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Modification of the School Cafeteria Environment Can Impact Childhood Nutrition: Results from the Wise Mind and LA Health Studies

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Abstract

Recent changes in nutrition standards for the National School Lunch and School Breakfast Programs assume that modification of the nutritional serving practices of school cafeterias will result in improved childhood nutrition in the school environment. The primary aim of this paper is to summarize the findings from two recent cluster randomized controlled trials (Wise Mind and LA Health) that tested the hypothesis that modification of school cafeteria environments, including changes in nutrition standards, would yield beneficial changes in childhood nutrition and healthy eating in the school lunch environment. A secondary aim was to investigate the association of participant characteristics and changes in nutrition and healthy eating. A third aim was to investigate the relationships between the food intake of children and: 1) foods selected by the children and 2) food that was uneaten during the lunch meal (plate waste). The studies used similar approaches for modifying the school cafeteria environment and both studies used the digital photography method to measure changes in food intake, food selection, and plate waste. Both studies reported significant improvements in childhood nutrition, and the LA Health study reported improved healthy eating, following introduction of the cafeteria modification program in comparison to baseline and/or control arms. These studies confirm the hypothesis that interventions that modify the school cafeteria environment can beneficially impact childhood nutrition.

Keywords

childhood nutrition; obesity prevention; cafeteria modification; digital photography; nutrition standards; eating behavior

In 2012, the U.S. Department of Agriculture issued new standards for nutrition in the National School Lunch and School Breakfasts Programs (U.S. Department of Agriculture, 2012). The new rule requires most schools to: 1) increase the availability of certain foods, fruit, vegetables, whole grains, and fat-free or low-fat fluid milk, and 2) reduce the levels of sodium, saturated fats and trans-fat, in school breakfasts and lunches. This change in nutrition standards came in response to recent recommendations from the American Association of Pediatricians (Davis et al., 2007), the American Dietetic Association (Bergman, 2010), the Institute of Medicine (2009), and an expert panel assembled by the

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Conflict of Interest

The authors disclose no conflicts of interest.

National Heart, Lung, and Blood Institute of the National Institutes of Health (Pratt, Stevens, & Daniels, 2008). These changes in nutrition standards for school cafeterias are based on the assumption that modification of foods served in school cafeterias will result in favorable/healthy changes in the food intake and nutrition of children during school meals. The primary aim of this pair of studies was to test this hypothesis using cluster randomized controlled trial methodology and measurement of children's food intake and nutrition using a method that has been developed for use in cafeteria settings (Williamson et al., 2004; Williamson et al., 2003; Williamson et al., 2002). In this study, healthy eating was defined using the Healthy Eating Index (HEI; Guenther, Reedy, Kregs-Smith, Reeve, & Basiotis, 2007; Guenther, Krebs-Smith, Reedy, et al., 2008). A secondary aim was to test for the association of characteristics of the student participants, i.e., sex, race, age, baseline body mass index, and baseline food selection/intake, with changes in nutrition and healthy eating. A third aim was to test relationships between food intake and: foods served/selected by children and foods uneaten during the meal (plate waste).

Findings from earlier randomized controlled trials have supported the hypothesis that changes in the school environment (including cafeterias) can result in improved nutrition (Burgess-Champoux, Chan, Rosen, Marquart, & Reicks, 2008; Cunningham-Sabo et al., 2003; Osganian et al., 1996; Perry et al., 1998; Siega-Riz et al., 2011). Collectively, these studies have reported that at least some aspects of child eating behavior can be beneficially modified by changing the school cafeteria environment to reduce servings of fat and sugar and increasing the availability of fresh fruits and vegetables. Studies conducted over the past 15 years have used a variety of approaches for modifying the school cafeteria environment and for measuring changes in childhood nutrition and/or food intake. These measurement strategies have included: self-report surveys (e.g., Mendoza, Watson, & Cullen, 2010; Siega-Riz, et al., 2011; Spiegel & Foulk, 2006), direct observation of eating behavior (e.g., Burgess-Champoux, et al., 2008; Perry, et al., 1998), or weighed foods (Leahy, Birch, & Rolls, 2008). Many of these earlier studies measured foods that were served, but did not measure food or nutritional intake or plate waste (e.g., Bartholomew & Jowers, 2006; Cunningham-Sabo, et al., 2003; Osganian, et al., 1996).

