices or responses of participants while assisting with meal service and completing surveys. Actions were also taken to ensure that meal presentation style was consistent between all meals offered and between meal sessions, so that presentation was not a confounding factor. Performing the trial in a lab setting allowed for isolation of meal type in impacting differences investigated, similar to an efficacy trial. Despite being in a lab setting, attempts were taken to create an environment similar to a lunchroom and to create meals similar to lunches served within a school lunchroom. The current study also included the youngest and broadest age group, elementary school-aged children, which is the earliest age group with which interventions can occur for the biggest prevention impact. Finally, a former foodservice director and Registered Dietitians were investigators on the current study, with knowledge on the NSLP nutrition standards and school foodservice operations.

As with any study, there were limitations that require caution when interpreting the current study findings. A convenience sample was used to obtain participants, which may limit generalizability beyond our study sample. Sampling occurred mainly in the Manhattan, KS, area, which is a generally higher SES area in Kansas and which may have been exacerbated by the inclusion of several participants who were children of Kansas State University faculty members. Higher SES and higher education level of parents and participants could bias results to having higher acceptability of BPSL. The service style for meals was serve, and not offer. The serve style was most appropriate for initial investigations for the purposes of the current study, to isolate independent variables. The offer service system of meals could result in different acceptability of meals, as participants would have the ability to select different options for each meal component and to refuse up to two components as compared to selecting from two complete meals. Based on selection rationales and taste testing survey comments, it appears that some individual food items may have impacted selection of entire meals. Thus, repeating the study with the offer service system may impact meal item selection. Performing the current study in a lab could be considered a strength methodologically for isolating effects of independent variables, however it could also be considered a limitation as the lab setting is not true-to-life for school foodservice operations. Thus, caution must be taken in generalizing results to actual school foodservice settings.

There are several directions for future research based on the current study. Future research should examine actual taste preference and sensory aspects of meals for acceptability, not just plate waste. It would also be of benefit to investigate the differences in acceptability, especially selection differences, when a larger variety of lower DQ options are available, not including favorites like hot dogs and pizza. This could further elucidate the selection between BPSL and TSL conditions. Future studies should also perform further analysis of skill and equipment needs and assess the cost implications of such differences. Time needed to prepare varying DQ meals should also be further investigated within the school foodservice setting. Additional validated measures for preference and feasibility of school lunches are needed. Future research should also investigate implications of the offer system, as compared to serve style used in the current study, on the acceptability of higher DQ school lunches.

## Conclusions

These results indicate that there are no differences in the acceptability, and minimal differences in the feasibility of high DQ school lunches as compared with less healthful, competitive options. Thus, perceived concerns/barriers related to lower acceptability and higher cost of improved DQ school lunches, might not be actual barriers. Time differences, however, were significant and may be a barrier to improving DQ of school lunches. An important finding from the current study was that when higher DQ and less healthful, competitive foods are served concurrently, the less healthful, competitive foods, may be selected more often than the higher DQ options. Additionally, earlier exposure to higher DQ lunches, before less healthful, competitive options, may improve their acceptability. These results may inform key school lunch stakeholders including policy-makers seeking to further improve DQ provided by NSLP nutrition standards, and to combat the recent relaxation of NSLP nutrition standards. Given that the overall goal of the NSLP is to provide healthy food to children, these results suggest that further investigation of whether schools should serve competitive foods in the lunchroom is needed.

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# Chapter 6 - Conclusions

The overall purpose of this dissertation was to better understand the implications of improving the DQ of school lunches. The included studies sought to support that overall purpose, and were based on several practical questions that arose from reviewing the literature on child DQ and school lunches. Could school lunches meeting NSLP nutrition standards vary widely in DQ? If so, how do they vary, and what are drivers of that variation? What does a "gold standard," or best practice, school lunch look like? Do schoolchildren find best practice, or higher DQ, school lunches acceptable, and are these school lunches feasible? This final chapter summarizes the evidence presented in this dissertation to begin answering these questions, and to provide support for better understanding the importance of improving school lunch DQ.

The first study, found in chapter 2, investigated the first practical question – could school lunches meeting NSLP nutrition standards vary widely in DQ? The purpose of this study was to determine whether there was a significant difference in nutrient content and DQ between a typical school lunch menu (TM) and a best practice school lunch menu (BPM). The approach used in this study was a cross-sectional content analysis comparing the nutrient content and DQ of six weeks of a TM from an actual school district and a BPM created to optimize nutrition regardless of feasibility. There were large significant differences in nutrient content, including calories (13% difference), protein (21%), carbohydrate (14%), saturated fat (30%), sodium (45%), fiber (148%), vitamin A (242%), vitamin D (17%), phosphorus (25%), and magnesium (74%). There was also a large significant difference in DQ of ~22% between BPM and TM. Differences were such that the BPM had more favorable nutrient content and DQ. Not only were these differences statistically significant, but considering the nutrients and the size of the differences, they are likely to be clinically significant as well. Thus, it is possible for variation in

DQ even in school lunches that all meet NSLP nutrition standards. This study also showed that meeting minimum NSLP nutrition standards, as the TM did, achieves a HEI score of 75/100. According to the USDA CNPP, this score is indicative that the DQ "needs improvement." The results from this study provide justification for further improvement in school lunch DQ.

Based on findings from the first study, there was the possibility for statistically and clinically significant variation in the DQ of school lunches while meeting NSLP nutrition standards. Thus, the second study, presented in chapter 3, investigated the second practical question – if there is the possibility for variation in DQ of school lunches while meeting NSLP nutrition standards, how do they vary, and what are drivers of that variation? The purpose of this study was to determine whether there were differences in the nutrient content and DQ of middle school lunch menus meeting NSLP requirements by SES and rurality. In order to answer this question, 286 Kansas school districts were stratified by SES (percent of students receiving free/ reduced-price lunches). Following stratification, 68 school districts were randomly selected from each strata, and a cross-sectional content analysis of 85 middle school lunch menus was performed to determine nutrient content and DQ. Results indicated, overall, that nutrient content and DQ were not different for higher SES versus lower SES schools, or for more rural versus more urban schools. There was no significant difference in DQ by SES or rurality. Menus differed by SES in added sugar content by ~80%, in calcium content by ~1%, and in sodium content by ~48%. Differences in added sugar and calcium content favored high SES menus, while differences in sodium content favored low SES menus. Menus did not differ in nutrient content or DQ by rurality alone; however, there were differences in calcium content due to the interaction between SES and rurality, such that as the school district becomes more rural, the difference in calcium content by SES diminishes to the point that in most rural locations the lower SES calcium content exceeds the higher SES calcium content. Overall, it does not appear that middle school lunch menus in Kansas differ significantly in nutrient content or DQ by SES or rurality, which can be interpreted as a positive result, where NSLP standards may be playing a role effectively improving DQ without creating disparities in nutrition provided by school lunches. An additional finding was that the menus analyzed provided meals with a mean HEI score of 62/100, which "needs improvement." This HEI score also indicates that some Kansas school lunches may not be meeting NSLP nutrition standards, as the state-wide average of 62/100 is lower than the HEI score of 75/100 determined in chapter 2 to be achieved from meeting minimum NSLP nutrition standards. While rurality and SES do not appear to be significant correlates of school lunch DQ variations, overall, there is room for improvement across the entire state in order to maximize positive health and educational outcomes associated with higher DQ lunches.

The study presented in chapter 2 indicated that there is the possibility for significant variation in DQ of school lunches meeting NSLP nutrition standards. Additionally, when school lunches meet minimum NSLP nutrition standards, on average, they would have a HEI score of 75/100, which indicates a need for improvement. The study in chapter 3 added that rurality and SES do not seem to be drivers of variability in school lunch DQ in the state of Kansas. Similarly to chapter 2, the study in chapter 3 also indicated the need for improvement in DQ of Kansas middle school lunches, with an overall average HEI score of 62/100. Based on the need for improvement, and the possibility for statistically and clinically significant improvement in the DQ of school lunches, the third study, presented in chapter 4, investigated the practical question – what does a "gold standard," or best practice, school lunch look like? The purpose of this critical review was to examine and summarize previous research on child DQ recommendations and implementation of healthful school lunches in order to develop healthful school lunch best practices. Twenty-five good or average quality articles were reviewed and appraised, and their results were summarized and synthesized to create a list of evidence-based school lunch best practices, including implementation recommendations. A list of these best practices is presented in the results section of chapter 4. If implemented, these best practices could improve DQ by 35–71 points and encourage selection and consumption of resultant higher DQ school lunches.

Next, having determined what best practices are needed for high DQ school lunches, the fourth study, presented in chapter 5, investigated the practical questions – do schoolchildren find best practice, or higher DQ, school lunches acceptable, and are these school lunches feasible? The purposes of this study were: 1) to determine whether there were differences in the acceptability of best practice school lunches as compared to typical school lunches; 2) to determine whether there were differences in the feasibility of best practice school lunches as compared to typical school lunches; and 3) to determine whether the presence of both meal types in one meal setting influenced the acceptability of the best practice school lunch. This final study was a randomized crossover trial with 36 elementary school-aged participants, investigating differences in the acceptability and feasibility of BPSL with higher DQ and best practices implemented (HEI score 90–95/100), and TSL with average DQ and meeting baseline NSLP nutrition standards (HEI score 70–75/100). There were no differences in acceptability, as measured by total taste test score, taste test score subcomponents, average total plate waste, meal component plate waste, and satiety before or after adjusting for covariates. Of note when adjusting analyses by BMI percentile, several significant differences in acceptability surfaced, suggesting that there may be differences in acceptability of higher DQ lunches based on weight status. Importantly, in meal condition 3, where BPSL and TSL were offered concurrently, participants selected the TSL significantly more often than the BPSL. The choice that participants had in this condition represented the choice between less healthful, competitive foods in the lunchroom and high DQ foods. In terms of feasibility, there were minimal differences in cost, equipment, and skill needed to prepare BPSL and TSL meals. There was, however, a significant difference in the time needed to prepare meals, favoring the TSL. In this laboratory-based study, BPSL preparation time was unrealistically long due to lack of large-scale kitchen equipment, experienced lunchroom cooks, and value-added products (i.e., pre-chopped fresh broccoli), and due to researchers prioritizing accuracy over efficiency. Thus, elementary school-aged children may find high DQ school lunches to be just as acceptable as lower DQ, competitive food options, when offered separately. When served concurrently, children may be more likely to choose the lower DQ, competitive food more often. Additionally, high DQ school lunches may be just as feasible as typical school lunches. Results from this study provide important information for decision and policy-makers working to improve the DQ of school lunches. These results also challenge the previously reported perceived barriers concerning lower acceptability and feasibility of higher DQ school lunches, and provide support for efforts to further improve the DQ of school lunches and NSLP nutrition standards.

With some answers to the practical questions posed at the outset, this dissertation achieves its purpose of providing evidence to better understand the implications of improving the DQ of school lunches. The studies included in this dissertation show that there is the possibility for significant, statistically and clinically, improvement in DQ with implementation of best practices; that DQ does not differ across the state of Kansas by SES or rurality; that meeting minimum NSLP nutrition standards, results in an HEI score of 75/100, which “needs improvement;” and that a large sample of Kansas schools appears to have DQ of approximately

62/100 across the state, which again indicates the need for improvement. Best practices were synthesized, providing a road map for improvement in the DQ of school lunches. And finally, there are negligible differences in the acceptability and feasibility between high DQ and typical (average DQ) school lunches; however, high DQ school lunches may be chosen significantly less often when provided alongside competitive foods. Thus, it is worth focusing on all schools to improve the DQ of school lunches beyond what has been accomplished through minimum NSLP nutrition standards. When using evidence-based guidelines for providing higher DQ lunches, it appears that schoolchildren will find these lunches to be acceptable. Higher DQ lunches are also likely to be feasible for school foodservice operations.

## Implications for Practice

With the overall results from this dissertation in mind, there are numerous practical implications of this research. The first study, in chapter 2, indicated that improving the nutrition provided through school lunches beyond minimum NSLP nutrition standards could result in clinically and statistically significant improvements in the DQ of lunches for schoolchildren. Additionally, meeting minimum NSLP nutrition standards provides a DQ score of approximately 75/100, which needs improvement. Thus, it is worth further investigating and investing in improvements in the DQ of school lunches. This information supports decision-makers at the school, state, and federal level seeking to improve the DQ of school lunches. This information also challenges recent flexibilities allowed within the NSLP nutrition standards related to grains, sodium, and flavored milk, which result in a decrease in the DQ attained when meeting the current minimum NSLP nutrition standards by ~5–15 points. Instead, these results support moving in the opposite direction and further improving DQ of school lunches achieved by meeting minimum NSLP nutrition standards.

The second study, presented in chapter 3, expanded on this premise and indicated that there were no differences in the DQ of Kansas school lunches by SES or rurality. These results suggest that individuals working to improve the DQ of school lunches should focus efforts and resources on schools across all SES and all locations equally. The results also indicated that Kansas school lunches need improvement in DQ, supporting continued work toward improving the DQ of school lunches in Kansas.

Chapter 4 provided some of the most practical implications for schools and state Child Nutrition Program coordinators with development of evidence-based school lunch best practices. These best practices could be useful to school foodservice directors in planning menus and to school wellness committees in creating nutrition-related wellness policies and initiatives. These best practices could also be useful to state Child Nutrition Program coordinators in creating state-mandated wellness policies and foodservice director and staff training programs. On the federal level, these best practices could be used similarly to CACFP best practices, and be provided as a supporting document to the NSLP nutrition standards through Team Nutrition.

Chapter 5 provides further evidence for the importance of improving the DQ of school lunches. The results of this study indicated no differences in the acceptability and minimal differences in the feasibility of best practice school lunches. These findings challenge previously reported perceived barriers to further improving the DQ of school lunches, and to call into question whether or not low DQ competitive foods should be offered within school lunch.

## Future Research Directions

There were several directions for future research discovered during the course of this dissertation. Future research should seek to further quantify the impact of improving DQ, in and out of the lunchroom, on health, academic, and financial outcomes in childhood, and track them into adulthood. This work could be done through longitudinal studies using cost-benefit analysis. Additionally, there is great need for valid measures of SES and rurality of school districts, valid scoring systems of DQ specific to school lunches and of the larger school food environment, and valid measures of child food preferences. Future research should also investigate the impact of offer versus serve meal service styles in the cafeteria on the DQ of meals consumed by schoolchildren. Also, more efficacy and effectiveness trials are need for implementation techniques encouraging the selection and consumption of higher DQ foods in the lunchroom, such as Smarter Lunchrooms initiatives. Finally, future research should investigate other barriers to higher DQ school lunches, beyond previously reported perceived barriers.

