Published in final edited form as:

Nutr Res. 2012 September ; 32(9): 659–668. doi:10.1016/j.nutres.2012.07.001.

Secondary analyses of data from four studies with fourth-grade children show that sex, race, amounts eaten of standardized portions, and energy content given in trades explain the positive relationship between BMI and energy intake at school-provided meals

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Abstract

Results from a 2012 article showed a positive relationship between children's body mass index (BMI) and energy intake at school-provided meals. To help explain that positive relationship, secondary analyses investigated 1) whether the relationship differed by sex and race, and 2) the relationship between BMI and six aspects of school-provided meals—amounts eaten of standardized portions, energy content given in trades, energy intake received in trades, energy intake from flavored milk, energy intake from a la carte ice cream, and breakfast type. Data were from four studies conducted one per school year (1999–2000 to 2002–2003). Fourth-grade children (n=328; 50% female; 54% Black) from 13 schools total were observed eating school-provided breakfast and lunch on one to three days per child for 1,178 total meals (50% breakfast). Children were weighed and measured. Marginal regression models were fit using BMI as the dependent variable. For Purpose One, independent variables were energy intake at school-provided meals, sex, race, age, and study; additional models included interaction terms involving energy intake and sex/race. For Purpose Two, independent variables were the six aspects of school-provided meals, sex, race, age, and study. The relationship between BMI and energy intake at school-provided meals differed by sex ($p<0.0001$; stronger for females) and race ($p=0.0063$; stronger for Black children). BMI was positively related to amounts eaten of standardized portions ($p<0.0001$) and negatively related to energy content given in trades ($p=0.0052$). Explaining the

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AEP-A, JAR, CHG, and CJF have no conflicts of interests to disclose.

The authors appreciate the cooperation of children, faculty, staff of elementary schools, and staff of Student Nutrition Services of the Richmond County School District (Augusta, Georgia, USA).

The authors appreciate comments provided by David B. Hitchcock, PhD (Department of Statistics, University of South Carolina) concerning this manuscript.

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positive relationship between BMI and energy intake at school-provided meals may contribute to school-based obesity prevention efforts.

Keywords

Body Mass Index; Children; Energy Intake; Nutrition Surveys; Primary Schools

1. Introduction

As childhood obesity rates remain high at nearly 17% [1], the school environment and school meal programs are common targets for preventing childhood obesity [2–4]. The recent reauthorization of Child Nutrition Programs in the *Healthy, Hunger-Free Kids Act of 2010* [5] requires science-based nutrition standards for all foods sold in schools that are consistent with the most recent Dietary Guidelines for Americans. In their 2010 report *Solving the Problem of Childhood Obesity within a Generation*, the White House Task Force on Childhood Obesity identified the provision of healthy food in schools as one of four priority areas [6]. As an important source of nutrition for children [4], and with the current focus on obesity prevention and related policies, understanding the impact that school meals have on childhood obesity is critical.

Research related to school meals and childhood obesity has primarily focused on participation in programs that provide meals at schools (rather than on actual intake at school meals). However, studies that have assessed the relationship between school-meal participation and body mass index (BMI) have provided conflicting results. For example, studies that assessed school-meal participation based on children's and/or parental reports have found a positive relationship between school-lunch participation and BMI [7], no relationship between school-lunch participation and overweight status [8], and a negative relationship between school-breakfast participation and BMI [9]. Studies that assessed school-meal participation using daily electronic administrative records or nametag records showed no relationship between school-meal participation and BMI [10,11].

Results published in 2010 [10] and 2012 [11] from studies with fourth-grade children showed that children's energy intake at school-provided meals, rather than participation in them, was related to obesity. For both publications, energy intake at school-provided breakfast and lunch was assessed from direct meal observations conducted in public elementary schools. For the 2010 publication [10], Baxter and colleagues analyzed data on children (95% Black) collected from a dietary-reporting validation study conducted in a district in Columbia, South Carolina that had implemented offer-versus-serve foodservice. (When a district implements offer-versus-serve foodservice, children may decline one or two food items offered at breakfast or lunch, respectively, which may impact energy intake at school meals.) For the 2012 publication [11], Paxton and colleagues analyzed data on children (54% Black) from four cross-sectional dietary-reporting validation studies conducted in a district in Augusta, Georgia that had not implemented offer-versus-serve foodservice. Results from both publications showed that although children's BMI was not significantly related to school-meal participation, energy intake at school meals was significantly and positively related to BMI.