The Wise Mind (Williamson et al., 2007) and LA Health (Williamson et al., 2008; Williamson et al., 2012) studies provided an opportunity to test the hypothesis that school cafeteria modification can beneficially impact food intake and nutrition using cluster randomized trial methodology. Both studies used the digital photography method for measuring food selection, plate waste, and food intake, from which the Healthy Eating Index was calculated. The digital photography method was developed and validated over the past decade. In an initial series of studies Williamson and colleagues developed the method and established it as a valid, reliable, and accurate method for measuring food selection, plate waste, and food intake of adults and children (Martin et al., 2007; Martin et al., 2010; Williamson, et al., 2004; Williamson, et al., 2003; Williamson, et al., 2002). This paper provides different and more detailed descriptions of the methodology and food intake/nutrition/healthy eating results of the two school-based childhood obesity prevention studies (Williamson, et al., 2007, 2012)¹. This paper also provides analyses of the relationships between food intake, food selection, and plate waste from both studies.

¹In previous reports of the primary outcomes of the Wise Mind (Williamson, et al., 2007) and LA Health (Williamson, et al., 2012) studies, statistical methods differed from those used in this paper. Furthermore, the statistical methods reported in the two papers also differed. In this paper we designed the statistical analyses to be very similar so that the findings of the two studies could be more appropriately compared. In the previous reports, many of the covariates used in this paper were not employed. Also, the previous reports did not include analysis of HEI, which is an important addition to the information presented earlier.

Method

Description of the Two Studies

Wise Mind—The Wise Mind study (Williamson, et al., 2007) compared the efficacy of an environmental approach for weight gain prevention in children to an active control condition that employed an environmental approach for modifying expectancies related to use of alcohol, tobacco, and drugs. A total of 670 second to sixth grade students from four private schools were enrolled in the study and 661 were measured at baseline. The study spanned two academic years, and 578 students were available for evaluation at the end of the study (18 months). Two schools were randomly assigned to each treatment arm. The environmental approach for weight gain prevention focused upon modification of eating habits and physical activity, and the active control group focused upon modification of expectancies related to substance use. The environmental arm included a program to modify the school cafeteria environment. The study found no differences in weight gain prevention for the two treatment arms. The cafeteria modification program was associated with reduction of total caloric intake and reduction of dietary fat intake in comparison to the active control group and/or relative to baseline.

LA Health—The LA Health study (Williamson, et al., 2008; Williamson, et al., 2012) tested the efficacy of two school-based programs for the prevention of body weight/fat gain in comparison to a control group. Children (N=2097) from rural communities enrolled in Grades 4 to 6 of public schools completed baseline measurement for this 28-month study. Schools were clustered geographically to create 17 school clusters with an average of 123 children per cluster. School clusters were randomly assigned to one of three prevention arms named: 1) Primary Prevention (PP), 2) Primary + Secondary Prevention (PP+SP), or 3) Control. The PP and PP+SP arms included the same cafeteria modification program that was tested in the Wise Mind study. For the purposes of this paper, the PP and PP+SP arms were combined to form a cafeteria modification (CM) arm. Relative to the Control (C) arm, the two arms that employed the PP program were associated with decreased body fat and reduced intake of dietary fat.