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# Appendix B - Samples of the Typical Menu and the Best Practice Menu (Week 1)

| **Menu Type** | **Monday** | **Tuesday** | **Wednesday** | **Thursday** | **Friday** |
|---|---|---|---|---|---|
| **Typical Menu** | Chicken dippers<br>Broccoli with cheese sauce<br>Side salad<br>Pineapple<br>Rice<br>Milk | Bean and cheese burrito<br>Corn<br>Canned peaches<br>Salsa cup<br>Milk | Popcorn chicken<br>Au gratin potatoes<br>California vegetables<br>Tropical fruit mix<br>Dinner roll<br>Milk | Chicken and noodles<br>Mashed potatoes<br>Green beans<br>Side salad<br>Mandarin oranges<br>Dinner roll<br>Milk | BBQ pork sandwich<br>Baked beans<br>Potato wedges<br>Applesauce unsweetened<br>Milk |
| **Best Practice Menu** | Crispy baked chicken<br>Arugula lemon pesto pasta salad<br>Fresh steamed broccoli<br>Fresh peaches<br>Milk | Sloppy farmer Joes<br>Baked sweet potato fries<br>Watermelon<br>Milk | Baked Cajun fish<br>Mediterranean quinoa salad<br>Fresh steamed peas<br>Fresh strawberries<br>Milk | Chicken and bean enchilada bake<br>Fresh pineapple<br>Black beans<br>Milk | Spanish chickpea stew<br>Whole grain cornbread<br>Fresh apples<br>Side mixed green salad with Italian dressing<br>Milk |

# Appendix C - Samples of HEI Score Calculations (Week 1 Best Practice Menu)

| HEI Component | Scoring Criteria | Monday | Tuesday | Wednes-day | Thursday | Friday |
|---|---|---|---|---|---|---|
| **Calories** | | 667 | 623 | 606 | 638 | 615 |
| **Total Fruit** | ≥0.8c/1000kcal | 4.5 (94%) | 5 (100%) | 5 (103%) | 5 (98%) | 5 (102%) |
| **Whole Fruit** | ≥0.4c/1000kcal | 4.5 (94%) | 5 (100%) | 5 (103%) | 5 (98%) | 5 (102%) |
| **Total Vegetables** | ≥1.1c/1000kcal | 5 (136%) | 5 (146%) | 5 (150%) | 5 (142%) | 5 (148%) |
| **Greens & Beans** | ≥0.2c/1000kcal | 5 (375%) | 0 | 5 (825)% | 5 (588%) | 5 (102%) |
| **Whole Grains** | ≥1.5oz/1000kcal | 10 (175%) | 10 (214%) | 10 (165%) | 10 (157%) | 10 (136%) |
| **Dairy** | ≥1.3c/1000kcal | 10 (128%) | 10 (115%) | 10 (123%) | 10 (127%) | 10 (125%) |
| **Total Protein Foods** | ≥2.5oz/1000kcal | 4.5 (90%) | 5 (128%) | 5 (132%) | 5 (125%) | 5 (98%) |
| **Seafood & Plant** | ≥0.8oz/1000kcal | 0 | 0 | 5 (413%) | 5 (392%) | 5 (305%) |
| **Fatty Acids** | (PUFA+MUFA)/SFA>2.5 | 10 (2.73) | 4 (1.11) | 10 (2.42) | 3 (0.68) | 10 (3.28) |
| **Refined Grains** | ≤1.8oz/1000kcal | 10 | 10 | 10 | 10 | 10 |
| **Sodium** | ≤1.1g/1000kcal | 10 | 10 | 10 | 10 | 10 |
| **Empty Calories** | ≤19% of energy | 20 | 20 | 20 | 20 | 20 |
| **Total Score** | 100 | 93.5 | 84 | 100 | 93 | 100 |

**Sample Calculations:**

Total Fruit = 500/daily cal/.8 = %

.5c/daily cal = x/1000cal

x = 500/daily cal

x/.8 = % of .8c/1000cal this day meets

10% = 0.5, 20% = 1, 30% = 1.5, 40% = 2, 50% = 2.5, 60% = 3, 70% = 3.5, 80% = 4, 90% = 4.5, 100% = 5 (MAX)

Whole Grains = 1000(oz)/daily cal/1.5

oz/daily cal = x/1000cal

x = 1000(oz) / daily cal

x/1.5 = % of 1.5oz/1000cal this day meets

10% = 1, 20% = 2, 30% = 3, 40% = 4, 50% = 5, 60% = 6, 70% = 7, 80% = 8, 90% = 9, 100% = 10 (MAX)

*5% = 0.5 points (i.e. 15% = 1.5)

# Appendix D - Menu Portioning Assumptions

1. Start with the first full week. If there is a week with missing days, use the non-full week's days to fill in the missing days.
2. If main dish is a combination of meat/meat alternate and grain components, provide enough to ensure that 2oz meat/meat alternate or 14g protein and 2oz grain or 30g carbohydrate.
3. If multiple options for the fruit, based on meal planning principles of variety and flavor pairing, choose what complements the meal flavor or week variety best.
4. If multiple options for the vegetable, choose what needs to be met still for vegetable variety NSLP requirements.
5. If multiple entrees/ lunches, decide if you will use the first, second, etc. and consistently use that ordered entree/ lunch.
6. Salad = 1c salad, 1 T dressing, choose appropriate dressing to compliment flavor of meal if no dressing specified
7. Steamed vegetables = add 1t butter
8. If something has cheese sauce, gravy, or dip, give 1/8c or 2 T.
9. Roll not as a sandwich bun = add 1 t butter
10. Peanut butter as 2oz meat alternate = 4 T
11. Yogurt as 2oz meat alternate = 1c
12. Burrito = 1 1/2oz tortilla, 1/2oz rice, 2oz ground beef if meat/ meat alternate not specified
    a. If smothered, add 1/4c salsa, 1 T reduced-fat sour cream, 1 T cheese sauce
13. Tacos = assume hard unless otherwise specified, assume ground beef if meat/ meat alternate not specified, add 1/8t taco seasoning

14. Stir-fry = 2oz meat, 3/4c Asian medley vegetable, 1t oil, 1t soy sauce, 1t teriyaki sauce
15. Super nachos = 2oz ground beef, 2T cheese sauce, 2oz chips
16. Roasted vegetables = squash if not specified, choose squash type to meet vegetable variety required for week, add 1t oil
17. Taco salad = 1c lettuce, 1/4c salsa, 1oz cheddar cheese, 1oz ground beef, 1/8t taco seasoning
18. Sancho = burrito + 1/4c enchilada sauce
19. Taco burger = 1 1/2oz ground beef, 1/2oz cheddar cheese, 1/8t taco seasoning
20. Tater tot casserole = 1oz egg, 1oz cheddar cheese, 3/4c tater tots
21. Cowboy cavatini = 2oz penne, 1/4c marinara sauce, 1 1/2oz ground beef, 1/2oz mozzarella cheese, 1/8t taco seasoning
22. Enchilada = assume beef if not specified
23. Fajita = 2oz meat, 2oz tortilla, 1/4c onion, 1/4c green pepper, 1/4c red pepper, 1/4t fajita seasoning, 1t oil
24. Fajita or burrito bowl = swap out tortilla and use 2oz rice for grain
25. Strawberries and bananas for fruit = 1/4c fresh strawberries + 1/4c fresh banana
26. Grilled cheese = 2oz bread, 2oz American cheese, 2t butter
27. Cheeseburger = 1 1/2oz ground beef, 1/2oz cheese
28. Pork carnitas = soft taco shell for grain, pulled pork for meat
29. Mac and cheese with an additional protein source (fish sticks, meatballs, little smokies) = provide at least 1oz of additional protein source
30. Apple crisp for fruit = applesauce
31. Spaghetti pie = 2oz mozzarella cheese, 2oz spaghetti noodles, 1/4c marinara

32. Pancake = add 1T syrup
33. Pigs in a blanket = 2oz hot dog, 2oz crescent roll
34. Spaghetti = use 1/4c marinara sauce
35. Walking tacos = 2oz Fritos, 1 1/2oz ground beef, 1/8t taco seasoning, 1/2oz cheddar cheese, 1/4c lettuce, 1/4c salsa
36. Meat sauce = amount of ground beef needed for meal + 1/4c marinara sauce
37. Beef and noodles = 2oz ground beef, 2oz egg noodles, 1/4c beef gravy
38. Chicken and noodles = 2oz grilled chicken, 2oz egg noodles, 1/4c chicken gravy
39. Cheesy bread stick = provide 1/4c marinara for dipping
40. Beef wrap = 2oz roast beef lunch meat, 2oz tortilla
41. Chili = assume beef
42. Pasta bake = 2oz rigatoni, 1/4c marinara sauce, 2oz mozzarella cheese
43. Italian hot ham and cheese = 2oz Italian bread, 1oz ham, 1oz provolone, 1 T Italian dressing
44. Frito pie = 2oz Fritos, 1/2oz cheddar cheese, 10g protein from chili
45. Apple salad = 1/2c apple, 2 T vanilla NF yogurt
46. BBQ chicken = 2oz grilled chicken + 2T BBQ sauce
47. Meatball sub = 2oz meatballs, 2oz bun, 2T marinara sauce
48. Beef taco supreme = 2oz hard taco shell, 1 1/2oz ground beef, 1/8t taco seasoning, 1/2ox ground beef
49. Sloppy Joe = 2oz ground beef, 1/4c sloppy Joe sauce
50. Chicken Alfredo = 2oz linguini, 2oz grilled chicken, 1/4c Alfredo sauce
51. Cowboy beans = use baked beans

52. Sloppy nachos = 2oz ground beef, 2T sloppy Joe sauce, 2T cheese sauce, 2oz tortilla chips
53. Taco crunch = beef hard taco
54. Sausage + gravy = 2oz sausage + 2T white gravy
55. Cowboy cornbread = chili + cornbread
56. Smothered steak = 2oz steak, 2T mushroom gravy
57. Tater tot enchilada bake = 1 1/2oz ground beef, 1/2oz cheddar cheese, 2T enchilada sauce, 3/4c tater tots
58. Chicken and waffles = chicken tenders in amount to reach 14g protein, at least 1 1/2oz waffle, 2T syrup
59. Fish taco = 2oz soft tortilla, 2oz tilapia, 1/4c coleslaw
60. Pizza quesadilla = 2oz tortilla, 1 1/2oz mozzarella cheese, 1/2oz pepperoni
61. Chef salad = 2c lettuce, 1/2 egg, 1/2oz cheddar cheese, 1/2oz ham, 1/2oz turkey, 2T Italian dressing
62. Sidekick for fruit = use juice
63. French bread pizza = 2oz French bread, 2oz mozzarella cheese, 1/4c marinara sauce
64. Gran's fruit salad = 1/8c each banana, grapes, strawberries, mandarin oranges + 2T vanilla pudding
65. Tri-tater = use tater tots
66. Chili dog = 2oz hot dog, 1/4c chili
67. Cheesesteak = 1oz sirloin, 1oz provolone
68. Roasted vegetable/ potatoes = add 1t oil

69. Roasted vegetable = use whatever vegetable needed to meet vegetable variety requirement for the week (butternut squash, yellow squash, zucchini)

# Appendix E - ESHA Codes Used for Nutrient Analysis

| Vegetable | Code | Fruit | Code | Grain | Code |
|---|---|---|---|---|---|
| Salad, garden | 78311 | Grapes, fresh | 71089 | roll, white | 71351 |
| Broccoli, fresh | 5556 | Apple, fresh | 3002 | roll, whole grain | 42057 |
| Broccoli, frozen | 5030 | Banana, fresh | 3021 | biscuit, plain | 71182 |
| Cauliflower, fresh | 5050 | Orange, fresh | 3083 | biscuit, whole grain | 78962 |
| Cauliflower, frozen | 5053 | Apple, canned use applesauce | 16419 | cornbread/muffin | 42116 |
| California mix veg, frozen | 63991 | Applesauce | 16419 | breadstick | 71259 |
| Green beans, fresh | 5009 | Pineapple, canned | 71114 | garlic toast | 72857 |
| Green beans, frozen | 5013 | Mandarin Orange | 71773 | blueberry muffin | 15480 |
| Celery, fresh | 5054 | Jello Fruit cup (1 individual cup | 78367 | cinnamon roll | 38912 |
| Carrots, fresh | 15304 | Strawberries, fresh | 3135 | oatmeal raisin cookie | 47003 |
| Carrots, frozen | 5358 | Peaches, canned | 71051 | chocolate chip cookie | 47001 |
| Peas & Carrots, frozen | 5123 | Pears, canned | 9897 | pita bread, white | 71227 |
| Pea | 5118 | Tropical fruit, canned (1 individ | 71961 | pita bread, whole grain | 71228 |
| Corn | 16944 | Fruit cocktail | 3164 | english muffin, whole grain | 93724 |
| Spinach, salad | 78410 | Strawberries, frozen | 3137 | english muffin, white | 42289 |
| Spinach, cooked (add oil/garlic) | 5148 | Cantaloupe, fresh | 3075 | pancakes, white | 45066 |
| Pepper, green, fresh | 6844 | Honeydew, fresh | 3080 | pancakes, whole grain | 45008 |
| Pepper, red, fresh | 5295 | Blueberries, fresh | 3029 | french toast sticks, white | 42354 |
| Cucumber | 5071 | Blueberries, frozen | 3031 | waffles, white | 45209 |
| Squash, roasted veg. | 5317 | Rasberries, fresh | 3648 | waffles, whole grain | 67292 |
| Asian veg (no additions) | 66157 | Rasberries, frozen | 78714 | french toast sticks, whole grain | 79055 |
| Black Beans (7g pro = 4.5oz.) | 9262 | Blackberries, fresh | 3924 | granola (1.5 oz) | 40063 |
| Baked Beans | 7038 | Blackberries, frozen | 3028 | tortilla chips | 17395 |
| Refried beans | 17370 | Watermelon | 3142 | fritos | 44278 |
| Pinto beans | 7051 | Kiwi | 27502 | hard taco shell | 42443 |
| Lettuce, plain | 5083 | Apple, salad | 95944 | soft taco shell, white | 33427 |
| Tomato, cherry | 15327 | Juice cup, frozen (4oz OJ) | 78377 | soft taco shell, whole grain | 33484 |
| Sweet potato, baked | 5542 | Raisins | 3130 | tortilla, white | 33427 |
| Sweet potato, puff | 67301 | Craisins | 3487 | tortilla, whole grain | 33484 |
| Sweet potato, tater tot | 67301 | Summer fruit salad (.25 side) | 29647 | hot dog bun, white | 42021 |
| Sweet potato, fries | 41749 | Plum, fresh | 3123 | hot dog bun, whole grain | 93716 |
| Potato, mashed | 93812 | Apricot halves, canned | 3152 | hamburger bun, white | 42020 |
| Potato, baked (3 oz.) | 5338 | Apple crisp (.75c) | 45532 | hamburger bun, whole grain | 93715 |
| Potato, French fries (3oz) | 41742 | Pears, fresh | 3104 | french bread, white | 55363 |
| Potato, tater tots (3oz) | 17852 | Peach, fresh | 3097 | sandwich bread, white | 71242 |
| Potato, hasbrown (3oz) | 17852 | Pineapple, fresh | 3111 | sandwich bread, whole grain | 93801 |
| Potato, tri tator (3oz) | 17852 | Apple, baked use applesauce | 16419 | pretzel bun | 42093 |
| Potato, au gratin | 83204 | Apricots, fresh | 3657 | rice, white (.5c) | 38013 |
| Potato, scalloped | 5270 | mango, fresh | 3220 | rice, brown (.5c) | 38010 |
| Potato salad | 56005 | Avocado | 3016 | savory rice (.5c) | 82874 |
| Cole Slaw | 5461 | banana cream pie | 88022 | spaghetti noodles, white | 38118 |
| Zucchini | 5598 | Apple,juice,unsweetened | 3008 | spaghetti noodles, whole grain | 93626 |
| Onion | 5102 | Nectarine | 3216 | linguini, white | 38118 |
| Snow peas | 13960 | cherries | 3036 | linguini, whole grain | 93626 |
| Tomato Soup (1 cup) | 50028 | Italian Ice (0.5 c) | 25891 | penne, white | 94103 |
| Glazed carrots | 5633 | Orange juice | 21113 | penne, whole grain | 93623 |
| breaded fried broccoli | 5513 | | | rotini, white | 94068 |
| Beets | 5022 | | | rotini, whole grain | 93624 |
| cauliflower poppers (124g) | 5539 | | | rigatoni, white | 82854 |
| Yellow Squash | 82848 | | | egg noodles, white | 38047 |
| breaded fried broccoli | 5513 | | | goldfish | 93767 |
| Lentils | 7006 | | | saltine crackers | 43506 |
| Black eyed peas (frozen) | 4438 | | | mexican rice | 78701 |
| Roasted Potato + (add 1 tsp oil) | 5338 | | | fried rice | 23938 |
| Kale salad | 5208 | | | Crescent roll(2.75 oz=2 oz) | 16638 |
| Broccoli Slaw + (add 2T 44704) | 78317 | | | apple cake | 46098 |
| Curly Fries (3 oz) | 8987 | | | italian bread | 71219 |
| Edamame | 9929 | | | spanish rice | 78725 |
| Romaine salad | 5088 | | | cinnamon chips | 14174 |
| Butternut squash | 5317 | | | stuffing (6oz) | 42037 |
| Lima beans | 5019 | | | egg noodles, WG (1.5oz) | 59781 |
| Broccoli salad | 95947 | | | Birthday cake (0.85 pieces) | 46015 |
| | | | | lo mein | 83362 |
| | | | | cheese biscuit (4 oz) | 24646 |
| | | | | Flatbread (WG) | 67267 |
| | | | | Cavatappi (1.5 oz) | 59738 |
| | | | | whole wheat soft pretzel | 24400 |
| | | | | Pretzel | 44015 |
| | | | | Lemon Poppy Seed Muffin (1 each) | 83241 |
| | | | | Cheez-It | 43661 |
| | | | | oat roll | 42070 |
| | | | | whole grain crackers | 43508 |
| | | | | oatmeal raisin cookie | 47003 |