Given these findings, it is plausible that specific aspects of school-provided meals—such as amounts eaten of standardized portions, flavored milk, food trading (giving and/or receiving foods), and a la carte foods—could influence children's energy intake at school meals and children's BMI. However, to the authors' knowledge, only two publications have investigated the relationship between children's BMI and specific aspects of school-

provided meals. Results from the Third School Nutrition Dietary Assessment Study showed that offering elementary school children french fries or dessert more than once per week at school lunch was associated with higher BMI [12]. To explain the positive relationship between BMI and energy intake at school-provided meals found in the 2010 publication (mentioned in the previous paragraph), secondary analyses by Guinn and colleagues [13] showed that BMI was (a) positively related to amounts eaten of standardized portions, (b) positively related to energy intake from flavored milk, and (c) negatively related to energy intake received in food trades. However, BMI was not significantly related to the energy content of items selected, the number of meal components selected, the number of meal components eaten, or the percentage of energy content given in food trades [13].

In addition, results from national surveys and other studies [14–20] using dietary recalls or food frequency questionnaires have found differences by sex and/or race in children's mean daily intake of energy and nutrients and/or in the percentage of children who met nutrition recommendations. However, as most studies have relied on reported intake (which was based on memory and thus prone to reporting errors), it is unclear whether there are differences by sex and/or race in children's actual intake. Investigating differences in children's intake by sex and race using an objective (rather than self-reported or parental-reported) measure of energy intake may enhance understanding of sex and race health disparities.

For this article, secondary analyses were conducted using data from four cross-sectional studies to help explain the positive relationship between fourth-grade children's BMI and energy intake at school meals that was found by Paxton and colleagues and published in 2012 [11]. The two purposes of this article address two fundamentally different questions. Purpose One was to investigate whether the relationship between BMI and daily energy intake at school-provided meals differed by sex and by race. Purpose Two was to investigate the relationship between BMI and six aspects of school-provided meals: (a) amounts eaten of standardized school-meal portions, (b) energy content given in food trades, (c) energy intake received in food trades, (d) energy intake from flavored milk, (e) energy intake from a la carte ice cream, and (f) breakfast type (cold versus hot). As data analyzed were from four dietary-reporting validation studies conducted in Augusta, Georgia, this article's sample was not a true mathematical random sample of fourth-grade children in the United States. However, as the four studies included direct meal observations (which are expensive and time consuming to conduct), their data allowed cost-effective albeit preliminary investigations of the two purposes using a sample of children with approximately equal numbers by race (Black, White) in a district that had not implemented offer-versus-serve foodservice.

2. Method and materials

2.1 Sample

The institutional review boards for research involving humans at the Medical College of Georgia and University of South Carolina approved this project. Data were from four cross-sectional studies conducted during four consecutive school years with fourth-grade children from six to 11 public elementary schools per school year (13 schools total) from one district in Augusta, Georgia. Written parental consent and child assent were obtained. Data collection methods for each study are summarized in this article and described in detail elsewhere [21–24].

Table 1 provides information on each of the four studies. Schools were selected from among 33 in the district that had high daily participation in school breakfast and lunch (irrespective of whether meals were free, reduced price, or full price), so that for each study, data could

be collected on a stratified random sample of fourth-grade children with approximately equal numbers of children by sex and race (Black, White). As those schools selected had very few children of other races, analyses for this article excluded children of other races. If children were in more than one of the four studies (i.e., children who repeated fourth grade), data from the “first” fourth-grade school year only were included. During each study’s school year of data collection, a mean of 59% to 70% of the children across all grades at the schools were eligible to receive free or reduced-price school meals [21–24]. Nationally, from 1999–2003, an average of 57% of lunches and 84% of breakfasts served were free or reduced price [25,26]. Of the children who agreed to participate in a study, a subset of children was randomly selected (to fill cells stratified by sex and race) and observed eating school breakfast and school lunch.