Cafeteria modification (CM) program—The environmental program that was tested in both studies was designed with the goal of preventing inappropriate weight and/or fat gain by modifying the school environment to improve healthy eating habits, increase physical activity, and decrease sedentary behavior at school and to encourage these same behavioral changes outside the school environment. The goals of the CM program were based on nutrition recommendations from the American Academy of Pediatrics (Davis, et al., 2007): five fruits and vegetables per day, less than 30% of dietary energy from total fat, less than 10% of dietary energy from saturated fat, and 20 to 30 grams of fiber/day. The research team worked closely with school principals, teachers and cafeteria personnel to encourage appropriate portion sizes, calories, and nutrient content of school lunches. The goals related to the school lunches were largely accomplished by modifying existing recipes. For example, more whole grains, low fat cheese, and leaner ground beef were incorporated into school lunches. The recipe modification also required purchasing new and healthier items, such as canned fruit in its own juice versus canned fruit in heavy syrup. The recipe modification also required a shift in the purchasing of foods such that less money was allocated for unhealthy foods to allow for greater acquisition of foods in alignment with the Academy's recommendations; and fewer unhealthy commodities were requested in favor of items in accordance with the recommendations. Portion sizes were altered so that they were in accordance with the National School Lunch Program (NSLP). The portion sizes being served prior to the intervention were typically greater than the NSLP recommendations. Therefore, the alterations largely involved working with the cafeteria staff to reduce portion

sizes to the recommended levels. Posters, handouts and display items in the classroom and cafeteria promoted the nutrition goals using a series of campaigns related to healthy nutrition and physical activity (Williamson, et al., 2008; Williamson, et al., 2012; Williamson, et al., 2007). In all schools in both studies, some portion of the food was served, e.g., entrees, and some portion was selected by students, e.g., salads and condiments. For consistency of terms, we use the term “food selection” to describe the foods observed on the child’s plate before eating lunch. In both studies, the efficacy of the CM program was tested against a control arm.

Digital Photography Method: Changes in Food Selection, Plate Waste, and Food Intake

Based on previous research findings (Martin, et al., 2007), identical digital photography methods were used in the two studies (Williamson, et al., 2012; Williamson, et al., 2007). On three consecutive days, the digital photography method was used to measure the food selection, plate waste, and food intake of students enrolled in the study. At lunch, foods selected by the students prior to eating and after eating were photographed by research associates using two digital video cameras. One camera was used to photograph incoming trays (food selection), and the second camera was used for photographing outgoing trays (plate waste). Differences between food selection and plate waste defined food intake. Digital photographs of the reference portion, food selection, and plate waste for test meals were captured and processed through a computer application designed for estimation of food portions in digital photographs by trained observers who were blind to treatment arm assignment of each participant. Photographs were evaluated in a random order so that observers would be unaware of school or treatment arm associated with each photograph. Food portions were compared to standard serving sizes in a reference photograph of each food that was served at lunch that day. Research associates used the software to simultaneously view photos of the food selection and plate waste test meals along with photos of the reference portion of each food. The observers independently estimated the percent (categorized in 10% increments) of the reference portion of each food in the photographs and entered these estimates into the computer application for food composition analysis using nutrient data from the Pennington Biomedical Research Center nutrient database and the United States Department of Agriculture (U.S. Department of Agriculture, 2000, 2006). Intra-class correlation coefficients were calculated to quantify agreement across raters, and these coefficients provided evidence indicative of very high agreement (> 0.90) for each measurement period and for each outcome measure, e.g., total kcal or kcal from macronutrients (Williamson, et al., 2012; Williamson, et al., 2007). Digital photography was used to measure food intake, food selection, and plate waste for each individual child at baseline, before introducing the cafeteria modification program, and at each measurement point, including the end of each study, i.e., 18 months for the Wise Mind study and 28 months for the LA Health Study. The unit of measurement for all nutrient measures was kcal, which is a continuous variable.

Healthy Eating Index (HEI)

The study used the most recent version of the HEI, i.e., HEI-2005, (Guenther et al., 2008, Guenther et al., 2007). The HEI measures compliance with the 2005 Dietary Guidelines for Americans (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005). The HEI-2005 is comprised of 12 component scores that are summated to provide a single score that ranges from zero, which reflects an unhealthy diet, to 100, which reflects a healthy diet (Guenther et al., 2008, Guenther et al., 2007). The HEI-2005 can be used to evaluate and monitor the diet of populations or individuals and was recommended for use in evaluating changes in nutrition (Guenther et al., 2007). Support has been found for the content and construct validity of HEI-2005, and its ability to distinguish groups with diet quality differences (Guenther et al., 2007). The HEI-2005 was developed to