| Protein | Code | Extras | Code | Combo foods | Code |
|---|---|---|---|---|---|
| Lit'l smokies | 13232 | Ranch | 44696 | Macaroni and cheese (6oz) | 33948 |
| Cheese, cheddar | 47863 | Italian | 8020 | Lasagna (1 cup) | 83202 |
| Hamburger | 58125 | Butter | 8000 | Meatloaf (2 oz.) | 94216 |
| Chicken Nuggets (4oz) | 38954 | Oil (1t) | 44975 | Bierock | 2oz roll 71351, |
| Pork Cutlet (breaded) | 12087 | Garlic (.25t) | 9473 | Corndog (2 each) | 38953 |
| Chicken popper/popcorn (3 oz.) | 76484 | Terykari sauce | 9531 | Pizza, cheese (0.9slice) | 93674 |
| Chicken giggles | 38954 | Sweet and sour red sauce- | 26459 | Pizza, pepperoni (0.9 slice) | 93676 |
| Chicken tenders/fingers (3.5oz) | 52664 | Marinara | 39134 | Stromboli (0.5each) | 82711 |
| Chicken patty, breaded (3.5oz) | 14728 | Salsa | 91049 | Buffalo chicken calzini | |
| Chicken, grilled | 67033 | Cheese sauce | 53523 | Chicken cacciatore (0.5 entrée) | 82920 |
| Chicken drumstick, breaded (1.25 each) | 76339 | Gravy, beef | 53023 | Goulash | 1oz ground bee |
| Pork riblet | 68905 | Gravy, chicken | 53022 | Chicken tetrazzini (1.1c) | 56199 |
| Pork loin | 12063 | Fajita seasoning (.25t) | 91932 | Cheese breadstick (4oz) (2 Each) | 78770 |
| Pork chop, breaded | 12081 | Taco seasoning (.125t) | 66958 | Bosco stick (2 each) | 78770 |
| Pork, pulled | 76508 | Jelly | 23294 | Crispitos (1.5) | 77061 |
| Chicken salad | 82752 | Syrup | 25002 | Cheesy pull-aparts | |
| Tuna salad | 82753 | Alferdo sauce | 82679 | Beef Stroganoff (1.1entree) | 82816 |
| Egg salad | 52066 | Gravy, sausage (1/4c) | 92571 | Enchilada, chicken (2each) | 83331 |
| Hummus | 7957 | Guacamole | 20771 | Chicken parmesan (no noodles, | 78715 |
| Peanut butter | 4627 | Sour cream | 54380 | Cheeseburger hot pocket (1.25) | 57776 |
| Yogurt | 89921 | BBQ sauce | 53000 | Beef & noodles (.5pkg) | 16400 |
| String cheese | 48252 | White gravy | 68546 | Beef tamale (pie) 1.4 each | 16811 |
| Fish patty, breaded (4oz.) | 67356 | Honey | 25309 | Ravioli (2c, no extra marinara needed) | 38956 |
| Fish sticks, breaded | 17002 | Enchilada Sauce | 4498 | Sausage pizza (0.85 piece) | 93678 |
| Fish, grilled/baked | 52517 | Chili Seasoning | 66959 | Rock and Roll Beef Wrap | 2 oz tortilla 334 |
| Cheese, Mozz. | 47889 | Caesar dressing | 44705 | Egg roll, chicken (4.75 oz.) | 15271 |
| Cheese, American | 1000 | Poppy Seed dressing | 38839 | pizza, cheese, stuffed crust (0.6 slice) | 28397 |
| Cheese, swiss | 1071 | queso cheese (30 g) | 51842 | cheese tortellini | 92216 |
| Cheese, provalone | 47899 | Cajun seasoning | 91947 | beef enchilada (2 each) | 88791 |
| meatballs (3.5 oz) | 78688 | Vanilla Pudding | 2657 | Mexican pizza (0.5 whole pizza) | 17683 |
| Ham, baked | 12314 | | | Taco soup (1 cup + 1oz. Beef + 1oz. Cheese | 40692 |
| Turkey luncheon meat | 15736 | | | Pepperoni Calzone (0.67 each) | 18638 |
| Ham luncheon meat | 13263 | | | Ham and Cheese Hotpocket (1.25 each) | 70920 |
| Roast beef luncheon meat | 89758 | | | Sancho | 1.5 oz tortilla 3 |
| Sausage | 13269 | **Dairy** | **Code** | pizza, pepperoni, stuffed crust (.5 individua | 89306 |
| Hot dog | 48642 | 1% milk | 18760 | Chili | 28167 |
| Ground beef | 58125 | | | Pepperoni Hot Pocket (1 each) | 18625 |
| Sirloin steak | 39074 | | | Fiesta Chicken Pasta | 23777 |
| Salsibury steak (7.5oz), no extra gravy | 93824 | | | Fried Mozarella sticks (4 each) | 23964 |
| Country fried steak (.75 each) | 57943 | | | Chicken tortilla soup (1 cup + 1.5oz. chicke | 40692 |
| Steak/beef fingers (2.5oz) | 11708 | | | Tuna noodle casserole (6 oz.) | 83335 |
| Bacon | 51151 | | | Uncrustable WG | 80031 |
| Eggs, scrambled (4oz=14g prot) | 19516 | | | Hamburger casserole | 6oz mac and ch |
| Chicken, teriyaki | 15915 | | | Breakfast pizza (1.5 slice) | 83373 |
| Chicken, sweet and sour (4 oz) | 66875 | | | Egg roll, pork (1.75 each) | 14971 |
| Chicken, general tso (5oz) | 83366 | | | Cheeseburger pizza (1 slice) | 78896 |
| Sloppy joes sauce (1/8c) add grn beef | 53714 | | | Chicken bacon ranch pizza (1.25 slice) | 48735 |
| Turkey, baked | 16038 | | | BBQ chicken pizza (.75 slice) | 82893 |
| Chicken Parmesan | 78715 | | | Chicken taquito (3 each) | 67308 |
| Chili, beef (3/4c) | 28167 | | | Chicken cordon bleu (3 each) | 76948 |
| Chicken nuggets, whole grain | 76501 | | | Pizza poppers/ crunchers (8 each) | 91615 |
| Chicken, orange (4oz.) | 83319 | | | | |
| Shrimp poppers (4oz) | 23956 | | | | |
| Chicken fried steak (3oz) | 57943 | | | | |
| Pork fritter | 12081 | | | | |
| White chicken chili (1 indv. Cup) | 33280 | | | | |
| Cowboy cavatini | | | | | |
| BBQ beef (4 oz) | 58383 | | | | |
| BBQ chicken leg (4 oz) | 68490 | | | | |
| Breaded beef patty (3oz) | 11623 | | | | |
| Baked chicken leg | 15154 | | | | |
| Roast beef | 10281 | | | | |
| Pepperoni (7g pro = 1.25 oz.) | 13021 | | | | |
| Salami (7g pro = 2 oz.) | 13023 | | | | |
| cheese, parmesan | 1075 | | | | |
| Turkey burger | 26795 | | | | |
| Hash, beef (4.5 oz.) | 56150 | | | | |
| Ham patty | 12169 | | | | |
| wings, boneless, spicy | 76469 | | | | |
| Deviled Egg (2 each) | 24640 | | | | |
| Bratwurst | 58010 | | | | |
| Pork chop | 38899 | | | | |
| Spicy chicken | 77163 | | | | |

# Appendix F - HEI Calculator Instructions and Equations for DQ Analysis

HEI Calculator Instructions:

1. Sum all nutrients for each day to obtain a daily total for each nutrient.
2. Copy and paste HEI equations at the end of those sums.
3. Fill in the amounts at beginning of calculator – whole fruit (c), dark green veg (c), whole grain (oz.), seafood/ plant protein (oz.).
    a. If menu does not say whole grain, assumed products were white or whole grain-rich and received 0 for whole grain section (except for corn grain products).
4. Score amounts at end of calculator using scoring scale below for fatty acid ratio, sodium, and saturated fat.

| FA Ratio | FA Score | Sodium | Na Score | Sat Fat | SF Score |
|---|---|---|---|---|---|
| 2.5 | 10 | 1.1 | 10 | 8 | 10.0 |
| 2.4 | 9.1 | 1.2 | 9 | 8.5 | 9.0 |
| 2.3 | 8.4 | 1.3 | 8 | 9 | 8.4 |
| 2.2 | 7.7 | 1.4 | 7 | 9.5 | 7.8 |
| 2.1 | 7.0 | 1.5 | 6 | 10 | 7.2 |
| 2.0 | 6.3 | 1.6 | 5 | 10.5 | 6.6 |
| 1.9 | 5.6 | 1.7 | 4 | 11 | 6.0 |
| 1.8 | 4.9 | 1.8 | 3 | 11.5 | 5.4 |
| 1.7 | 4.2 | 1.9 | 2 | 12 | 4.8 |
| 1.6 | 3.5 | 2.0 | 1 | 12.5 | 4.2 |
| 1.5 | 2.8 | | | 13 | 3.6 |
| 1.4 | 2.1 | | | 13.5 | 3.0 |
| 1.3 | 1.4 | | | 14 | 2.4 |
| 1.2 | 0.7 | | | 14.5 | 1.8 |

| | |
|---|---|
| 15 | 1.2 |
| 15.5 | 0.6 |
| 16 | 0.0 |
| | |

5. Check that no scores at end of calculator (cell columns CN-CZ) are over the max HEI score for that component.
    a. Max scores = total fruit 5, whole fruit 5, total vegetable 5, dark green/ legume 5, whole grain 10, dairy 10, total protein foods 5, seafood/ plant proteins 5, fatty acid ratio 10, refined grain 10, sodium 10, added sugar 10, saturated fat 10
6. Check that HEI score (cell column BM) is not over 100.

<u>HEI Calculator Equations:</u>

*The Excel calculator requires three sets of cells to transform input data from nutrient analysis and menu into the HEI score. The three cells are consecutively linked and build off of each other.

General Cell Rationale:

1. First cell = amount of that nutrient of food group in the lunch
    a. Some first cells were automatically completed for all lunches due to the NSLP nutrition standards. Every lunch must contain 0.5c fruit, 0.75c vegetable, 1c dairy, 2oz protein, 0 refined grain, and minimal added sugar (full credit given to all lunches).

2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
    a. The HEI score is per 1000 calories, so the first cell must be standardized to 1000 calories using a ratio.
3. Third cell = (second cell)/(amount to receive max score per HEI-2015)*(max score for the component)
    a. This is the actual score the lunch received for this HEI scoring component. Because we were unable to put a maximums or minimums on this equation, researchers needed to check all third cells to ensure that they did not exceed that HEI scoring components' max score (instructions #4 and #5 above).

Total Fruit:

1. First cell = 0.5
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = (second cell)/0.8*5

Whole Fruit:

1. First cell = amount of whole fruit served in the lunch in cups
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = (second cell)/0.4*5

Total Vegetable:

1. First cell = 0.75
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)

3. Third cell = (second cell)/1.1*5

Dark Green/ Legumes:

1. First cell = amount of dark green/ legume served in the lunch in cups
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = (second cell)/0.2*5

Whole Grain:

1. First cell = amount of whole grain served in the lunch in ounces
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = (second cell)/1.5*10

Dairy:

1. First cell = 1
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = (second cell)/1.3*10

Total Protein:

1. First cell = 2
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = (second cell)/2.5*5

Seafood/ Plant Protein:

1. First cell = amount of seafood/ plant protein served in the lunch in ounces
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = (second cell)/0.8*5

Fatty Acid Ratio:

1. First cell = [(cell with amount of PUFA from nutrient analysis) + (cell with amount of MUFA from nutrient analysis)]/(cell with amount of saturated fat from nutrient analysis)
2. Second cell = (first cell)
3. Third cell = hand scored based on second cell value and table score (instruction #4 above)

Refined Grain:

*All lunches received full credit due to NSLP nutrition standards requiring whole grain-rich grains, so all received 10 points for this HEI component.