The district provided meals that complied with standards for the School Breakfast Program and the National School Lunch Program [27]; for example, school breakfast and school lunch provided one-fourth and one-third, respectively, of the recommended daily allowance for energy for children. Meal composition was the same whether children paid full price or received meals for free or at a reduced price. Unlike the 2010 publication by Baxter and colleagues [10] and the recent publication by Guinn and colleagues [13], this district had not implemented offer-versus-serve foodservice, so children could not refuse meal components [27]. In other words, for lunch, each child’s meal included an entrée (from two choices), milk, two servings of vegetable or fruit, and bread/grain. For school breakfast each day, children chose either a cold breakfast (i.e., ready-to-eat cereal, graham or animal crackers, milk, and juice or fruit) or a hot breakfast (e.g., sausage biscuit, milk, and juice). Each child decided how much he or she consumed of the standardized portion of each food on his or her meal tray at breakfast and at lunch each day.

2.2 Weight/height measurements and age

Using standardized procedures [28,29], research dietitians measured children’s weight and height (without shoes) at school on days when no meal observations were conducted. Digital scales and portable stadiometers were used to obtain measurements after lunch in March for the first three studies and after breakfast but before lunch in November for the fourth study. Inter-measurer reliability was assessed daily for pairs of research dietitians on a random sample of 10% of children. For each study, intraclass correlation reliability was >0.99 for weight and for height [30]. The age of each child at the time of measurement was calculated by subtracting the date of birth (obtained from school records) from the date of measurement. Because BMI is the recommended measurement to use to identify youth who are obese [31], BMI (kg/m^2) was calculated for each child. For descriptive purposes, BMI percentile was used to categorize children as *underweight* (<5th percentile), *healthy weight* (5th to <85th percentiles), *overweight* (85th to <95th percentiles), *obese* (95th to <99th percentiles), and *severely obese* (99th percentile) [31,32].

2.3 Direct Observations of School Meals

Research dietitians completed direct meal observations for 328 children with one to three breakfasts per child and one to three lunches per child (with both meals on the same day for an individual child and on multiple days for some children according to the study’s design), for a total of 1,178 school meals (50% breakfast). Research dietitians followed written protocols to observe one to three children simultaneously during regular meal periods and for entire meal periods (to account for food trading) with children seated according to their school’s typical arrangement. On days when observations were conducted, children wore nametags (created by researchers) that were distributed immediately before meals to all children in the study and in classes scheduled for observation; nametags were collected immediately after meals. Before data collection for each study, research dietitians conducted

practice observations to decrease reactivity. Training of observers included review of the written protocol, modeling, and pre-data collection of interobserver reliability [21–24]. Interobserver reliability was assessed between pairs of observers throughout data collection each week for three of the studies and bimonthly for one study with results that exceeded 89% [21–24].

Items and amounts eaten in servings of standardized school-meal portions were recorded using paper forms. Food trades for an individual child were defined as food(s) given away and/or received. For any food trades given or received, observers recorded the amount in servings of standardized school-meal portions. The milk flavor selected by children was recorded by observers as white (i.e., plain), chocolate, or strawberry. Ice cream purchased a la carte at lunch by children was recorded by observers.

2.4 Definitions for Six Aspects of School Meals

2.4.1 Amounts eaten of standardized portions—Amounts observed eaten were recorded using the following qualitative labels: none, taste, little bit, half, most, and all. Amounts were then quantified in servings of standardized school-meal portions as none=0.0, taste=0.1, little bit=0.25, half=0.5, most=0.75, all=1.0, or as the number of servings if more than one was eaten. Energy information (in kilocalories [kcal]) for standardized school-meal portions was obtained from the Nutrition Data System for Research database (Nutrition Coordinating Center, University of Minnesota, Minneapolis) or from the district's nutrition program. Quantified, observed amounts were multiplied by per-serving energy values of standardized school-meal portions. For each observed meal for a child, the values for daily energy intake were summed across items eaten. For each child, energy intakes for breakfast and lunch on the same day were summed.

2.4.2 Energy content given in food trades—The percentage of energy content given in food trades for a child on a particular school day was calculated as the number of kcals from items given away in food trades divided by the number of kcals from items on the school-meal trays, multiplied by 100.

2.4.3 Energy intake received in food trades—The percentage of energy intake received in food trades for a child on a particular school day was calculated as the number of kcals from items received in food trades divided by the number of kcals eaten at the school meals, multiplied by 100.