represent food intakes and nutrients based on 1000 kcal units. Nutrient density standards for the HEI-2005 were based on dietary patterns of 1000 to 2400 kcal (Guenther et al., 2007). Studies of reliability and validity used 24-hour recall data (Guenther et al., 2007). In the current study, food intake at lunch over 3 days was used to calculate HEI-2005 scores, which represents a number of meals (i.e., 3) similar to that used in the original studies of reliability and validity of the HEI-2005. Further, 99.7% of our participants had > 1000 kcal for food selection and 89.5% had > 1000 kcal for food intake; hence, our data are consistent with the HEI representing 1000 kcal units. It is important to note that in this study, we were exclusively interested in testing changes in nutrition in the school cafeteria environment, i.e., not changes that occurred outside the school cafeteria environment. The HEI-2005 was calculated based on the HEI Technical Report (Guenther et al., 2007) by representing study menus in MyPyramid values and calculating the HEI-2005 with the code provided by the USDA (<http://www.cnpp.usda.gov/HealthyEatingIndexSupportFiles0102.htm>).

Statistical Methods

Four schools were randomized in the Wise Mind study and 17 school clusters (groups of schools) were randomized in the LA Health study. All data were collected at the individual child level. For food intake and food selection, changes from the baseline to follow-up measurements were utilized as the primary response outcomes. The interventions were considered to have fixed effects on outcomes whereas school clusters and subjects were viewed as having random effects. For each study, a single-stage, mixed effects (fixed and random) statistical model was employed to investigate significance of the observed differential effects of cafeteria modification versus control. Separate models were used to analyze each outcome for each study. Baseline values, gender, baseline age, and baseline BMI z scores were included in the analytic models as covariates. Race was also included in the model for LA Health study as the covariate, but not for Wise Mind study due to 95% of participants being white. The results were summarized by intervention as least squares adjusted means. Partial correlations were calculated to assess association between significant covariates and outcome variables.

Pearson correlation coefficients were reported to assess the pair-wise linear associations between food intake, food selection, and plate waste in both treatment arms for both studies, for baseline outcomes, end of study outcomes, and outcome changes from baseline to end of study. All analyses were performed using Statistical Analysis Software 9.2 (SAS Institute, Cary, NC). Statistical significance was defined as $p < 0.05$.

Results

Description of the Study Participants

For a detailed description of the two study cohorts, the reader should refer to the original papers that describe the overall results of the two studies (Williamson, et al., 2012; Williamson, et al., 2007). Table 1 presents a description of the two cohorts. Several aspects of the two cohorts are noteworthy: 1) the Wise Mind cohort was slightly younger, less overweight, and came from a predominantly urban population and from private schools, 2) the LA Health cohort came from an exclusively rural population and from public schools, 3) the LA Health cohort was predominantly African-American and the Wise Mind cohort was predominantly white, and 4) the LA Health cohort had a slightly higher proportion of girls in comparison to the Wise Mind cohort.

Changes in Food Selection and Food Intake

Figure 1 depicts total kcal changes in food selection and food intake in the Wise Mind study (Figure 1A) and LA Health study (Figure 1B). Figure 2 depicts changes in food selection

and food intake for fat (kcal), saturated fat (kcal), carbohydrates (kcal), and protein (kcal). Both figures illustrate the findings from the Wise Mind and LA Health² studies so that the results can be easily compared across studies and so that changes in food selection and food intake can be compared.

Overall change in total kcal—Figure 1 describes the findings pertaining to mean changes in total energy (kcal) for food selection and food intake (averaged across three lunch periods). In the Wise Mind study (Figure 1A), total kcal of food selection ($M = -109 \pm 11.1$; $p = 0.028$) and food intake ($M = -56 \pm 11.5$; $p = 0.045$) for the CM arm decreased from baseline, but did not change over time for the C arm. For food selection and food intake, the arms differed; food selection ($F = 33.8$, $df = 1,2$, $p = 0.028$); food intake ($F = 20.9$, $df = 1,2$, $p = 0.045$). In the LA Health study (Figure 1B), the arms did not differ for food selection or intake, but lower total kcal relative to baseline was observed for the CM arm for food selection ($M = -137 \pm 23.4$; $p < 0.0001$) and intake ($M = -103 \pm 21.4$; $p = 0.0002$); whereas changes from baseline were only observed for the control arm for food selection ($M = -71 \pm 32.1$; $p = 0.043$).