Sodium:

1. First cell = (cell with amount of sodium from nutrient analysis)
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = hand scored based on second cell value and table score (instruction #4 above)

Added Sugar:

*All lunches received full credit due to NSLP nutrition standards requiring certain types, amounts, and frequencies of sugar-sweetened beverages, desserts, and fruit with added sugar, so all received 10 points for this HEI component.

Saturated Fat:

1. First cell = (cell with amount of saturated fat from nutrient analysis)
2. Second cell = (first cell)*1000/(cell with calorie data from nutrient analysis)
3. Third cell = hand scored based on second cell value and table score (instruction #4 above)

# Appendix G - Description and Summary of Included Full-text Articles by Research Question

| Author, year, country (if not US), [reference number] | Purpose | Study design, data collection, sample, response/ retention rate | Main outcomes | Study quality* |
|---|---|---|---|---|
| **Question 1 – What are the dietary quality recommendations to optimize nutrition for children 5–18yo?** | | | | |
| Bradlee et al, 2013, [15] | To investigate the associations between usual adolescent food intake patterns and lipid levels in older adolescent girls. | Longitudinal study (10-year, National Heart, Lung and Blood Institute's Growth and Health Study), 3-day diet records (dietary intake categorized as five major USDA food groups, performed 8 of 10 years followed), fasted blood samples (lipid levels, biennially, high density lipoprotein cholesterol (HDL), triglycerides (TG), | **Individual food groups:** Dairy and fruit intakes were inversely associated with total, LDL, and non-HDL cholesterol levels. One serving of fruit per day was inversely associated with LDL:HDL ratio. Small amounts of nuts, seeds, and legumes were inversely associated with LDL. Whole grains and lean meat, poultry, and fish were not associated with lipid levels. **Food combinations:** The three eating patterns | 0 |

| | | |
|---|---|---|
| | low density lipoprotein cholesterol (LDL), LDL:HDL ratio), 1500 girls (ages 9–10yo at baseline, 18–20yo at end of study), 63% response rate. | associated with favorable lipid levels included dairy/ fruit/ non-starchy vegetables, dairy/ whole grains, and fruit/ non-starchy vegetables/ whole grains. **Relative risks:** Consuming 2 or more servings of dairy, fruit, and non-starchy vegetables per day led to a 40% reduction in high non-HDL cholesterol risk, 50% reduction in high LDL risk, and 41% reduction in high LDL:HDL ratio risk. Consuming higher whole grains, dairy/ fruit, and non-starchy vegetables led to a 30% reduction in high TG risk compared to lower consumption and similar reductions as stated earlier in risk of high LDL and LDL:HDL ratio. Consuming 2 or more servings of lean meat/ poultry/ fish, fruit, and non-starchy |

| | | | | |
|---|---|---|---|---|
| | | | vegetables per day led to a 40% reduction in high LDL:HDL ratio risk. The most favorable HDL was achieved by consuming high fruit, non-starchy vegetables and lean meat/ poultry/ fish. Results were independent of effects from confounders. **Overall:** For optimal lipid levels in adolescence, consider a dietary pattern consisting of ≥2 servings of fruits and non-starchy vegetables, ≥2 servings of dairy, ≥0.75 servings of whole grains, and lean meat, poultry, and fish daily. | |
| Burrows et al, 2017, Australia, [16] | To systematically review and evaluate the available literature on effects of dietary intake and behaviors on academic achievement in | Systematic review, literature search using 7 databases, critical appraisal of quality performed, 40 studies included with 166,148 participants total, response rate N/A. | **Breakfast Consumption:** Associations with breakfast consumption were the most common associations found. Higher breakfast intake was associated with increased academic achievement. **Junk Food/ Fast Food:** Associations with junk/ fast food were the next | + |

| | | |
|---|---|---|
| | children and adolescents. | most common associations found. Lower intake of energy-dense and nutrient-poor foods was associated with higher academic achievement. Lower SSB intake was associated with higher academic achievement. **Fruits and Vegetables:** Fruit and vegetable intake was positively correlated with academic achievement. **Micronutrients:** Folate and iron were the most commonly reported micronutrients to be associated with academic achievement. Energy, protein, B vitamins, and omega-3 FA were also positively associated with academic achievement. **Fish Consumption:** Increased fish intake was associated with higher academic achievement. **Diet Quality:** Higher measures of diet quality were associated with |

| | | | | |
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| | | | higher academic achievement, especially if the focus was on adequacy and variety as compared to moderation and balance. The Mediterranean diet was associated with higher academic achievement as compared to the Western diet.<br>*Regionally widespread studies showing relationships are of international interest. | |
| Chan et al, 2017, Australia, [17] | To review the literature on the impact of diet quality on ‘school-valued’ outcomes (i.e., academic performance, in-class behavior, other behavior at school, attendance, mental health) in school-aged students ages 6–18yo. | Scoping review; structured review using EMBASE, MEDLINE, CINAHL, PsycINFO, Scopus, Science Direct, and Web of Science, 35 articles (34 cross-sectional and 1 RCT) included; regions included in review: North America, Europe, Oceania, Asia, and South America; sample size range | **Overall Diet Quality:** Positively associated with academic achievement, not significantly associated with behavior, positively associated with mental health outcomes.<br>**Fruit and Vegetable Intake:** Positively associated with academic achievement, not consistently associated with mental health outcomes.<br>**Discretionary Calorie Intake:** Negatively | + |

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| | | 107–16,188 participants; response rate N/A. | associated with academic achievement, significantly associated with behavior problems, not consistently associated with mental health outcomes. Sugar intake was associated with increased academic stress.<br>**Increased Energy Intake:** Negatively associated with academic achievement.<br>**Fat Intake:** Total and saturated fat were not significantly associated with academic achievement. Increase PUFA and decreased cholesterol intake was associated with improved academic performance. Dietary fat was not associated with mental health outcomes.<br>**Fish Intake:** Not significantly associated with behavioral problems or academic performance. | |
| Cohen et al, 2016, [18] | To investigate the impact of dietary | Systematic review; systematic literature search using PubMed, | **Healthy Dietary Pattern:** Associated with higher executive functioning. | + |

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| | consumption on executive functioning (i.e., memory, accuracy, attention, cognitive control, cognitive flexibility) in children and adolescents (6–18yo). | ERIC, PsycINFO, and Web of Science; 21 articles included; response rate N/A. | **Glycemic Index:** Mixed results, with the majority of studies suggesting a negative association with attention, memory, and accuracy and positive association with speed. **Macronutrients:** MUFA and PUFA intakes were associated with improved executive functioning. Cholesterol, saturated fat, and total fat intakes were associated with poorer executive functioning. **Whole Grains:** Associated with improved executive functioning. **Junk Foods:** Associated with poorer executive functioning. **Fruits and Vegetables:** Associated with greater executive functioning. **Proteins:** Fish consumption was associated with greater executive functioning. Red and processed meat intake was associated with poorer executive |

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| | | | functioning.<br>*Healthy diet = high in whole grains, fruits, vegetables; includes lean proteins or proteins high in PUFA/ MUFA; low in red/ processed meats, saturated fat, trans fat, sugar; low glycemic index (GI); higher in MUFA/ PUFA.<br>*Unhealthy diet = high in refined grains, sugar, saturated fat, trans fat; high GI. | |
| Florence et al, 2008, Canada, [19] | To examine the association between diet quality and academic performance. | Cross-sectional (2003 Children's Lifestyle and School-Performance Study (CLASS) looking at health, nutrition, physical activity, school performance, and socioeconomic determinants of Nova Scotian 5th graders), Harvard/ Yale Food Frequency Questionnaire (YAQ) (used to calculate DQI-I and HEI | Students reporting higher diet quality were significantly less likely to fail (26% and 41% less likely in second and third highest quality tertiles compared to first, 18% and 31% following adjustment for covariates). The association between overall diet quality and academic performance existed independent of covariates. Variety and adequacy diet quality components were most | + |

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| | | scores, validated), standardized test scores for academic performance (Elementary Literacy Assessment – pass/ fail), 4,451 participants, 82% response rate based on those who received consent forms. | significantly associated with academic performance, rather than moderation and balance. | |
| Fu et al, 2007, Taiwan, [20] | To examine associations between unhealthful eating patterns and unfavorable overall school performance in Taiwanese elementary schoolchildren. | Cross-sectional (Nutrition and Health Survey 2001–2002), Scale for Assessing Emotional Disturbances (overall performance in school), 22-food group questionnaire (food intake frequency), 2,222 participants (Taiwanese schoolchildren, 6–13yo), 78.8% response rate. | Significant positive associations were found between high-quality/ high-nutrient density (i.e., vegetables, fruit, meat, fish, eggs) food intake frequency and overall performance. Weak significant associations were found between sweets and fried foods intake frequency and overall performance. After adjusting for confounding variables, children consuming low intake of high-nutrient density foods and high intake of sweets and fried foods | + |

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| | | | were 1.6 times more likely to have unfavorable overall performance. After adjusting for confounders, children with all 3 unhealthy eating patterns were 3.03 times more likely to have unfavorable overall performance. | |
| Funtikova et al, 2015, [21] | To investigate the role of childhood diet in development of cardiometabolic risk factors. | Narrative review (PubMed, Cochrane, Medline), literature review (not systematic), 124 articles included, response rate N/A. | **Sodium intake:** A 40–50% reduction in salt intake led to a significant decrease in systolic, diastolic, and overall blood pressure (BP) in children. The recommended sodium level for 1–5yo is 2g/d, however a study of 3–4yo found elevated BP with >1200mg sodium/d. No associations were found between childhood sodium consumption and adult high BP. **Fat intake:** Positive associations were found between fat intake and obesity; between total, saturated and unsaturated, and myristic fat intake and | 0 |

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| | | cholesterol levels; between total and saturated fat and incidence of diabetes; and between total fat and MUFA and apolipoprotein-A1 (HDL). Negative associations were found between PUFA and apolipoprotein-B (LDL). Olive oil and nut intake was associated with lower BMI and obesity prevalence, respectively. Vegetable oils were associated with lower fasting glucose. Added saturated fats were associated with higher TG levels.<br>**Dairy intake:** In the majority of studies, dairy intake was inversely associated with body fat, BMI, insulin resistance, blood glucose levels, BP, and type 2 diabetes.<br>**Fruit and vegetable intake:** Higher intake was associated with lower BMI and lower odds of being overweight. Higher |

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| | | | intake was inversely associated with central adiposity and waist circumference, BP, and CRP. Some studies showed the opposite, but could be explained by methodological practices. **Vitamin intake:** Vitamin D was inversely associated with TG, total cholesterol, LDL, abdominal adiposity, BP, risk of metabolic syndrome, and arterial stiffness. Vitamin D was positively associated with HDL, better glucose levels, and improved lipid metabolism. Negative associations were found between vitamin B12 and folate and homocysteine levels and BP. Vitamins A, C, and E were negatively associated with general and abdominal adiposity and positively associated with improved glucose and lipid metabolism and risk of |

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| | | metabolic syndrome.<br>**Fiber intake:** Higher total fiber intake was associated with lower waist circumference and lack of metabolic syndrome traits. Higher total fiber intake was associated with lower abdominal adiposity and lower CRP.<br>**Cereal and grain intake:** Breakfast cereal intake was associated with lower BMI and higher diet quality, independent of sugar content. Higher whole grain intake was associated with lower risk of obesity (≥1.5 servings/d and 40% lower), lower homocytseine levels, lower C-peptide levels, lower fasting insulin, lower waist circumference, and higher folate levels.<br>**Meat intake:** Studies were not consistent. Type and quality of meat played a major role.<br>**Fast food, SSB intake:** |

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| | | | Direct associations were found between childhood SSB intake and future obesity. Positive associations were found between SSB intake and BMI, waist circumference, overweight, general and abdominal obesity, cardiometabolic risk, TG, BP, glucose, and salt intake. SSB intake was negatively associated with HDL. Fast food intake was associated with higher BMI, higher body fat percentage, and higher odds of obesity. **Dietary patterns:** The Western dietary pattern (high in red meat, meat derivatives, sweets, pastries, fast food, SSB, fried foods, snacks) was associated with obesity, increased TG, higher general and abdominal adiposity, insulin resistance, and increased risk of metabolic syndrome. Healthy dietary |

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| | | | patterns (higher in plant-based foods and fish) were associated with healthier cardiovascular profile and improved glucose and lipid metabolism. Vegetarian diets were associated with lower BMI, lower waist circumference, lower LDL, and higher HDL, independent of physical activity. The Mediterranean diet was associated with lower prevalence of metabolic syndrome, lower HDL, lower risk of overweight and obesity, lower body fat percentage, and higher sodium intake. **Diet quality:** Diet quality indices were inversely associated with BMI, BP, lipid levels, inflammatory markers, body fat, and waist circumference. | |
| Goley et al, 2010, England, [22] | To examine the effects of an intervention providing and | 12-week cluster randomized controlled intervention trial, | After adjusting for confounders, teacher-pupil on-task engagement was 3.4 times more likely in | 0 |

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| | promoting healthier school food at lunch and improving school dining environment on learning-related behavior after lunch in class. | learning-related behavior (observed by trained researchers, data from qualification and curriculum authority national optional test scores 2005/2006), 6 primary schools matched in triplets and randomly assigned to 1 of 2 intervention groups (nutrition first or environment first) or the wait-list control group, 17,306 observations of 146 schoolchildren, retention rate not reported. | intervention schools compared to control schools in the hour following lunch. Pupil-pupil on-task behavior was less likely in intervention groups compared to control group. There were general trends for overall increased alertness in intervention schools. There was a 2.2% increase in uptake of school meals in all schools. Environmental intervention changes included newsletters to parents about meals, dining room supervisor behavior management training, stickers for those taste testing new foods or eating fruits/ vegetables, displays and assemblies on healthy eating, new dining room rules introduced, taste testing sessions, promotion of changes at parent events and through mailers, |

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| | | | staggered lunches to decrease line length/ waiting, dining room music, layout changes, and grab-and-go lunches. | |
| Haapala et al, 2015, Finland, [23] | To investigate associations between the Baltic Sea Diet Score (BSDS) and the Dietary Approaches to Stop Hypertension (DASH) score and cognition in a sample of Finnish children. | Cross-sectional (baseline data from the Physical Activity and Nutrition in Children (PANIC) Study) 4-day food record, diet quality via DASH score and BSDS, non-verbal reasoning via Raven's Coloured Progressive Matrices (CPM), 428 participants, no response rate reported. | After adjusting for all covariates, lower BSDS and DASH score were associated with lower Raven's CPM score. Within the BSDS, higher red meat and sausage consumption was associated with lower Raven's CPM score. Within the DASH score, lower fruit and fruit juice consumption and higher red meat and sausage consumption were associated with lower Raven's CPM score. Associations were stronger for overall scores as compared to scores for individual components. | 0 |
| Henriksson et al, 2017, Europe, [24] | To determine associations between diet quality and attention | Cross-sectional study (used data from the HELENA study, 2006–2007, 1 city center each from | There were lack of associations between individual macronutrient consumption and attention capacity. There were | + |