2.4.4 Energy intake from flavored milk—At most meals, children were allowed to select milk flavor. Flavored milk was defined as any milk that was not white. White, chocolate, and strawberry milk flavors contained 102, 146, and 160 kcals per 8-ounce carton, respectively. The percentage of energy intake from flavored milk for a child on a particular school day was calculated as the number of kcals from flavored milk divided by the number of kcals eaten at the school meals, multiplied by 100.

2.4.5 Energy intake from a la carte ice cream—The kcal content per serving of a la carte ice cream ranged from 60 to 280 kcals. The percentage of energy intake from a la carte ice cream for a child on a particular school day was calculated as the number of kcals from a la carte ice cream divided by the number of kcals eaten at the school meals, multiplied by 100.

2.4.6 Breakfast type—Items recorded by observers at breakfast were used to categorize breakfast type as cold or hot. Ready-to-eat cereal must have been observed eaten for breakfast type to be categorized as cold. Likewise, ready-to-eat cereal could not have been

observed eaten for breakfast type to be categorized as hot. A cold breakfast contained 370 kcals on average, while a hot breakfast contained 450 kcals on average.

2.5 Statistical Analyses

To account for the dependence of data collected within school and for multiple meal observation days per child, generalized estimating equation methodology was used to fit marginal regression models for both purposes. A modified sandwich variance estimator (computed under an independent working correlation assumption) was used to calculate standard errors. This is the most common modeling approach when analyzing correlated data [33]. For all analyses, BMI was used as the dependent variable, instead of BMI percentile, because sex and age were included as independent variables. Although analyses for Paxton and colleagues' 2012 article [11] included 342 children and 1,264 total school meals, as this article's analyses investigated breakfast type as one of the six aspects of school-provided meals, it included 328 children and 1,178 total school meals because children and their corresponding meals were excluded when the observed breakfast could not be categorized as cold or hot. Thus, for this article, 14 children total, and 43 breakfasts and 43 lunches from those children on the same days, were excluded from analyses because breakfast observations indicated intake of items from both cold and hot breakfasts ($n=15$), beverage only ($n=22$), nothing ($n=4$), or fruit only ($n=2$). Statistical analyses were performed using SAS/STAT® software (Version 9.2, Copyright © 2002–2008, SAS Institute Inc., Cary, NC).

For Purpose One, three models were fit with BMI as the dependent variable. For Model 1, independent variables included daily energy intake at school-provided meals (in units of 100 kcal for ease of interpretation), sex, race (Black, White), age (in months), and study (which was the same as school year). To determine whether the relationship between BMI and daily energy intake at school-provided meals differed by sex, Model 2 included the same independent variables as Model 1 and an interaction term for energy intake and sex. Likewise, to determine whether the relationship between BMI and daily energy intake at school-provided meals differed by race, Model 3 included the same independent variables as Model 1 and an interaction term for energy intake and race.

For Purpose Two, to investigate the relationship between BMI and six aspects of school meals, one marginal regression model was fit with BMI as the dependent variable. Independent variables included the six aspects of school-provided meals—amounts eaten of standardized school-meal portions, energy content given in food trades, energy intake received in food trades, energy intake from flavored milk, energy intake from a la carte ice cream, breakfast type—and sex, race, age, and study.

3. Results

3.1 Descriptives

Of the 328 children, 50% were female, 54% were Black, and the mean age (standard deviation) was 10.22 (0.57) years. The average BMI was 20.2 (4.3) kg/m², less than 1% were underweight, 57.9% were healthy weight, 19.2% were overweight, 18.9% were obese, and 4.0% were severely obese. For the 1,178 total school meals observed, 132 children had one breakfast and one lunch (with both meals on one day per child), 131 children had two breakfasts and two lunches (with both meals on two days per child), and 65 children had three breakfasts and three lunches (with both meals on three days per child). Table 1 shows the number of school meals observed per study that were included in this article's analyses.

For the 328 children observed for a total of 1,178 school meals, the number of food trades given was 116 at breakfast and 391 at lunch; the average (standard error) energy content

given in food trades was 88 (4.1) at breakfast and 91 (3.7) at lunch. The number of food trades received was 133 at breakfast and 451 at lunch; the average energy intake received in food trades was 131 (8.3) at breakfast and 144 (6.8) at lunch. The number of milks selected by flavor at breakfast and lunch, respectively, was 334 and 109 for white, 202 and 426 for chocolate, and 50 and 122 for strawberry. The number of a la carte ice creams at lunch was 153. The number of breakfasts by category was 208 cold and 381 hot. Table 2 provides means and standard deviations for daily energy intake by sex and race and for each of the six aspects, grouped by BMI quartile (for ease of presentation).