Fat—Figures 2A and 2B illustrate findings for changes in food selection and intake pertaining to dietary fat (kcal). In the Wise Mind (Figure 2A) and LA Health (Figure 2B) studies, reduced food selection (Wise Mind: $M = -60 \pm 10.6$; $p = 0.030$; LA Health: $M = -78 \pm 10.4$; $p < 0.0001$) and intake (Wise Mind: $M = -41 \pm 5.0$; $p = 0.015$; LA Health: $M = -58 \pm 8.9$; $p < 0.0001$), relative to baseline, were observed for the CM arm, but no changes for the control arm were observed. In both studies, greater reductions in food intake were observed for the CM arm relative to C (Wise Mind: $p = 0.026$; LA Health: $p = 0.043$). Also, in the LA Health study, CM and C differed for changes in food selection ($p = 0.039$) and this difference approached significance in the Wise Mind study ($p = 0.079$).

Saturated fats—Changes in food selection and intake of saturated fats are described in Figures 2C and 2D. Relative to baseline, in both studies, reductions in food selection (Wise Mind: $M = -22 \pm 3.0$; $p = 0.018$; LA Health: $M = -24 \pm 3.6$; $p < 0.001$) and food intake (Wise Mind: $M = -16 \pm 1.4$; $p = 0.0074$; LA Health: $M = -18 \pm 3.2$; $p < 0.001$) were observed in the CM arm. In the control arm, a significant reduction in the selection of saturated fat was also observed in the LA Health study ($M = -11 \pm 4.9$; $p = 0.03$). Differences in reductions of saturated fats between CM and C were observed only for food intake ($p = 0.02$) in the Wise Mind study.

Carbohydrates—Changes pertaining to carbohydrates for the two studies are shown in Figures 2E and 2F. Relative to baseline, selection ($M = -56 \pm 15.4$; $p = 0.002$) and intake of carbohydrate by participants in the CM program ($M = -41 \pm 11.6$; $p < 0.003$) was reduced in the LA Health study, but not in the Wise Mind study. Treatment arm differences were not observed for food selection or intake in either study (all p values > 0.05).

Protein—Figures 2G and 2H describe changes in food selection and intake pertaining to protein. In the Wise Mind study, selection of protein was reduced from baseline ($M = -20 \pm 3.8$; $p = 0.03$) in the CM arm, but no other significant changes from baseline were observed for either study. Also, no differences between arms were observed for food selection or intake in either study (all p values > 0.05).

²For purposes of comparison of the two studies, we elected to present the treatment arm X time (M18 and M28) interaction effect for the LA Health study. The primary finding was a significant treatment arm X time effect for fat intake, which was previously reported by Williamson, et al. (2012) and illustrated in Figure 3 of that paper. The reader should note that with only one exception in the LA Health study, protein selection and intake, there was a significant time effect, showing that both treatment arms had reduced food selection/intake across time; i.e., baseline to M28.

Changes in HEI

Table 2 summarizes the changes HEI associated with food selections and food intake in the Wise Mind and LA Health studies. The Wise Mind study ended at Month 18 (M18), and the LA Health study included measurements at M18 and at the conclusion of the study, Month 28 (M28). Table 2 summarizes the findings for M18 in the Wise Mind study and M18 and M28 in the LA Health study. At M18, no differences were observed between treatment arms and no differences in change from baseline were observed for either study (all p values > 0.05). In the LA Health study, differences between treatment arms were observed at M28 and significant changes from baseline were observed for both treatment arms and for food selection and intake. For both food selection and intake, HEI scores increased (improved) for the CM arm and decreased (worsened) for the C arm.

Association of Covariates with Changes in Food Selection and Food Intake

In both studies, the following covariates were tested in all statistical analyses related to nutrient values and HEI values: 1) baseline food selection/intake of the child, 2) sex of the child, 3) age of the child, and 4) baseline BMI z score of the child. In the LA Health study, race of the child was also tested as a covariate³.