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| | capacity in European adolescents. | Austria, Greece, France, Spain, Germany), dietary intake (2 non-consecutive computer-based self-automated 24-hour recalls with dietitian assistance as needed, validated), dietary quality [Dietary Quality Index for Adolescents (DQI-A), validated; DASH diet score (DASHDS); adapted version of Mediterranean Diet Score (MDS)], attention capacity (d2 Test of Attention, valid and reliable), 384 adolescents (165 males, 219 females, 12.5–17.5yo, sub-sample from HELENA study with complete data on attention capacity), 96% of those with attention capacity data had complete | significant positive associations between DQI-A and DASHDS and attention capacity, such that a 1-point increase in diet score was associated with a 0.15–0.16 point increase in attention capacity. MDS was not significantly associated with attention capacity. In terms of DQI-A component scores, diet quality and diet equilibrium were positively associated with attention capacity. Even a 1-point higher score for the soft drink and sodium component (i.e., lower consumption, max score of 9) was associated with higher attention capacity. All associations were after adjustment for confounders (i.e., age, sex, BMI, maternal education, income, study location, and physical activity). |

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| | | data (11% with attention capacity data from original study sample). | | |
| Hu et al, 2016, [25] | To investigate whether dietary intake quality and patterns in adolescence predict weight gain through young adulthood. | Longitudinal study (Project EAT – Eating and Activity in Teens and Young Adults, 10 year study), self-report height and weight (to calculate BMI), 152-item Youth and Adolescent Food Frequency Questionnaire (YAQ) for adolescents and Willett Food Frequency Questionnaire (FFQ) for adults (to measure dietary intake), 2,656 participants (from 31 urban and suburban high schools in Minneapolis-St. Paul metro area), no response rate reported. | Weight gain from age 15 to 25 years was 2.2kg less for those with A Priori Diet Quality scores (APDQS) at age 15 above the median as compared to below the median. Those whose APDQS was above the median or improved between ages 15 and 25 years gained 5.7kg less weight than those below median or whose scores did not improve/ worsened. Results were similar for BMI. After adjusting for covariates, a 15-unit higher APDQS at age 15 was associated with 1.5kg less weight gain and 0.47kg/m$^2$ less increase in BMI. Results were similar across race and sex and independent of energy intake, eating behavior, physical activity, and cigarette | 0 |

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| | | | smoking. Excess weight gain was greater in those overweight or obese at age 15 than those at normal weight. | |
| Jennings et al, 2011, United Kingdom, [26] | To develop a modified dietary quality index for children and to determine if this modified index was associated with weight status and dietary intake in 9–10yo children. | Cross-sectional; dietary intake (4-day food diary), anthropometrics [height, weight, waist circumference (WC), percent body fat (%BF), BMI, waist:hip ratio (WHR)], dietary quality [Healthy Diet Indicator (HDI), Dietary Quality Index (DQI), Mediterranean Diet Score (MDS)]; 1700 children (9–10yo), 92 school in Norfolk, UK; no response rate reported. | **DQI:** Weight, BMI, WC, WHR, and %BF were significantly lower for highest quintile scores as compared to lowest quintile scores. **HDI:** Positively associated with parental education and meeting physical activity recommendations. WC, WHR, and %BF were significantly lower for highest quintile scores as compared to lowest quintile scores. **MDS:** Positively associated with parental education and meeting physical activity recommendations. No significant associations with weight status. *Results independent of energy intake, physical activity levels, gender, | 0 |

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| | | | age, underreporting, and energy density. | |
| McIsaac et al, 2015, Canada, [27] | To investigate the associations between health behaviors (healthy eating and physical activity) and academic performance in Nova Scotian elementary school students (ages 9–12yo). | Cross-sectional; dietary intake [100+ item Harvard Youth Adolescent FFQ (YAQ)], dietary quality [Dietary Quality Index – International (DQI-I) and Youth Healthy Eating Index (YHEI)], academic performance (grades in math and language arts); 535 children (ages 9–12yo); school response rate 100%, average participant response rate 46%. | Poor academic performance was positively associated with unhealthy behaviors including low DQI, low YEHI, consuming ≥ 1 sugar-sweetened beverage daily, skipping breakfast, and low physical activity levels. There was a 2–5-fold increase in odds of poor academic performance with highest levels of these unhealthy behaviors as compared to lowest levels. The associations of diet quality and physical activity with academic performance appeared to be independent, and not additive. Diet appeared to have a stronger association than physical activity with academic performance. | 0 |
| Nyardi et al, 2014, Australia, | To determine prospective associations | Prospective cohort study (14-year and 17-year follow-up | Higher consumption of a Western dietary pattern by one standard deviation in | 0 |

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| [28] | between dietary patterns of consumption at 14yo and cognitive performance at 17yo. | data from the Western Australia Pregnancy Cohort (Raine) Study), dietary pattern (212-item semi-quantitative FFQ, reliable; 38 food groups determined from factor analysis for patterns), cognitive performance (CogState computerized cognitive battery, reliable and valid), 602 adolescents (288 females, 314 males), 22% of original sample with complete data. | z-score was associated with significantly lower cognitive performance in terms of longer reaction times, higher number of errors, and fewer correct responses. Higher consumption of a Healthy dietary pattern by one standard deviation in z-score was associated with significantly lower number of errors. Being in the 99th percentile for Western dietary pattern and first percentile for Healthy dietary pattern resulted in a difference of 44 milliseconds in reaction time, such that the healthier diet had a faster reaction time. Clinically, this is a substantial difference in cognitive performance. In terms of individual food groups, consuming <8.57g/d of green leafy vegetables and <201.3g/d of fresh fruit was associated with poorer |

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| | | | performance related to reaction time and number of errors. Consuming >13.58g/d of French fries and >4.29g/d of potato chips was associated with poorer performance in terms of longer reaction time, higher number of errors, and fewer correct responses. Consuming >60.32g/d of red meat was associated with poorer performance with fewer correct responses. Results were after adjusting for confounders (i.e., income, presence of biological father, maternal education, family function, gender).<br>*Healthy dietary pattern – high intake of fruits, vegetables, legumes, whole grains, fish.<br>*Western dietary pattern – high intake of fast food, refined foods, fried foods, soft drinks, red and processed meats. | |
| Nyaradi et al, 2015, | To determine the associations | Cross-sectional (Western Australian | *Dietary patterns: Healthy = high in fruits, | 0 |

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| Australia, [29] | between diet quality/ type and academic achievement/ performance in 14yo Australian schoolchildren. | Pregnancy Cohort Study, followed from birth to 14yo, only using 14yo data for this study), dietary assessment (212-item semi-quantitative FFQ, dietary pattern determined by placing foods into 38 groups and conducting factor analysis), Western Australian Literacy and Numeracy Assessment (4 sections combined for an overall score, nationwide standardized test), 779 participants, no response rate reported. | vegetables, whole grains, legumes, fish. Western = high in take-out, red and processed meats, SSB, refined and fried foods. **Overall patterns:** After adjusting for confounders, the highest quartile score for the Western dietary pattern was associated with a 46-point decrease in math score, a 59-point decrease in reading score, and a 57-point decrease in writing score compared to the lowest quartile score for the Western dietary pattern (all differences significant). The lowest quartile score for the healthy dietary pattern was associated with a 9-point decrease in math score, a 28-point decrease in reading score, and a 42-point decrease in writing score compared to the highest quartile score for the healthy dietary pattern (significant trend in differences in scores). | |

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| | | | **Individual food groups:** Higher intake of SSB was associated with lower math and reading scores. Higher intake of processed meat and fried potatoes was associated with lower reading scores. Higher intake of fruits and vegetables was associated with higher math and reading scores. Higher intake of whole grains was associated with higher reading scores. | |
| Perichart-Perera et al, 2010, Mexico, [30] | To determine associations between key energy sources and indicators of CVD in Mexican, school-aged children. | Cross-sectional study (3 public urban schools, low SES, Mexico City, Mexico, 2004–2006), energy-adjusted intake of 13 food groups (two multiple-pass 24-hour recalls, nutrient analysis), CVD risk indicators (BP>130/85mmHg, BMI >85th percentile overweight and >95th percentile obese, fasting blood samples | Diastolic BP was positively associated with high-fat dairy and sugar-sweetened beverage intake. Glucose levels were positively associated with sugar-sweetened beverage and fruit intake and negatively associated with vegetable oil and meat intake. Insulin levels were positively associated with white bread intake. HDL cholesterol was positively associated with high-fat dairy intake. | 0 |

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| | | – >150mg/dL triglyceride levels, >200mg/dL total cholesterol, <40mg/dL HDL, >130mg/dL LDL, >100mg/dL glucose, >15microunits/mL insulin, glucose insulin ratio <7; screen time, moderate to intense physical activity), 185 children ages 9–13, 52% of students met inclusion criteria and had complete data available. | Triglycerides were positively associated with added fats. Each of the associations noted accounted for 20–23% of the variation in CVD risk indicator. | |
| Qureshi et al, 2009, [31] | To investigate associations between intake of foods within food groups and serum CRP levels in 5–16yo children. | Cross-sectional study (used NHANES data from 1999–2002), Food Pyramid food item servings (single computer-assisted multi-pass 24-hour recall, servings estimated using USDA Dietary Guidelines), highly-sensitive C-reactive protein levels (hs- | Children in the low CRP classification consumed lower total energy and more grains; dairy foods, except for cheese; fruits, especially citrus, melons, and berries; and vegetables. Several food groups were consumed too infrequently to detect any statistically significant results, including yogurt, whole grains, dark green | 0 |

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| | | CRP), blood samples, classified into three groups – low, average, or high risk of future CVD), 4110 US children ages 5–16, 70% of surveyed children included. | leafy vegetables, and deep yellow and orange vegetables. No associations with CRP levels were found with meat or other protein food groups. Results were after adjusting for confounders, including height-for-age, race/ ethnicity, socioeconomic status, age, gender, and sedentary behavior. | |
| Setayeshgar et al, 2016, Canada, [32] | To examine the associations of diet quality with prospective changes in adiposity of children. | Prospective cohort (QUebec Adipose and Lifestyle InvesTigation in Youth, QUALITY cohort, ages 8–10 years in the 2005 to 2008 time period, 2 year average follow-up), 3 non-consecutive 24-hour diet recalls (used to calculate Diet Quality Index – International (DQII) scores), DEXA and height and weight (body composition, BMI), | DQII scores ranged from 34–75. Scores were high for variety and adequacy, but low for moderation and balance. Higher baseline DQII score was associated with smaller increase in body fat over 2 years. After adjusting for confounders, 10-unit increase in DQII was associated with smaller gain in central fat mass and percent body fat. The diet adequacy component was associated with all body fat indices, such that a 1-unit improvement in | 0 |

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| | | 546 participants, 87% response rate. | adequacy was associated with smaller gain in fat mass, central fat mass, body fat percentage, and percent central body fat. No associations were found with BMI over the 2-year period. Relationships found were independent of sex, age, total energy intake, physical activity, and Tanner stage. | |
| **Question 2 – What are effective techniques to encourage healthy food selection and consumption in the school lunchroom?** | | | | |
| Ensaff et al, 2015, United Kingdom, [33] | To assess effects of nudge strategies in a real-world school-dining environment. | Intervention trial (intervention school and control school, 6-week summer nudge strategy intervention targeting high plant-based foods), student transactions (school food choices made, equivalent weeks year before (pre) and year after (post) intervention), 980 and 1,132 students (years 1 and 2, respectively), schools were fully | *Nudge strategies = small changes to the choice architecture targeting selection of specified foods. At the intervention school, selection of fruit, vegetarian daily specials, sandwiches containing salad, and salads increased significantly post-intervention compared to baseline. During the intervention, students were 2.5, 3, and 7.5 times more likely to select plant- | + |

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| | | compliant. | based food items in general (i.e., the targeted nudge strategy foods), fruit/ vegetable/ salad, and salad, respectively, compared to baseline. | |
| Gosliner, 2014, [34] | To increase understanding of factors in school lunch environments that predict adolescent fruit and vegetable consumption at school, particularly length of lunch period and quality/ variety of fruits and vegetables served. | Cross-sectional (observational and student survey data); student survey of food consumption patterns at school, attitudes about importance of buying fruits and vegetables at school, and demographics; school meal observation survey of produce served, produce quality, presence of snack foods, produce verbal promotion, and student involvement; 31 middle and high schools in California (5,439 students); response rate 99.5%. | Length of lunch period was significantly associated with fruit and vegetable consumption at school. Odds of eating fruits and vegetables at school were 40% and 54% higher (significant), respectively, if the lunch period was 34 minutes or longer. Odds of eating fruit were significantly 44% higher if the quality was good or excellent as opposed to fair or poor. The odds of eating vegetables were significantly 48% higher if a salad bar present. Student involvement was associated with 34% higher odds of eating vegetables (significant). If students reported thinking it was important to be able | 0 |

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| | | | to buy fruits and vegetables at school, they were significantly more likely to consume fruits (74%) and vegetables (90%). Students who ate breakfast were 55% more likely to consume fruits and vegetables. | |
| Greene et al, 2017, [35] | To determine whether fruit-promoting Smarter Lunchrooms techniques increase selection and consumption of fruits in the cafeteria by middle school children. | 9-week cluster RCT with pre-post-test control design (treatment groups: fruit, vegetable, control; intervention to increase convenience, attractiveness, normativeness of fruit); selection (number of items chosen in each food category) and consumption (quarter-waste plate waste assessment); 11 middle schools in upstate New York, 7,752 tray observations; district response rate 91%. | Fruit selection increased in treatment schools by 36% and decreased in control schools by 22%. Fruit consumption increased in treatment schools by 14% and decreased in control schools by 16%. The intervention also resulted in a non-significant positive effect on vegetable selection, but not consumption. The intervention resulted in a significant 10% increase in milk selection, but not consumption. Training was determined to be feasible. Perceived effectiveness of and staff motivation for the | 0 |

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| | | | intervention varied. *Technique Used: Fruit placed first in serving line. Two or more fruits offered and in 2 or more different locations. Fruit was attractively displayed at eye level. Fruit was labeled with creative names (generated by student focus groups). Creative fruit names were also displayed on all menus. Dry-erase boards at eye-level displayed fruit factoids. Training sessions with kitchen staff were 1-hour long, followed by continued training and support as needed by cooperative extension. | |
| Gustafson et al, 2017, [36] | To determine the effectiveness of involving students in the design of vegetable promotion materials on food choice and consumption. | 7-month RCT with pre-/post-test design (treatment groups: control, participation only, marketing only, participation and marketing); food choice and consumption (digital photography plate | **Pre-intervention Period:** Students selected and consumed significantly fewer vegetables in the participation only group as compared to the control group. Students selected significantly fewer vegetables in the marketing only group as | 0 |