3.2 Purpose One

Table 3 provides a summary of the regression output for each of the three models for Purpose One. For Model 1, daily energy intake at school-provided meals was positively related to BMI ($p<0.0001$); the average BMI increased 0.52 kg/m^2 for each 100-kcal increase in intake at school meals. Sex was significantly related to BMI ($p=0.0040$); the average BMI was 1.36 kg/m^2 greater for females than males. Race was also significantly related to BMI ($p=0.0002$); the average BMI for Black children was estimated to be 1.62 kg/m^2 greater when compared to White children. Age and study were not significantly related to BMI at the $\alpha=0.05$ level (the significance level used throughout this article unless noted). Daily energy intake at school-provided meals, sex, and race remained significant in Model 1 when a Bonferroni-adjusted significance level ($0.05/5=0.01$) was used.

Models 2 and 3 allowed for direct investigation of whether the relationship between BMI and daily energy intake at school-provided meals differed by sex and race, respectively, by adding the appropriate interaction term to Model 1. The results in Table 3 show that this relationship differed by sex ($p<0.0001$) and by race ($p=0.0063$); additionally, both interaction estimates remained statistically significant when a Bonferroni adjustment ($0.05/6=0.0083$) was used in each model. The positive interaction estimate from Model 2 (0.57 kg/m^2) suggests that the (linear) relationship between BMI and energy intake at school-provided meals was stronger for female children; Table 2 shows that means for daily energy intake at school-provided meals increased by BMI quartile for females more so than for males. The positive interaction estimate from Model 3 (0.42 kg/m^2) suggests that the relationship between BMI and daily energy intake at school-provided meals was stronger for Black children; Table 2 shows that means for daily energy intake at school-provided meals increased by BMI quartile for Black children more so than for White children.

3.3 Purpose Two

Table 4 provides a summary of the regression output for Purpose Two. Among the six aspects of school-provided meals, two were significantly related to BMI. Amounts eaten of standardized school-meal portions was positively related to BMI ($p<0.0001$); BMI increased 2.98 kg/m^2 on average per 100-kcal increase. Energy content given in food trades given was negatively related to BMI ($p=0.0052$); BMI decreased 1.04 kg/m^2 on average for every 100 kcal given. When a conservative Bonferroni adjustment ($0.05/10=0.005$) was used, the amount eaten estimate remained significant, and the estimate for energy given in food trades remained borderline significant. The four remaining aspects of school-provided meals (energy intake received in food trades, energy intake from flavored milk, energy intake from a la carte ice cream, and breakfast type) were not statistically significant (four p values >0.1365) after accounting for all other variables studied. Conclusions for sex, race, age, and study were similar to those in Model 1 for Purpose One.

To further investigate the effects of the six aspects of school-provided meals, Table 4 also includes Pearson correlations for five of these aspects; excluded is breakfast type because it is binary (hot, cold). One notes that most of these estimates are only low to moderate, with

the exception of the positive correlation between amounts eaten of standardized school-meal portions and energy intake received in food trades ($r=0.42$). This suggests that energy intake received in food trades, while not statistically significant after accounting for the effects of all other variables studied in the regression analysis ($p=0.1366$), may still be related to BMI because of its association with amounts eaten of standardized school-meal portions. This assertion is made very cautiously because none of the other variables are accounted for in the $r=0.42$ estimate (also ignored is the within-school and within-child dependence). This notwithstanding, the size of this estimate shows that it might be unwise to completely ignore the interdependencies that may exist among the specific aspects of school-provided meals when interpreting the regression results.

4. Discussion

This article's analyses were conducted to address two different questions to help explain the positive relationship between fourth-grade children's BMI and energy intake at school-provided meals found by Paxton and colleagues and published in a 2012 article [11] using data from four cross-sectional studies with a sample of children with almost equal numbers by race (Black, White) in a district in Augusta, Georgia that had not implemented offer-versus-serve foodservice. Results from Purpose One showed that the positive relationship between BMI and daily energy intake at school-provided meals, as assessed by direct meal observations, was stronger for females and for Black children. These findings help fill gaps in knowledge, as most studies of children's intake have relied on subjective measures (self-reported or parental-reported) rather than on an objective measure (direct meal observations).