Baseline food selection/intake—In all analyses, across both studies, baseline food selections were negatively correlated with changes in food selection. Correlations of baseline food selections with changes in food selection ranged from -0.58 to -0.72 (p values < 0.0001). Correlations of baseline food intake with changes in food intake at M28 ranged from -0.51 to -0.72 (p values < 0.0001).

Sex—In the Wise Mind study, sex of the child was a significant covariate ($p < 0.05$) for food selections related to HEI ($r = 0.09$), and for HEI related to food intake ($r = 0.10$). In the LA Health study, sex was a significant covariate ($p < 0.05$) for food selections related to changes in saturated fats ($r = -0.05$) and for changes in intake of total kcal intake, fat, saturated fats, protein, and carbohydrates, but these relationships were weak (r values < -0.15). In all cases, changes in food selection or intake of girls were slightly higher than that of boys.

Age—In the Wise Mind study, age of the child was a significant covariate for food selection associated with total kcal ($r = 0.13$, $p < 0.0001$), carbohydrates ($r = 0.19$, $p < 0.0001$), and HEI ($r = -0.14$, $p < 0.002$) and food intake for all variables except protein and fat (r values ranged from 0.15 to -0.13 , p values < 0.05). In the LA Health study, age was a significant covariate for food selection of protein ($r = 0.09$, $p < 0.0001$) and HEI ($r = -0.11$). For food intake, age was correlated with changes in protein ($r = 0.08$, $p < 0.0001$), carbohydrates ($r = -0.04$, $p = 0.05$), and HEI ($r = -0.13$, $p < 0.0001$) HEI. The relationship between age and changes in outcomes was variable, with increased age associated with both beneficial and unhealthy changes. All relationships were relatively weak ($< \pm 0.20$).

Baseline BMI z scores—In both studies, baseline BMI z scores were not significant covariates related to changes in food selection or changes in food intake related to HEI. In both studies, baseline BMI z scores were correlated with changes in fat and protein intake and in Wise Mind, baseline BMI z scores were correlated with changes in total kcal intake and carbohydrate intake (r values range from 0.08 to 0.18). Also, In LA Health, baseline BMI z scores were correlated with changes in saturated fat intake ($r = 0.10$, $p = 0.0007$).

³As noted earlier, in the Wise Mind study, 95% of the study cohort was white. Therefore, we did not attempt to statistically control for race in this study due to the very small number of non-white children.

Race—Race of the child was only tested in the LA Health study. Race was a significant covariate in analyses of fat selection ($r = 0.05$) and saturated fat selection ($r = 0.05$, p values < 0.01). In both cases, white children slightly lowered selections of fat and saturated fat in comparison to African-American children. For food intake, race was negatively correlated with carbohydrate intake ($r = -0.08$, $p < 0.0001$), indicating that African-American children slightly lowered intake of carbohydrates in comparison to white children.

Correlations between Food Intake and Food Selection and Plate Waste

Correlations between food intake and food selection and between food intake and plate waste were consistent across both studies and both treatment arms for total kcal and all four macronutrients, and at baseline, end of study (EOS), and changes from baseline to EOS. Every correlation was statistically significant ($p < 0.001$).

CM arm—In both studies, correlations of food intake and food selection were positive and moderate to large in magnitude (r values ranged from 0.53 and 0.81). The magnitudes of correlations between food intake and plate waste were somewhat smaller (r values ranged from -0.23 and -0.69) and were negative.

C arm—A similar pattern of correlations was found for the control arm. The correlations between food intake and food selection were positive, with r values ranging from 0.55 to 0.81. The correlations between food intake and plate waste were negative with r values ranging from -0.22 to -0.64 .