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| | | waste method, before and after eating); 4 public elementary schools in rural Nebraska, 1,614 tray observations; no response rate reported. | compared to the control group, but consumption was not significantly different. Student selection and consumption of vegetables was not significantly different in the participation and marketing only group as compared to the control group.<br>**Design Phase (2-weeks):** No significant changes in vegetable consumption. Significant increase in selection of vegetables in the participation and marketing group, increase of one-third serving.<br>**Promotion Phase (1 month):** Significant increase in consumption of vegetables in the participation and marketing group as compared to the control, increase of 100% in consumption. No significant changes in vegetable consumption for the other treatment |

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| | groups. All treatment groups saw a significant increase in vegetable selection, increase of 1 full serving by the participation and marketing group. All treatment groups also saw an increase in vegetables left on their tray. **Follow-up Period (2 months after implementation):** Students consumed significantly more vegetables in the participation and marketing group as compared to pre-intervention and the control group, increase of almost a half serving. The marketing only group also saw a significant increase in vegetable consumption from pre-intervention. *Interventions: Participation only (students drew menu vegetables on posters but not printed for marketing), |

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| | | | marketing only (vegetable posters printed and hung above salad bar, but students did not draw them), participation and marketing (students drew menu vegetables on posters, vegetable posters printed and hung above salad bar). | |
| Hanks et al, 2013, [37] | To investigate how small changes to school cafeterias following principles of libertarian paternalism influence choice and consumption of healthy foods. | Field/ pilot study of interventions changing cafeterias based on convenience (improve fruit and vegetable convenience), attractiveness (improve fruit and vegetable attractiveness relative to other options), and normativeness (make fruit and vegetable selection seem normal); tray waste evaluation; 2,756 tray observations in cafeterias in 2 western New York high schools (grades | With the cafeteria changes, students were 13.4% and 23% more likely to take fruit and vegetables, respectively. Students had 18% and 25% increased consumption of fruit and vegetables, respectively. Students were 16% and 10% more likely to consume entire fruit and vegetable serving, respectively. Results were observed with a wide range of less-healthy options simultaneously available. Changes took 3 hours to implement and cost under $50. | 0 |

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| | | 7–12); response rate N/A, compliance not reported. | | |
| Siegel et al, 2016, [38] | To evaluate the impact of the Power Plate initiative in elementary schools in a small Midwestern city's school district. | Intervention trial (13-day Power Plate initiative), Power Plate selection, 3 elementary schools (Midwestern Ohio, suburban), retention rate not reported. | *Power Plate (PP) initiative = entrée with whole grain, fruit, vegetable, plain low-fat milk; green emoticon sticker placed on PP foods; children given prize (sticker, tattoo, Frisbee, bracelet, mini beach ball) for choosing PP on prize days.<br>PP selection increased from 4.5% to 49.4%, a 1100% increase. The school with the oldest children had the smallest increase. | 0 |
| Williamson et al, 2013, [39] | To investigate the relationship between food intake, food selection, and plate waste from 2 school cafeteria modification intervention studies. | 2 efficacy trials of modified school cafeteria environments (Wise Mind – 18 months, 4 private schools, control used; LA Health – 28 months, 17 randomized school clusters, control used; same cafeteria | *Cafeteria modification intervention = 5 fruits and vegetables/d, <30% total calories from fat, <10% total calories from saturated fat, 20–30g fiber/d, recipe modification (more whole grains, low fat cheese, leaner ground beef), purchase healthier | + |

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| | | modification intervention), digital photography method (changes in food selection and plate waste), 3-day HEI-2005 scores (diet quality), 578 students (Wise Mind) and 2,097 students (LA Health), 86% retention rate (Wise Mind). | versions of items, shift purchasing (less money allocated to unhealthy foods, more allocated to healthy foods), request fewer unhealthy commodities, bring portion sizes back to NSLP recommendations (larger than recommendations), promote nutrition goals via posters/ handouts/ display items. **Food selection and intake:** There was a significant decrease in selection of calories and fat and in intake of calories, fat, and saturated fat in intervention compared to control schools. There was a significant decrease in selection of calories, fat, saturated fat, carbohydrate, and protein and in intake of calories, fat, saturated fat, and carbohydrate after the intervention compared to |

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| | baseline. **Diet quality:** HEI scores were not significantly different from baseline after 18 months. At 28 months, there were significantly higher HEI scores (3.9 points for intake, 5.3 points for selection) for the intervention and significantly lower HEI scores for the control. Race, sex, and age were significant covariates in the change that occurred. BMI z-score was not a significant covariate. |

*Study quality based on Academy of Nutrition and Dietetics Evidence Analysis Library Quality Criteria Checklist. Quality rated as positive (+), neutral (0), or negative (-).

## Appendix H - Recipes for BPSL Meal Items

# Crispy Baked Chicken

**Servings Size:** 2 oz. Tenders **Yield:** 8

### Ingredient

½ cup prepared ranch dressing

1 egg

1 lb. chicken tenders

2 tsp. vegetable Oil

1 ¼ cup whole-grain panko breadcrumbs

1 tsp garlic powder

1 tsp onion powder

1 tsp poultry Seasoning

¼ tsp salt

¼ tsp pepper

### Nutrition Information

SERVING SIZE: 2 oz. Chicken Tenders

Amount per Serving
Calories 206 kcal
Protein 17.62 g
Carbohydrate 13 g
Total Fat 10.58 g
Saturated Fat 2.55 g
Cholesterol 95.52 mg
Vitamin A 78.34 IU
Vitamin C 0.33 mg
Iron 1.12 mg
Calcium 31.07 mg
Sodium 255.65 mg
Dietary Fiber 1.19 g

EQUIVALENTS: 2 oz. chicken tenders provides 1.5 oz equiv meat/meat alternate and .25 oz equiv WGR grain.

### Directions

1. Whisk together dressing and egg in a 5-quart bowl. Add chicken and turn to coat. Cover and refrigerate at least 3 hours or overnight.
2. Preheat convection oven to 375°F. Coat a cookie sheet pan with oil.
3. Mix breadcrumbs, garlic powder, onion powder, poultry seasoning, salt and pepper in a large bowl.
4. Remove the chicken from the marinade, letting excess drip off coat in the breadcrumb mixture, then place on the prepared sheet pan, allowing at least ½-inch between each piece.
5. Bake until internal temperature reaches 165°F, about 1 hour.

Source: Fresh from Vermont New School Cuisine Cookbook

# Whole-Grain Cornbread

**Serving Size:** 1-piece **Yield:** 9 pieces

## Ingredients

¾ cup whole-grain cornmeal

¾ cup whole-wheat pastry flour

¼ cup sugar, granulated

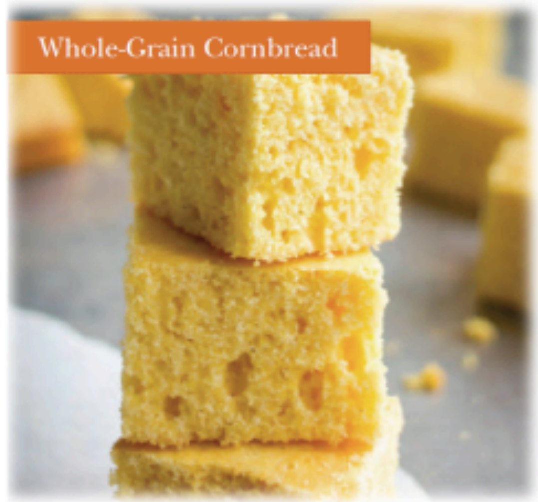
½ tsp. salt

1-1/8 tsp. baking powder

1 egg

¾ cup Milk, skim

2 Tbsp. melted salted butter or olive oil




## Directions

1. Preheat oven to 350°F. Grease 9x9 pan.
2. Whisk together cornmeal, flour, sugar, salt and baking powder in a large bowl. Whisk together egg, milk and melted butter (or olive oil) in another large bowl. Add the dry ingredients to the wet ingredients and stir just until combined.
3. Pour into the prepared pan and spread evenly. Bake until golden brown. 20-25 minutes. Cut into 9 pieces.

## Nutrition Information

**SERVING SIZE: 1 piece**

Amount per Serving:
Calories 146 kcal
Protein 3.72 g
Carbohydrate 24.40 g
Total Fat 3.97 g
Saturated Fat 0.66 g
Cholesterol 21.08 mg
Vitamin A 100.90 IU
Vitamin C 0 mg
Iron 1.08 mg
Calcium 32.00 mg
Sodium 210.64 mg
Dietary Fiber 1.75 g

**EQUIVALENTS: 1 piece provides**
**1.25 oz. equivalence whole-grain rich grain.**

Source: Fresh from Vermont New School Cuisine Cookbook

# Broccoli Salad

**Serving Size:** ½ cup **Yield:** 8

## Ingredients

1 lb. broccoli

1/6 red onion (medium)

2/3 cup reduced-fat mayo

1 ½ Tbsp. cider vinegar

2 tsp granulated sugar

¾ cup raisins

## Directions

1. Trim broccoli and cut into bite-sized pieces.
2. Trim and peel onion. Cut into small dice.
3. Whisk mayonnaise, vinegar and sugar in a large bowl. Stir in the broccoli, onion and raisins.

## Nutrition Information

**SERVING SIZE: ½ cup**

Amount per Serving:
**Calories 130 kcal**
**Protein 2.18 g**
**Carbohydrate 17.86 g**
**Total Fat 6.50 g**
**Saturated Fat 0.89 g**
**Cholesterol 0 mg**
**Vitamin A 339.15 IU**
**Vitamin C 49.06 mg**
**Iron 0.69 mg**
**Calcium 33.69 mg**
**Sodium 156.80 mg**
**Dietary Fiber 2 g**

**EQUIVALENTS: ½ cup provides 3/8 cup dark green vegetable and 1/8 cup fruit.**

Source: Fresh from Vermont New School Cuisine Cookbook

# Whole-Grain Pizza Crust

**Serving Size:** 1-piece **Yield:** 8 Servings

## Ingredients

2/3 cup warm water

1 tsp dry active yeast

½ tsp honey

2 ½ tsp olive oil

1 ¼ cup whole-wheat flour

¾ cup + 2 Tbsp. enriched all-purpose flour

1 1/8 tsp kosher salt

Cornmeal for sprinkling

## Directions

1. Stir together water and yeast in a large mixing bowl until dissolved. Add honey; let stand 5 minutes.
2. Add oil, whole-wheat flour and all-purpose flour to the yeast mixture then add salt.
3. Using a dough hook on a standing mixer, knead the dough on the lowest speed for 10 minutes. Watch the dough carefully in the first few minutes to make sure that it comes together in a ball and is soft but not too sticky. It should be stuck just on the bottom of the mixing bowl but pull away from the sides. If it is very sticky then add flour a little at a time, until it's the right consistency.
4. Oil a large bowl and transfer the dough to the bowl. Cover loosely with a large plastic bag and let rise until doubled in bulk, about 1 hour. (Press your finger into the dough—if it leaves an imprint the dough is ready.)
5. Transfer the dough to a floured surface. Place dough ball on a floured surface and cover with the plastic bag. Let rise for 30 minutes. (Press your finger into the dough—if it leaves an imprint the dough is ready.)
6. Preheat oven to 475°F. Coat pizza pan with cooking spray. Sprinkle with cornmeal.
7. Roll and stretch ball of dough and place on the prepared pans. Top as desired. Bake until the crust is light brown, 15 to 18 minutes. Cut into 8 pieces.

## Nutrition Information

**SERVING SIZE: 1 piece**

Amount per Serving
Calories 140 kcal
Protein 4.32 g
Carbohydrate 27.05 g
Total Fat 1.98 g
Saturated Fat 0.28 g
Cholesterol 0 mg
Vitamin A 8.47 IU
Vitamin C 0.59 mg
Iron 1.50 mg
Calcium 9.02 mg
Sodium 220.85 mg
Dietary Fiber 2.81 g

EQUIVALENTS: 1 piece provides 1.75 oz. WGR grain.

Source: Fresh from Vermont New School Cuisine Cookbook

# Cheese Pizza Topping

**Serving Size:** 1-piece **Yield:** 8 Servings

## Ingredients

Pizza dough (see whole-grain pizza crust recipe)

1/8 cup fresh onions, chopped *or* 1 ½ Tbsp. dehydrated onions

½ tsp garlic powder

1/8 tsp black or white pepper

½ cup canned tomato paste

¼ cup water

¼ tsp salt

¼ tsp dried basil

¼ tsp dried oregano

1/8 tsp dried marjoram

1/8 tsp dried thyme

1 lb. lite mozzarella cheese, shredded

## Directions

1. Combine onions, granulated garlic, pepper, tomato paste, water, salt, basil, oregano, marjoram, and thyme. Simmer for 15 minutes.
2. Sprinkle 1 cup (4 oz.) shredded cheese evenly over prepared pizza crust in pizza pan.
3. Spread tomato mixture over cheese in pan.
4. Sprinkle 3 cups (12 oz.) remaining shredded cheese evenly over tomato mixture in pan.
5. Bake until crust is lightly browned. Conventional oven: 475° F for 15-18 minutes
6. Cut into 8 pieces.

## Nutrition Information

SERVING SIZE: 1 piece

Amount per Serving
Calories 280 kcal
Protein 19.85 g
Carbohydrate 31.42 g
Total Fat 8.06 g
Saturated Fat 4.17 g
Cholesterol 19 mg
Vitamin A 624 IU
Vitamin C 7 mg
Iron 2.17 mg
Calcium 430 mg
Sodium 497 mg
Dietary Fiber 1.9 g

EQUIVALENTS: 1 piece provides 2 oz. equiv. meat/meat alternate and 1.75 oz. WGR grain (if made with whole-grain pizza crust recipe)

Source: Institute of Child Nutrition - USDA Recipes for Schools

# Pulled Pork

**Serving Size:** 3 oz. **Yield:** 8 Servings

## Ingredients

2 lbs. boneless pork shoulder roast (sirloin roast)

kosher salt, to taste

½ tsp garlic powder

½ tsp red pepper flakes

1/3 cup chicken or vegetable broth

1/3 cup balsamic vinegar

1 Tbsp. Worcestershire sauce

1 Tbsp. honey

## Directions

1. Season the pork with salt, garlic powder and red pepper flakes and place it into the slow cooker.
2. Mix together the broth, vinegar and Worcestershire sauce and pour it over the pork, then pour the honey over and set the timer for 4 hours on High or 6-8 hours on Low.
3. Once the pork is cooked and tender (it should shred easily with a fork), remove from slow cooker with tongs into a serving dish.
4. Break apart lightly with two forks and put back into the slow cooker.
5. Ladle 1/2 cup sauce over the pork and keep warm until ready to eat.
6. Optional: Serve with whole-grain slider buns and BBQ sauce or other sauce of your choice.