Results from Purpose Two showed that BMI was positively related to two of six aspects of school-provided meals. First, BMI was positively related to amounts eaten of standardized school-meal portions. This result is intuitive and was also found by Guinn and colleagues [13] with data from a study with a sample of predominantly Black children in a district in Columbia, South Carolina that had implemented offer-versus-serve foodservice (as mentioned in the Introduction). Second, BMI was negatively related to energy content given in food trades. Although this result is also intuitive, the relationship between BMI and energy intake received in food trades was not significant after accounting for all other independent variables. Guinn and colleagues [13] found that BMI was negatively related to the percentage of energy intake received in food trades at school meals even after accounting for the other aspects studied in that article.

Results from Purpose Two failed to show a significant relationship between BMI and energy intake from flavored milk or from a la carte ice cream. Guinn and colleagues [13] found that BMI was positively related to energy intake from flavored milk. Although flavored milk in schools has become a controversial issue due to the added sugar when compared to plain milk, results from this article's analyses contribute to the body of evidence indicating that consumption of flavored milk, dietary calcium, and/or dairy foods may not be related to obesity [34–38]. To the authors' knowledge, this is the first investigation of the relationship between BMI and intake of a la carte ice cream at school meals.

Results from Purpose Two also failed to show a significant relationship between BMI and breakfast type. This was surprising as results from previous studies have shown that eating breakfast, particularly if ready-to-eat cereal was included, was associated with intake of fewer kcals [39–41]. However, these studies concerning ready-to-eat cereal relied on reported intake, which is prone to error. In fact, when direct school meal observations and children's dietary recalls from five studies were analyzed (including three of the four studies analyzed for the current article) to examine intrusions (items reported eaten but not observed

eaten) in breakfast reports, Baxter and colleagues [42] found that children who ate a cold breakfast almost never misreported a hot breakfast, but children who ate a hot breakfast often misreported a cold breakfast (i.e., ready-to-eat cereal); BMI percentile was not a significant covariate in analyses for that article [42]. To the authors' knowledge, the current article is the first investigation of the relationship between BMI and type (hot, cold) of school breakfast.

There are limitations to the current analyses. First, the four studies that provided the data were not designed to specifically address the two purposes, as noted in the Introduction. Second, weight/height measurements were available for only one time point per child rather than at the beginning and ending of the fourth-grade school year. Third, generalizability may be limited because the sample included only fourth-grade children from one district. Children in the final sample (one study per school year) do not constitute a simple random sample from the population of 33 schools. Instead, each study's design was primarily concerned with maintaining an equal representation of children by sex (50% female) and by race (54% Black; 46% White); these percentages are fairly consistent with the 2000 census data on sex and race in Augusta, Georgia [43]. Fourth, estimates of energy intake were based on standardized school-meal portions, which may be imprecise; however, the same process was used consistently for each observed child for each observed school meal. Fifth, direct meal observations only captured food trades for children being observed and not for child(ren) who gave food items to, or received food items from, children being observed.

The current analyses have several strengths. Energy intake at school meals was collected from direct meal observations, which avoided parental reports or children's self reports. Rigorous and consistent quality control procedures were implemented in all four studies for school-meal observations and for weight/height measurements.

Because many obesity prevention policies and interventions focus on school, it is important to understand the relationship between school-provided meals and childhood obesity. Results from these secondary analyses indicate that the positive relationship between BMI and daily energy intake at school-provided meals differed significantly by sex and by race, and that BMI was positively related to the amounts of standardized school-meal portions and negatively related to the energy content of foods given in food trades. These findings may help to inform school-based obesity prevention interventions and better tailor efforts towards improving children's intake at school-provided meals. For example, large and extra-large portions have been implicated as environmental contributions to the obesity epidemic [44], and research shows that children consume more when served large portions than when served age-appropriate portions [45,46]. Although regulations stipulate that school-provided meals provide age-appropriate portions to children [27], this article's analyses found a significant positive relationship between children's BMI and the amounts eaten of standardized school-meal portions. To support recommendations of the White House Task Force on Childhood Obesity, perhaps school-based nutrition education for school staff, children, and parents could emphasize aspects of conscious, mindful eating [47].