Discussion

The findings from both the Wise Mind and LA Health studies support the hypothesis that modification of the school cafeteria environment, including changes to foods that were served or made available to children, were associated with significant changes in food/nutrient intake and/or health eating. These findings support the recent decision to modify nutrition standards for the National School Lunch and Breakfast Program (U.S. Department of Agriculture, 2012) and support the recommendations made by many organizations and institutions (Bergman, 2010; Davis, et al., 2007; Institute of Medicine, 2010; Pratt, et al., 2008). The findings replicate the results from earlier studies that changes in nutrition standards in schools can be achieved (Bartholomew & Jowers, 2006; Bullock, Craypo, Clark, Barry, & Samuels, 2010; Cunningham-Sabo, et al., 2003; Hartstein et al., 2008; Osganian, et al., 1996) and that the dietary intake of children can be made more healthy by pursuing such changes (Burgess-Champoux, et al., 2008; Kropski, Keckley, & Jensen, 2008; Siega-Riz, et al., 2011).

Results related to changes in HEI were noteworthy; neither study found significant changes in healthy eating at M18, but the LA Health study observed significant improvement of HEI in the CM arm at M28, while observing significant worsening of HEI in the control arm. Comparison of the findings of the two studies (in Figures 1 and 2) on changes in nutrient values shows that the most consistent finding across studies was reduction of fat intake in both studies. In the Wise Mind study we found differences in food intake between treatment arms for total kcal, fat intake, and saturated fat intake; whereas in the LA Health study, we found treatment arm differences for fat intake only at M28. One explanation of these findings is that modification of school cafeterias in relatively low socio-economic public schools (LA Health), in comparison to private schools (Wise Mind) may be more difficult to achieve. This possibility has considerable implications for health policies related to the School Lunch Program and deserves more study.

These analyses included a number of covariates, which controlled for associations of participant characteristics with changes in food selection, food intake, and healthy eating. Baseline food selection/intake was the most consistent characteristic that correlated with changes in food selection, food intake, and HEI. In every analysis, greater amounts of food consumed at baseline were negatively correlated with changes in food intake; i.e., greater available foods or foods consumed at baseline was associated with greater reductions in these nutrient variables at the end of the studies. The association of other covariates (sex, age, race, baseline BMI) with nutrient or HEI outcomes was much weaker and much less consistent.

One of the strengths of this pair of studies is that similar approaches were used to modify the school cafeteria environments, to measure changes in the foods made available to the students, and to measure changes in food intake and healthy eating. These design features provided an opportunity for an initial exploratory analysis and replication in an independent study. The Wise Mind and LA Health studies are the first to use the digital photography method to assess changes in food selection and food intake (Williamson, et al., 2003). Using this method, we were able to estimate the magnitude of changes in total kcal and four macronutrients that occurred as a function of the CM program. Most impressive were changes in total kcal intake (~ 100 kcal/lunch), fat intake (~ 60 kcal/lunch), and saturated fats (~ 20 kcal/lunch). Somewhat similar results were observed across two studies with students with different demographic characteristics but it will be necessary to replicate the results in different geographic locations and with children of different ages.

Another contribution of this pair of studies was the discovery that the relationship between food selection and food intake was very strong and positive, i.e., as the availability of different foods and amounts of food was modified, food intake was modified accordingly. This set of findings was very robust and consistent across studies, treatment arms, type of food, and time of measurement. The strong positive correlations between food selections and food intake illustrate the potential importance of modifying the school cafeteria environment as one means of improving the nutrition of children while at school, as recommended by the recent policy change by USDA (U.S. Department of Agriculture, 2012). This pattern of correlations also confirms some of the implicit assumptions of the digital photography method (Williamson, et al, 2003): 1) food selections and plate waste vary across individuals, 2) both food selections (positively) and plate waste (negatively) are correlated with food intake, 3) food intake can be conceptualized as a product of both food selection and plate waste, and 4) these relationships are very robust.