## Nutrition Information

SERVING SIZE: 3 oz. pork

Amount per Serving
Calories 214 kcal
Protein 21 g
Carbohydrate 4 g
Total Fat 12 g
Cholesterol 72 mg
Sodium 196 mg
Dietary Fiber 0 g

SERVING SIZE: 2 slider buns (72g/1.6oz)

Amount per Serving
Calories 200 kcal
Protein 10 g
Carbohydrate 34 g
Total Fat 4 g
Saturated Fat 0 g
Cholesterol 0 mg
Vitamin A 0 mg
Vitamin C 0 mg
Iron 0 mg
Calcium 8%
Sodium 280 mg
Dietary Fiber 1 g

EQUIVALENTS: 2 slider buns provide 2.5 oz. WGR grain.

Source: © *Skinnytaste* - https://www.skinnytaste.com/crock-pot-balsamic-pork-roast/

# Asian Cabbage Salad

**Serving Size:** ½ cup **Yield:** 8 Servings

## Ingredients

1 package ramen noodles

1½ Tbsp. sunflower seeds

1 tsp vegetable oil

9 oz. (1/6 small) green cabbage

7 oz. (1/6 small) red cabbage

4 oz. (1/6 small) Napa cabbage

2 ½ oz. (1 medium) carrot

1 small scallions

1 Tbsp. + 2 tsp rice Vinegar

1½ Tbsp. granulated sugar

2 tsp low-sodium soy sauce

1/8 tsp sesame oil

1/8 tsp ground black pepper

## Directions

1. Preheat conventional oven to 375°F. Line a sheet pan with parchment paper.
2. Discard flavor packs from ramen noodles. Crumble noodles into a medium bowl. Add sunflower seeds and vegetable oil to the ramen noodles and stir to coat. Spread the mixture evenly on the prepared pan. Bake until browned, stirring once or twice, 3 to 5 minutes. Set aside to cool.
3. Quarter and core cabbage. Slice the cabbage quarters in a food processor fitted with a slicing blade. Transfer to a large bowl.
4. Trim and peel carrots. Shred in a food processor fitted with a shredding blade. Add to the cabbage.
5. Trim scallions and finely dice. Add to the vegetables and toss to combine.
6. Whisk vinegar, sugar, soy sauce, sesame oil and pepper in a small bowl until the sugar is dissolved.
7. Just before serving, toss the salad with the dressing and ramen mixture.

## Nutrition Information

SERVING SIZE: ½ cup

Amount per Serving
Calories 61 kcal
Protein 1.78 g
Carbohydrate 9.28 g
Total Fat 2.38 g
Saturated Fat 0.33 g
Cholesterol 0 mg
Vitamin A 2843.51 IU
Vitamin C 36.10 mg
Iron 0.77 mg
Calcium 52.66 mg
Sodium 93.32 mg
Dietary Fiber 2.07 g

EQUIVALENTS: ½ cup provides ½ cup other vegetable.

Source: Fresh from Vermont New School Cuisine Cookbook

# Appendix I - Meal Selection and Rationale Form

## Selection Question Responses

Tray ID _____ Meal Chosen: BPSL 1 BPSL 2

What are some reasons you chose that meal?

______________________________________________________________________

______________________________________________________________________

What are some reasons you did not choose the other meal?

______________________________________________________________________

______________________________________________________________________

Tray ID _____ Meal Chosen: BPSL 1 BPSL 2

What are some reasons you chose that meal?

______________________________________________________________________

______________________________________________________________________

What are some reasons you did not choose the other meal?

______________________________________________________________________

______________________________________________________________________

# Appendix J - Taste Test Survey

## Taste Test Survey

Color in the smiley face that best describes how you feel about the meal that you are tasting!

What do you think of the color/look of this meal?

Very Good Good Just Okay Bad Very Bad

What do you think of the taste/ flavor of this meal?

Very Good Good Just Okay Bad Very Bad

What do you think of the smell of this meal?

Very Good Good Just Okay Bad Very Bad

Do you think we <u>should serve this meal</u> on the lunch menu?

Very Good Good Just Okay Bad Very Bad

Any comments?

___

___

___

# Thank you for tasting!

# Appendix K - Plate Waste Recording Sheet

**Date:** _____/_____/_____
**Group:** 1 2 3
**Meal Session:** 1 2 3

| Tray ID | BPSL or TSL | Picture taken of tray? Yes or No | Was any food thrown away? Yes or No | Was any food traded while eating? Yes or No | Was any food taken out of the kitchen area? Yes or No | Weight of remaining fruit (g, to nearest 0.1) | Weight of remaining vegetablet (g, to nearest 0.1) | Weight of remaining grain (g, to nearest 0.1) | Weight of remaining protein (g, to nearest 0.1) | Weight of remaining milk (g, to nearest 0.1) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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| | | | | | | | | | | |
| | | | | | | | | | | |
| **Full BPSL Meal** | | | X | X | X | | | | | |
| **Full TSL Meal** | | | X | X | X | | | | | |

# Appendix L - Hunger Scale

## The Hunger Scale

Tray ID ______

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Stuffed | Full | Comfortable | Hungry | Ravenous |

# Appendix M - Summary and Comparison of Taste Test Acceptability of Individual Meals and Meal Types

| Meal | Taste Score^ | Smell Score^ | Appearance Score^ | Serve at School Score^ | Total Score~ |
|---|---|---|---|---|---|
| | | | Mean ± Standard Deviation | | |
| **BPSL1 (MC1)** | 4.1±0.9 | 3.8±1.3 | 4.3±0.7 | 4.5±1.0 | 16.7±3.1 |
| **BPSL2 (MC1)** | 4.6±0.6 | 4.3±0.8 | 4.4±0.8 | 4.2±1.0 | 17.5±2.4 |
| **BPSL (MC3)** | 4.2±0.8 | 4.3±0.8 | 3.8±1.0 | 4.2±1.0 | 16.5±2.7 |
| **Overall BPSL** | 4.4±0.7 | 4.2±1.0 | 4.3±0.8 | 4.3±1.0 | 17.2±2.6 |
| **TSL1 (MC2)** | 4.7±0.5 | 3.7±1.1 | 4.1±0.9 | 4.0±1.4 | 16.6±3.6 |
| **TLS2 (MC2)** | 4.7±0.5 | 4.3±0.9 | 4.4±0.7 | 4.6±0.7 | 18.0±2.2 |
| **TSL (MC3)** | 4.4±0.7 | 4.3±0.9 | 4.3±0.8 | 4.4±0.8 | 17.4±2.4 |
| **Overall TSL** | 4.6±0.6 | 4.3±0.9 | 4.4±0.7 | 4.5±0.8 | 17.7±2.3 |

*MC = meal condition

+[pre-meal hunger score (out of 5)] – [post-meal hunger score (out of 5)]

^Maximum score of 5

~Maximum score of 20

**Significant difference ($p$<0.017 for total taste test score and average total plate waste, $p$<0.006 for taste test score subcomponents and meal component plate waste), after adjusting for sex, grade level, BMI percentile, and meal group

# Appendix N - Summary and Comparison of Plate Waste Acceptability of Individual Meals and Meal Types

| Meal | Fruit Waste | Vegetable Waste | Grain Waste | Protein Waste | Milk Waste | Average Total Meal Waste |
|---|---|---|---|---|---|---|
| | | | %, Mean ± Standard Deviation | | | |
| **BPSL1 (MC1)** | 4.7±11.7 | 81.8±27.3 | 49.1±43.6 | 54.3±33.3 | 72.7±33.7 | 52.5±13.0 |
| **BPSL2 (MC1)** | 47.2±40.1 | 72.9±28.4 | 28.4±33.1 | 28.4±33.1 | 60.9±44.9 | 47.6±19.2 |
| **BPSL (MC3)** | 61.6±40.7 | 76.2±26.4 | 27.0±36.8 | 26.7±37.5 | 71.6±39.1 | 52.6±20.8 |
| **Overall BPSL** | 39.1±40.2 | 75.5±27.5 | 33.1±36.5 | 34.3±34.8 | 65.3±41.2 | 49.5±17.9 |
| **TSL1 (MC2)** | 50.6±47.8 | 94.6±6.2 | 45.2±46.7 | 18.5±34.4 | 91.5±21.3 | 60.1±16.9 |
| **TLS2 (MC2)** | 51.7±38.1 | 70.7±29.4 | 34.7±40.2 | 34.7±40.2 | 68.2±40.7 | 52.0±21.7 |
| **TSL (MC3)** | 45.0±41.2 | 35.4±36.4 | 37.5±36.8 | 26.6±35.6 | 61.8±45.2 | 41.2±21.6 |
| **Overall TSL** | 48.5±40.3 | 56.8±37.9 | 36.4±38.7 | 28.3±36.8 | 68.8±41.3 | 47.8±22.1 |

*MC = meal condition

**Significant difference ($p$<0.017 for total taste test score and average total plate waste, $p$<0.006 for taste test score subcomponents and meal component plate waste), after adjusting for sex, grade level, BMI percentile, and meal group

# Appendix O - Stated Reason for Meal Choice

**Meal Condition 1 (2 BPSL*)**

*BPSL1 = Oven baked chicken nuggets, broccoli salad, grapes, whole grain cornbread, low-fat milk

BPSL2 = Whole grain cheese pizza, side salad with Italian dressing, clementine, low-fat milk

| Participant | Meal Chosen | Reason Meal Selected Was Chosen | Reason Meal Not Selected Was Not Chosen |
|---|---|---|---|
| 001 | BPSL1 | Like the fruit and vegetable | Like the other one better |
| 002 | BPSL2 | Pizza is my favorite | Don't like cornbread |
| 003 | BPSL2 | Love pizza, just want pizza | Love cornbread, just want pizza |
| 004 | BPSL1 | Like broccoli | Didn't want salad |
| 005 | BPSL2 | Like oranges | Not feeling the nuggets today |
| 006 | BPSL1 | Like cornbread and nuggets | Don't like salad and messy oranges |
| 007 | BPSL1 | Like broccoli | Don't like cucumber |
| 008 | BPSL2 | I really like pizza | Broccoli |
| 010 | BPSL2 | Like pizza, lettuce, and cucumbers | Not a fan of broccoli |
| 012 | BPSL2 | Love pizza and oranges | Don't like broccoli and raisins |
| 014 | BPSL2 | It looks good | There's stuff in the broccoli |
| 015 | BPSL2 | Like pizza | Don't like broccoli |
| 016 | BPSL2 | Like pizza | No reason |
| 017 | BPSL2 | Don't like broccoli | Don't like broccoli |
| 018 | BPSL2 | No reason | More not like |
| 019 | BPSL2 | Like salad | Don't like broccoli with ranch |
| 020 | BPSL2 | Pizza and orange | No reason |
| 021 | BPSL2 | The chicken looks different | Chicken nuggets looked strange |

| | | | |
|---|---|---|---|
| 022 | BPSL2 | Like pizza | Don't like grapes |
| 023 | BPSL2 | Really like pizza | Broccoli does not agree with me |
| 024 | BPSL2 | Doesn't like dressing | There was dressing on the broccoli |
| 025 | BPSL1 | Like cornbread | No reason |
| 026 | BPSL1 | Like chicken and grapes | No reason |
| 027 | BPSL2 | Really like pizza and cutie | Not like broccoli |
| 028 | BPSL2 | Want pizza | Not like nuggets |
| 029 | BPSL1 | Like bread | Not feeling pizza |
| 030 | BPSL2 | Don't like other meal | Didn't like chicken and broccoli |
| 031 | BPSL1 | Like nuggets, grapes, and cornbread | Don't like the vegetable |
| 033 | BPSL2 | Like pizza | Don't like cornbread |
| 034 | BPSL2 | Last time had nuggets | Last time had nuggets |
| 035 | BPSL2 | Pizza, orange, and cucumber | Broccoli |
| 036 | BPSL1 | Like cornbread and grapes | Don't like oranges |
| 037 | BPSL1 | Like chicken | Like chicken |
| 038 | BPSL2 | Like salad | No reason |
| 040 | BPSL2 | Likes pizza more | Only like some chicken |
| 041 | BPSL2 | Like most stuff | Don't know |

**Meal Condition 2 (2 TSL$^{+}$)**

$^{+}$TSL1 = Chicken nuggets, broccoli with cheese sauce, pineapple fruit cup, dinner roll, low-fat milk

TSL2 = Cheese pizza, carrots with ranch, mandarin oranges, low-fat milk

| Participant | Meal Chosen | Reason Meal Selected Was Chosen | Reason Meal Not Selected Was Not Chosen |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 001 | TSL1 | The pizza will make me too full | The pizza will make me too full |
| 002 | TSL2 | Like pizza | Don’t like pineapple |
| 003 | TSL2 | Pizza is my favorite | Pizza is my favorite |
| 004 | TSL1 | Like nuggets | Like pizza, just didn’t want it |
| 005 | TSL2 | Like oranges | Don’t like pineapple |
| 006 | TSL2 | Like pizza | Like pizza |
| 007 | TSL2 | Not sure | Didn’t want chicken |
| 008 | TSL2 | Like pizza | Don’t like broccoli |
| 010 | TSL2 | Like pizza | Don’t like cheesy broccoli or packaged pineapple |
| 012 | TSL2 | Just really like pizza | Don’t like cheesy broccoli and ketchup |
| 013 | TSL2 | Like pizza | Don’t like cheese on broccoli |
| 014 | TSL2 | Like pizza | Like pizza |
| 015 | TSL2 | Like pizza | Don’t like chicken much |
| 016 | TSL2 | Like pizza | Like pizza |
| 017 | TSL2 | Like pizza | Don’t like broccoli |
| 018 | TSL2 | Looks better | The other one looks better |
| 019 | TSL2 | Like pizza and ranch | Don’t want a roll |
| 020 | TSL2 | Like carrots and pizza | Like carrots and pizza |
| 021 | TSL2 | Could smell pizza | Broccoli looks “eh” |
| 022 | TSL2 | Like carrots | Don’t like chicken |
| 023 | TSL2 | Like the whole tray | Not comfortable with broccoli |
| 024 | TSL1 | Hungry | Don’t like ranch |
| 025 | TSL1 | Like nuggets better | Like nuggets |
| 026 | TSL2 | Like pizza, carrots, ranch, and oranges | Don’t like broccoli |
| 027 | TSL2 | Like pizza | Like pizza more |
| 028 | TSL2 | Like pizza | No reason |
| 029 | TSL1 | Not in the mood for pizza | Not in the mood for pizza |

| | | | |
|---|---|---|---|
| 030 | TSL2 | Like pizza and fruit cup a lot | Don't like pineapples |
| 031 | TSL2 | Like pizza | Like pizza |
| 033 | TSL2 | Like oranges and carrots | No reason |
| 034 | TSL1 | Like chicken | Don't know |
| 035 | TSL2 | Like pizza | Don't like broccoli |
| 036 | TSL2 | Like oranges | Don't like broccoli |
| 037 | TSL2 | Want pizza | Want pizza |
| 038 | TSL1 | Like this one | Had that one last time |
| 040 | TSL2 | More vegetarian | Other one more vegetarian |
| 041 | TSL2 | Like pizza and fruit | Like pizza and fruit |