Acknowledgments

This research was supported by competitive grants R21HL096035 and R01HL063189 from the National Heart, Lung, and Blood Institute of the National Institutes of Health. The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute or the National Institutes of Health.

SDB's current and previous research has been funded externally by competitive grants from the National Institutes of Health as well as the United States Department of Agriculture. SDB has served as a grant reviewer for the National Institutes of Health and the Centers for Disease Control and Prevention. SDB is on the Board of Editors for the Journal of the Academy of Nutrition and Dietetics. JMT's current and previous research has been funded

externally by competitive grants from the National Institutes of Health. JMT has served as a grant reviewer for the National Science Foundation.

ABBREVIATIONS

BMI	body mass index
kcal	kilocalories

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Table 1
Information on four cross-sectional studies with fourth-grade children from Augusta, Georgia.

Study	School year	Number of schools	School codes ^a	Number of children invited to participate	Number (percent) of children invited to participate who provided parental consent and child assent	Number of randomly-selected children observed eating school-provided meals and included in analyses for current article ^b	Total number of school meals observed that were included in analyses for current article ^c
A [22]	1999–2000	6	a,b,c,d,e,f	523	382 (73%)	98	502
B [24]	2000–2001	11	a,b,c,d,e,g,h,i,j,k,l	915	669 (73%)	120	456
C [23]	2001–2002	10	a,b,c,d,e,g,h,i,j,k	799	451 (56%)	61	122
D [21]	2002–2003	6	b,e,f,g,k,m	443	312 (70%)	49	98

^aThere were 13 schools total in the four studies; the codes indicate which schools were in which study (or studies).

^bFor each study, schools were selected to obtain a final sample of fourth-grade children with approximately equal numbers of children by sex and race (Black, White).

^cAnalyses included only children observed eating breakfast that could be categorized as cold (i.e., ready-to-eat cereal, graham or animal crackers, milk, and juice or fruit) or hot (e.g., sausage biscuit, milk, and juice).

Table 2

Means (standard deviations) for daily energy intake at school-provided meals by sex and race, and for each of six aspects of school-provided meals, by body mass index (BMI) quartile^a, in a sample of 328 fourth-grade children observed eating a total of 1,178 school-provided meals (50% breakfast).

	BMI Quartile			
	First	Second	Third	Fourth
Number of fourth-grade children	82	82	82	82
Daily energy intake at school-provided meals (in kcal)				
Females (n=166)	767 (213)	737 (254)	828 (244)	927 (214)
Males (n=162)	859 (226)	903 (242)	929 (297)	939 (257)
Black children (n=176)	807 (245)	780 (243)	878 (303)	952 (254)
White children (n=152)	821 (212)	882 (270)	873 (240)	895 (187)
Amounts eaten of standardized school-meal portions ^b	0.88 (0.19)	0.89 (0.20)	0.92 (0.19)	0.93 (0.19)
Percentage of energy content given in food trades ^c	11.16 (21.85)	8.43 (14.64)	11.67 (26.19)	6.60 (12.26)
Percentage of energy intake received in food trades ^d	14.73 (19.10)	10.83 (16.77)	15.13 (20.20)	13.19 (18.21)
Percentage of energy intake from flavored milk ^e	16.72 (13.09)	16.91 (12.96)	16.28 (12.71)	15.73 (10.84)
Percentage of energy intake from a la carte ice cream ^f	6.06 (12.10)	5.53 (11.49)	3.99 (9.35)	4.76 (9.89)
Breakfast type ^g				
Number of cold	58	51	46	53
Number of hot	87	97	101	96

^aFor analyses, the dependent variable (BMI) was continuous but BMI quartiles were used in Table 2 for ease of presentation. Daily energy intake at school-provided meals was analyzed in units of 100 kilocalories (kcal) for ease of interpretation.

^bObserved amounts were quantified and multiplied by per-serving energy values of standardized school-meal portions.

^cThe percentage of energy content given in food trades for a child on a particular school day was calculated as the number of kcals from items given away in food trades divided by the number of kcals from items on the school-meal trays, multiplied by 100.

^dThe percentage of energy content received in food trades for a child on a particular school day was calculated as the number of kcals from items received in food trades divided by the number of kcals eaten at the school, multiplied by 100.