The findings of the study should be interpreted in the context of several limitations. We were unable to test the hypothesis that the plate waste of children reflected returning (uneaten) larger portions of healthy foods. This limitation was determined by the fact that HEI cannot be validly derived in small portions of food. In these two studies, plate waste < 250 kcal⁴ was observed frequently (83.5% of measurements in Wise Mind and 66.5% of measurements in LA Health). The findings of this study are strictly limited to changes in nutrition and food intake in the school cafeteria environment and should not be generalized to the non-school environment. The reader should note that in the Wise Mind study, we did not find differences between treatment arms for any nutrient variable related to plate waste (Williamson, et al, 2007). We did not gather socio-economic status data in the Wise Mind study, which limits our conclusions about the possible influence of this variable on the outcomes of the two studies. Also, it is impossible to assess the potential impact of demand

⁴There is no established cut-off for insufficient food to derive the HEI. In preliminary tests, our team established 250 kcal to be the lowest calorie limit to allow the derivation of meaningful HEI scores. This cut-off should be established by further research, however, before widespread use.

characteristics on the eating behavior of participants, but the studies did include control groups that underwent identical measurement procedures. Also, it is impossible to objectively evaluate the impact of foods that were traded among students or the impact of foods brought to school, but the research team believes that these factors were minimized by the procedures used in the studies (Williamson, et al, 2012). Finally, the reader should note that the use of cluster randomized controlled research designs (as used in both studies) has the effect of diminishing statistical power, i.e., the ability to detect differences across treatment arms, in comparison to traditional randomized controlled trials (Williamson, et al, 2012).

In summary, the findings concerning the CM program that was tested in the Wise Mind (Williamson, et al., 2007) and LA Health (Williamson, et al., 2008; Williamson, et al., 2012) studies provide support for one of the primary assumptions for changing policies related to school nutrition (U.S. Department of Agriculture, 2012): modification of food service practices is feasible and can improve healthy eating and the quality of nutritional intake of children in school cafeterias.

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Figure 1.

Changes in food selection and food intake for overall change (total kcal) from baseline to end of study in the Wise Mind (n = 604) and LA Health (n = 2015) studies. □ is for control arm and ■ is for CM arm. Brackets indicate *p* values for differences between the two arms (CM and C) for Wise Mind (WM) and the interaction for arms by time for LA Health (LAH); * indicates *p* < 0.05; *** indicates *p* < .0001 for within-group changes from baseline to end of study.

Figure 2.

Changes in food selection and food intake for macronutrients from baseline to end of study in the Wise Mind ($n = 604$) and LA Health ($n = 2015$) studies. □ is for control arm and ■ is for CM arm. Brackets indicate p values for differences between the two arms (CM and C) for Wise Mind (WM) and the interaction for arms by time for LA Health (LAH); * indicates $p < 0.05$; ** indicates $p < 0.01$; *** indicates $p < .0001$ for within-group changes from baseline to end of study.

Table 1

Baseline characteristics of the participants in the Wise Mind and LA Health studies

	Wise Mind	LA Health
N	660	2060
Sex (%female)	49.6	58.5
Race (%white)	94.9	31.6
	Mean(SD)	Mean(SD)
Age (years)	9.2(4.1)	10.5 (1.2)
BMI-for-age percentile	59.8(30.3)	69.7 (29.5)
Height (cm)	137.2(10.8)	146.5(9.7)
Weight (kg)	35.7(12.2)	46.8(16.4)

Table 2

Changes in HEI scores over time as a function of prevention arms

Study	Treatment	Adjusted Changes: M18	Adjusted Changes: M28	F
Wise Mind	CM	2.4 ± 2.6		.4990
	C	-.6 ± 2.6		
	CM	3.3 ± 1.8		.4002
	C	.7 ± 1.7		
LA Health	CM	1.0 ± 1.7	5.3 ± 1.7**	8.26*
	C	-.02 ± 2.3	-5.6 ± 2.3*	
	CM	1.2 ± 1.6	3.9 ± 1.7*	7.89*
	C	-.4 ± 2.3	-6.2 ± 2.3*	

Note: CM = cafeteria modification arm, C = Control arm.

Adjusted Changes represent changes from baseline.

* indicates a significant change from baseline at follow-up ($p < 0.05$);** indicates a significant change from baseline at follow-up ($p < 0.01$).

F value is associated with treatment arm effect for the Wise Mind study at month 18 and associated with group by time interaction for the LA Health study.

Statistically significant effects ($p < 0.05$) are indicated by *.