**Meal Condition 3 (1 BPSL, 1 TSL^)**

^BPSL = BBQ pulled pork on whole grain slider buns, Asian coleslaw, apple slices, low-fat milk

TSL = Hot dog on whole grain-rich bun, French fries, peach fruit cup, low-fat milk

| Participant | Meal Chosen | Reason Meal Selected Was Chosen | Reason Meal Not Selected Was Not Chosen |
|---|---|---|---|
| 001 | TSL | Like fruit cup | Usually don't eat that much food |
| 002 | TSL | Like fries | Hate coleslaw |
| 003 | BPSL | Don't like hotdogs | Don't like hotdogs |
| 004 | TSL | Like fries | No reason |
| 005 | TSL | Like hotdogs, fries, and ketchup | Don't like pork |
| 006 | BPSL | Like pork and BBQ | Don't like messy fruit cup |
| 007 | TSL | Don't like salad much | Don't like salad much |
| 008 | TSL | Don't like coleslaw, love hotdogs | Don't like coleslaw |
| 010 | TSL | Like hotdog | No reason |

| | | | |
|---|---|---|---|
| 012 | TSL | Like hotdog | Don't like pork |
| 014 | TSL | Like French fries and peaches | Stuff in the bun looks weird |
| 015 | BPSL | Like food on that tray – salad, apples | Don't like peaches |
| 016 | TSL | Like hotdog | No reason |
| 017 | TSL | Don't want apples | Don't like apples |
| 018 | TSL | Don't like salad | Don't like salad |
| 019 | BPSL | Like the sandwiches | Don't like hotdogs |
| 020 | TSL | Like hotdog | Don't like it |
| 021 | TSL | Not much of a salad eater, like fries | Don't like salad |
| 022 | TSL | Like peaches | Like peaches |
| 023 | TSL | Like hotdogs, more used to hotdog than BBQ | Looks a little strange |
| 024 | TSL | Don't really like coleslaw | Too much food |
| 025 | TSL | Like hotdog, fries, and ketchup | Don't like BBQ pork |
| 026 | TSL | Really like hotdog and fruit cup | Don't like BBQ |
| 027 | TSL | Like hotdog and less healthy | Not into the salad |
| 028 | TSL | Only like the apples on the other tray | Like more on other tray |
| 029 | BPSL | Like coleslaw and apples | Don't like hotdogs |
| 030 | TSL | Like hotdog and fries | Other plate too tiny |
| 031 | TSL | Hotdogs are good | Don't like coleslaw or BBQ pork |
| 033 | TSL | I don't know | Don't like salad |
| 034 | TSL | Like hotdog and fries | Not into coleslaw |
| 035 | TSL | Like French fries | Don't like coleslaw |
| 036 | TSL | Like hotdogs | Don't like BBQ |
| 037 | BPSL | Like apples | Don't want it |
| 038 | TSL | Love hotdogs | If hotdogs weren't here, would |

| | | | |
|---|---|---|---|
| | | | eat the other meal |
| 039 | TSL | Like ketchup | Too much food |
| 040 | TSL | Like this one more but not sure about either | No reason |
| 041 | TSL | Like everything but fries | Like some but not all |

# Appendix P - Taste Test Survey Comments

**Meal Condition 1 (2 BPSL*)**

*BPSL1 = Oven baked chicken nuggets, broccoli salad, grapes, whole grain cornbread, low-fat milk

BPSL2 = Whole grain cheese pizza, side salad with Italian dressing, clementine, low-fat milk

| Participant | Meal Chosen | Comments |
|---|---|---|
| 001 | BPSL1 | "A little bit like the chicken nuggets but not as much" |
| 002 | BPSL2 | "No carrots and purple stuff in salad." |
| 003 | BPSL2 | "The pizzs is the Best" |
| 004 | BPSL1 | none |
| 005 | BPSL2 | "Nope ☺" |
| 006 | BPSL1 | none |
| 007 | BPSL1 | "Liked grapes. The chicken is crunchy. The bread is soft." |
| 008 | BPSL2 | none |
| 010 | BPSL2 | "Nope" |
| 012 | BPSL2 | "AWSOME" |
| 014 | BPSL2 | "pizza is good ip" |
| 015 | BPSL2 | none |
| 016 | BPSL2 | none |
| 017 | BPSL2 | none |
| 018 | BPSL2 | none |
| 019 | BPSL2 | none |
| 020 | BPSL2 | none |
| 021 | BPSL2 | "The milk tastes like cheese. More cheese should be put on the pizza to prevent the sauce from going everywhere. Create a pepperoni option. I hate salad." |

| | | |
|---|---|---|
| 022 | BPSL2 | "The food is good every time I come I leave whith a happy Belly." |
| 023 | BPSL2 | none |
| 024 | BPSL2 | "Nothing frozen or not homemade" |
| 025 | BPSL1 | none |
| 026 | BPSL1 | none |
| 027 | BPSL2 | none |
| 028 | BPSL2 | none |
| 029 | BPSL1 | "Realy good, awesome" |
| 030 | BPSL2 | "Its good" |
| 031 | BPSL1 | none |
| 033 | BPSL2 | none |
| 034 | BPSL1 | "Pleas put it in my schools menu because are food is DESCUSTING D': ):" |
| 035 | BPSL2 | none |
| 036 | BPSL1 | none |
| 037 | BPSL1 | none |
| 038 | BPSL2 | "It was good probably people who like Italian ranch would like it...pizza taste kinda like calzone." |
| 040 | BPSL2 | "I think on the salad it should have more dressing on it." |
| 041 | BPSL2 | none |

**Meal Condition 2 (2 TSL$^+$)**

$^+$TSL1 = Chicken nuggets, broccoli with cheese sauce, pineapple fruit cup, dinner roll, low-fat milk

TSL2 = Cheese pizza, carrots with ranch, mandarin oranges, low-fat milk

| Participant | Meal Chosen | Comments |
|---|---|---|

| | | |
|---|---|---|
| 001 | TSL1 | "I don't know why But I tasted something in the chicken nuggets that I did not really like." |
| 002 | TSL2 | "The pizza was better than the circle pizza they serve at school" |
| 003 | TSL2 | "It is amazing. It is very good." |
| 004 | TSL1 | "NO BRocoi" |
| 005 | TSL2 | "Nope" |
| 006 | TSL2 | none |
| 007 | TSL2 | "I no how to make pissa" |
| 008 | TSL2 | none |
| 010 | TSL2 | "NOPE" |
| 012 | TSL2 | "This was AWSOME!" |
| 013 | TSL2 | none |
| 014 | TSL2 | "no." |
| 015 | TSL2 | none |
| 016 | TSL2 | none |
| 017 | TSL2 | none |
| 018 | TSL2 | "Petzza/all food at my school is taribel! I don't like red sas" |
| 019 | TSL2 | none |
| 020 | TSL2 | none |
| 021 | TSL2 | "Serve this pizza vs the last pizza" |
| 022 | TSL2 | "Thank's for the food" |
| 023 | TSL2 | "The fruit bowl was a bit messy." |
| 024 | TSL1 | none |
| 025 | TSL1 | none |
| 026 | TSL2 | none |
| 027 | TSL2 | "I think it was Asome. PJ could we have pancakes next time." |
| 028 | TSL2 | none |
| 029 | TSL1 | "Awesome" |
| 030 | TSL2 | none |
| 031 | TSL2 | "I really really like that" (to the pizza) "I like everything" |

| | | |
|---|---|---|
| 033 | TSL2 | none |
| 034 | TSL1 | "soggy Brocily." |
| 035 | TSL2 | "nope" |
| 036 | TSL2 | none |
| 037 | TSL2 | none |
| 038 | TSL1 | "No, not really." |
| 040 | TSL2 | "I don't like ranch I like blue cheese I also dont like the oranges" |
| 041 | TSL2 | none |

**Meal Condition 3 (1 BPSL, 1 TSL^)**

^BPSL = BBQ pulled pork on whole grain slider buns, Asian coleslaw, apple slices, low-fat milk

TSL = Hot dog on whole grain-rich bun, French fries, peach fruit cup, low-fat milk

| Participant | Meal Chosen | Comments |
|---|---|---|
| 001 | TSL | none |
| 002 | TSL | "I would put the burgers with the fries." |
| 003 | BPSL | "the Berger are okay." |
| 004 | TSL | none |
| 005 | TSL | "nope. The ketchup is a little sour and the fires are so good!" |
| 006 | BPSL | none |
| 007 | TSL | none |
| 008 | TSL | "More sweets" |
| 010 | TSL | "No" |
| 012 | TSL | "AWSOME" |
| 014 | TSL | "My mom will plopobly wont be that mad at my choice because sometimes im allowed to have hotdogs" |
| 015 | BPSL | none |

| | | |
|---|---|---|
| 016 | TSL | none |
| 017 | TSL | none |
| 018 | TSL | none |
| 019 | BPSL | “This was the best school lunch I have tasted.” |
| 020 | TSL | none |
| 021 | TSL | “the fries are cold” |
| 022 | TSL | “The food was really good.” |
| 023 | TSL | none |
| 024 | TSL | none |
| 025 | TSL | none |
| 026 | TSL | none |
| 027 | TSL | none |
| 028 | TSL | none |
| 029 | BPSL | none |
| 030 | TSL | none |
| 031 | TSL | none |
| 033 | TSL | none |
| 034 | TSL | “Peaches are little to sogy and slimy” |
| 035 | TSL | none |
| 036 | TSL | none |
| 037 | BPSL | none |
| 038 | TSL | “This meal was great I’m steel on the thought of very good I would love for this to be on the lunch menu at school. P.s. frys are a little cold” |
| 039 | TSL | “The peaches are sogy” |
| 040 | TSL | “I liked the sides but not the hotdog” |
| 041 | TSL | none |

# Appendix Q - Audit of Skill Needed to Prepare Meals

## Meal Condition 1

**BPSL 1: Crispy baked whole grain chicken**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Follow and scale standardized recipes; weigh and measure food ingredients accurately. Requires basic math skills and knowledge of common weights and measures.
- Operate the following kitchen equipment: oven, warmer, and cooler.
- Utilize the following kitchenware: knives, spatula, whisk, tongs, and measuring cups and spoons.

**BPSL 1: Broccoli salad**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Follow food safety procedures for the handling of fresh ready-to-eat (RTE) produce.
- Follow and scale standardized recipes; weigh and measure food ingredients accurately. Requires basic math skills and knowledge of common weights and measures.
- Utilize the following kitchenware: knives, spatulas, whisk, and measuring cups and spoons.

**BPSL 1: Whole grain cornbread**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Follow and scale standardized recipes; weigh and measure food ingredients accurately. Requires basic math skills and knowledge of common weights and measures.
- Operate the following kitchen equipment: electric mixers, and ovens.
- Utilize the following kitchenware: knives, spatula, whisk, and measuring cups and spoons.

**BPSL 2: Whole grain pizza crust**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Follow and scale standardized recipes; weigh and measure food ingredients accurately. Requires basic math skills and knowledge of common weights and measures.
- Knowledge of baking techniques.
- Operate the following kitchen equipment: electric mixer, dough hook, and oven.
- Utilize the following kitchenware: knives, pizza cutter, spatula, whisk, tong, rolling pin, and measuring cups and spoons.

**BPSL 2: Homemade pizza sauce**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Follow and scale standardized recipes; weigh and measure food ingredients accurately. Requires basic math skills and knowledge of common weights and measures.
- Operate the following kitchen equipment: stove top, tilt-skillets, and tilt-kettles.
- Utilize the following kitchenware: knives and measuring cups and spoons.

**Meal Condition 2**

**TSL 1: Frozen chicken nuggets**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Operate the following kitchen equipment: oven, warmer, and cooler.
- Utilize the following kitchenware: tongs.

**TSL 2: Frozen pizza**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.

- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Operate the following kitchen equipment: oven, warmer, and cooler.
- Utilize the following kitchenware: knives, pizza cutter, and spatula.

**Meal Condition 3**

**BPSL: Pulled pork sliders**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Follow and scale standardized recipes; weigh and measure food ingredients accurately. Requires basic math skills and knowledge of common weights and measures.
- Operate the following kitchen equipment: oven, warmer, and cooler.
- Utilize the following kitchenware: knives, tongs, and measuring cups and spoons.

**BPSL: Asian cabbage salad**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Follow food safety procedures for the handling of fresh ready-to-eat (RTE) vegetables and fruits.

- Follow and scale standardized recipes; weigh and measure food ingredients accurately. Requires basic math skills and knowledge of common weights and measures.
- Operate the following kitchen equipment: oven, food processor, and cooler
- Utilize the following kitchenware: knives, spatulas, whisks, and measuring cups and spoons

**TSL: Hot dog on a Bun**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Operate the following kitchen equipment: oven, stovetop, warmer, and cooler.
- Utilize the following kitchenware: tongs.

**TSL: Frozen French fries**

- Knowledge of principles and methods of preparing food in large quantities according to appropriate food safety and sanitation procedures.
- Practice proper operation of equipment to assure safety and avoid damage to equipment and clean and sanitize equipment properly.
- Operate the following kitchen equipment: oven, warmer, and cooler.
- Utilize the following kitchenware: tongs.

# Appendix R - Audit of Equipment Needed to Prepare Meals

## Meal Condition 1

**BPSL 1: Crispy baked whole grain chicken**

- Kitchen equipment: oven, warmer, cooler
- Kitchenware: knives, spatula, whisk, tongs, measuring cups and spoons

**BPSL 1: Broccoli salad**

- Kitchenware: knives, spatulas, whisk, measuring cups and spoons

**BPSL 1: Whole grain cornbread**

- Kitchen equipment: electric mixers, ovens
- Kitchenware: knives, spatula, whisk, measuring cups and spoons

**BPSL 2: Whole grain pizza crust**

- Kitchen equipment: electric mixer, dough hook, oven
- Kitchenware: knives, pizza cutter, spatula, whisk, tong, rolling pin, measuring cups and spoons

**BPSL 2: Homemade pizza sauce**

- Kitchen equipment: stove top, tilt-skillets, tilt-kettles
- Kitchenware: measuring cups and spoons

## Meal Condition 2

**TSL 1: Frozen chicken nuggets**

- Kitchen equipment: oven, warmer, cooler
- Kitchenware: tongs

**TSL 2: Frozen pizza**

- Kitchen equipment: oven, warmer, cooler
- Kitchenware: knives, pizza cutter, spatula

## Meal Condition 3

**BPSL: Pulled pork sliders**

- Kitchen equipment: oven, warmer, cooler
- Kitchenware: knives, tongs, measuring cups and spoons

**BPSL: Asian cabbage salad**

- Kitchen equipment: oven, food processor, cooler
- Kitchenware: knives, spatulas, whisks, measuring cups and spoons

**TSL: Hot dog on a Bun**

- Kitchen equipment: oven, stove top, warmer, cooler
- Kitchenware: tongs

**TSL: Frozen French fries**

- Kitchen equipment: oven, warmer, cooler

- Kitchenware: tongs