^eThe percentage of energy intake from flavored milk for a child on a particular school day was calculated as the number of kcals from flavored milk divided by the number of kcals eaten at school meals, multiplied by 100.

^fThe percentage of energy intake from a la carte ice cream for a child on a particular school day was calculated as the number of kcals from a la carte ice cream divided by the number of kcals eaten at the school meals, multiplied by 100.

^g Items recorded by observers at breakfast for the children observed were used to categorize breakfast type as cold (i.e., ready-to-eat cereal, graham or animal crackers, milk, and juice or fruit) or hot (e.g., sausage biscuit, milk, and juice).

Table 3
Summary of regression output for Purpose One (n = 328 fourth-grade children and 1,178 meals).

Independent variables	Daily energy intake at school-provided meals (breakfast and lunch) ^a	Sex ^b	Race ^c	Age	Study	Interaction between daily energy intake at school-provided meals ^a and sex	Interaction between daily energy intake at school-provided meals ^a and race
<i>Dependent variable</i>					Estimate ^d (p-value)		
BMI	0.5219 (<0.0001)	1.3570 (0.0040)	1.6214 (0.0002)	0.0489 (0.0518)	$\chi^2 = 5.05$ (0.1681)	—	—
BMI	0.2285 (<0.0001)	-3.4398 (0.0006)	1.4593 (0.0004)	0.0461 (0.0928)	$\chi^2 = 5.66$ (0.1295)	0.5733 (<0.0001)	—
BMI	0.2540 (0.0103)	1.2192 (0.0150)	-1.8816 (0.1405)	0.0574 (0.0258)	$\chi^2 = 5.18$ (0.1588)	—	0.4157 (0.0063)

^aDaily energy intake at school-provided meals was analyzed in units of 100 kilocalories (kcal) for ease of interpretation.

^bFemale children were coded as 1, and male children were coded as 0.

^cBlack children were coded as 1, and White children were coded as 0.

^dRegression estimates are in kg/m². The level of significance assumed for each regression estimate is 0.05. A Bonferroni-adjusted level of significance is 0.01 (0.05/5) for Model 1 and 0.0083 (0.05/6) for Models 2 and 3.

^eFor Model 1, independent variables included daily energy intake at school-provided meals (in units of 100 kcal), sex, race (Black, White), age (in months), and study (which was the same as school year).

^fModel 2 included the same independent variables as Model 1, and an interaction term for daily energy intake and sex.

^gModel 3 included the same independent variables as Model 1, and an interaction term for daily energy intake and race.

Table 4

Summary of regression output for Purpose Two (n = 328 fourth-grade children and 1,178 meals) with body mass index (BMI) as the dependent variable, and Pearson correlations for five of the six aspects of school-provided meals^a.

<i>Independent variables</i>	Regression estimate ^c (p-value)	Amounts eaten of standardized school-meal portions	Pearson correlations ^b			
			Energy content given in food trades	Energy intake received in food trades	Energy intake from flavored milk	Energy intake from a la carte ice cream
Amounts eaten of standardized school-meal portions	2.9786 (<0.0001)	1.00	-0.15	0.42	0.07	-0.15
Energy content given in food trades	-0.0104 (0.0052)	--	1.00	0.12	-0.08	0.08
Energy intake received in food trades	-0.0143 (0.1366)	--	--	1.00	0.04	-0.14
Energy intake from flavored milk	0.0064 (0.5335)	--	--	--	1.00	-0.18
Energy intake from a la carte ice cream	-0.0177 (0.2937)	--	--	--	--	1.00
Breakfast type	-0.4326 (0.1529)					
Sex ^d	1.0605 (0.0223)					
Race ^e	1.8760 (0.0021)					
Age	0.0523 (0.0669)					
Study	$\chi^2 = 2.75$ (0.4320)					

^aThe six aspects of school-provided meals are defined in Table 2 footnotes b through g. Daily energy intake at school-provided meals was analyzed in units of 100 kilocalories for ease of interpretation.

^bPearson correlations assess bivariate relationships between any two of five meal aspects with breakfast type excluded because it is binary (hot, cold).

^cRegression estimates are in kg/m². The level of significance assumed for each individual regression estimate is 0.05. A Bonferroni-adjusted level of significance is 0.005 (0.05/10).

^dFemale children were coded as 1, and male children were coded as 0.

^eBlack children were coded as 1, and White children were coded as 0.