

Original article

The School Food Environment and Student Body Mass Index and Food Consumption: 2004 to 2007 National Data

Yvonne M. Terry-McElrath, M.S.A.^{a,*}, Patrick M. O'Malley, Ph.D.^a, Jorge Delva, Ph.D.^{a,b}, and Lloyd D. Johnston, Ph.D.^a

^a*Institute for Social Research, University of Michigan, Ann Arbor, Michigan*

^b*School of Social Work, University of Michigan, Ann Arbor, Michigan*

Manuscript received November 13, 2008; manuscript accepted April 21, 2009

Abstract

Purpose: This study identifies trends in the availability of various food choices in United States' middle and high schools from 2004 to 2007, and examines the potential associations between such food availability and students' self-reported eating habits and body mass index (BMI)-related outcomes.

Methods: Data are based on nationally representative samples of 78,442 students in 684 secondary schools surveyed from 2004 to 2007 as part of the Youth, Education, and Society (YES) study and the Monitoring the Future (MTF) study. In the YES study, school administrators and food service managers completed self-administered questionnaires on their school's food environment. In the MTF study, students in the same schools completed self-administered questionnaires, providing data used to construct BMI and food consumption measures.

Results: Overall, there was a decrease in the availability of regular-sugar/fat food items in both middle and high schools, and some indication of an increase in high school availability of reduced-fat food items through school lunch or a la carte. Some minimal evidence was found for relationships between the school food environment and student BMI-related outcomes and food consumption measures.

Conclusions: United States secondary schools are making progress in the types of foods offered to students, with food items of lower nutritional value becoming less prevalent in recent years. Continued monitoring of food environment trends may help clarify whether and how such factors relate to youth health outcomes. © 2009 Society for Adolescent Medicine. All rights reserved.

Keywords:

Body mass index; Obesity; Overweight; Schools; Food environment; Fruit and vegetable consumption; Students

In the past decade, the epidemic of overweight and obesity in the general population, and particularly among youth in the United States, has captured the serious attention of the public and policy makers [1]. One specific area of concern is in-school availability of foods and beverages that do not meet the nutritional guidelines set forth by the United States Department of Agriculture (USDA) Food and Nutrition Service School Lunch and School Breakfast Programs [2–6]. Consumption of foods which are high in fat, sodium and sugars has been found to be associated with increased risk of obesity [7,8]. Unfortunately, the availability of non-nutritious

foods and beverages in schools has become nearly universal [9–12]. Recent initiatives at the school, local, state, and national levels aim to decrease (if not eliminate altogether) the availability of non-nutritious foods and beverages in schools, and correspondingly increase the availability of nutritious food options. Some of the larger initiatives include the 2004 School Wellness Policy provision of the National School Lunch Act; the May 2006 agreement between the Alliance for a Healthier Generation and the American Beverage Association, Coca-Cola, PepsiCo, and Cadbury Schweppes to limit portion sizes and caloric content of beverages offered to students during the regular and extended school day; and the October 2006 Alliance for a Healthier Generation Snack Foods Agreement reached with the Campbell Soup Company, Dannon, Kraft Foods, Mars, and PepsiCo relating to the

*Address correspondence to: Yvonne Terry-McElrath, M.S.A., Institute for Social Research, PO Box 1248, Ann Arbor MI 48106-1248.

E-mail address: yterry@umich.edu

nutritional content of foods sold in schools outside of the School Lunch and School Breakfast programs.

In light of such recent policy activity, it is important to evaluate co-occurring trends in the types of foods available in schools, and to see if such availability relates to student nutrition. The purposes of this study were: (1) to identify trends in the availability of various food choices in U.S. middle and high schools from 2004–2007, and (2) to examine the potential associations between such food availability and students' self-reported eating habits and BMI-related outcomes. We hypothesize that, given the increased policy focus on improving healthy food choices in U.S. schools, the availability of such foods also will have increased, and the availability of foods of lower nutritional value will have decreased. We further hypothesize that as school food nutrition improves, students will report increased consumption of healthy foods, and eventually decreased BMI-related outcomes of overweight and obesity.

Methods

This report uses data from two studies: Monitoring the Future (MTF), and Youth, Education, and Society (YES). The MTF study annually surveys nationally representative samples of 8th-, 10th-, and 12th-grade students located in approximately 410 public and private schools in the 48 contiguous states. Each school participates for 2 consecutive years, with half of the sample of schools “cycling out” of the study each year. In the YES study, administrators in schools that have just completed their second and final year of MTF participation are requested to complete a questionnaire describing school policies and programs related to various health issues including food services, substance use, etc.

MTF design and methods

The design and methods for the MTF study are summarized briefly below; a detailed description is available elsewhere [13]. At each of three grade levels (8th, 10th, and 12th), an independent stratified random sampling procedure was used that involves three stages: (1) selection of geographic regions; (2) selection of schools within regions with probability proportional to the estimated number of students in the target grade; and (3) selection of students within schools, usually by means of randomly selecting whole classrooms. If a selected school declined to participate, a replacement school was recruited (with similar size, geographic area, urbanicity, etc.). From 2004 to 2007, either an original or replacement school was obtained for 98% of sample units, resulting in approximately 405 schools per year (range, 402–410). Approximately 45,000 students were surveyed each year, with student response rates averaging 90% for 8th graders, 88% for 10th graders, and 82% for 12th graders. Absenteeism was the primary reason for missing data; less than 1% of students refused to complete the questionnaire. Sample weights were assigned to each student to take into account variations in

selection probabilities. Ethical approval for the study was obtained from the University of Michigan Behavioral Sciences Institutional Review Board [13], and informed consent was given for survey participation. Surveys were administered in group settings (that is, classrooms) by University of Michigan personnel; students self-completed the survey questionnaires during a normal class period.

YES design and methods

The half samples of nationally representative schools that were cycling out of the MTF study in 2004 through 2007 comprised the YES target sample. School administrators were asked to complete a self-administered questionnaire on a variety of school policies and relevant student participation. More than 85% of respondents were school administrators; teachers and other school personnel were other respondents. For some sections of the questionnaire, it was recommended that a person other than the school administrator (e.g., food service manager) answer if they were more likely to know the information. Specifically, the section of the questionnaire asking about the types of foods made available to students at school was answered by the food service manager or other food worker in 71% of schools where 8th graders were surveyed, 78% of schools in which 10th graders were surveyed, and 70% of those in which 12th graders were surveyed. In the remaining schools, the principal usually answered these food-related questions. Questionnaires were completed in late spring each year, and administrators were instructed to answer for the current (just ending) school year.

The combined number of YES secondary schools that participated in the 2004–2007 surveys was 693, reflecting a response rate of 84%. A comparison of all schools responding to the YES questionnaire with all schools eligible for participation in the YES study showed minimal differences in student outcomes. For example, mean BMI was 21.6 in both groups for 8th grade, 22.9 for both in 10th grade, and 23.6 for both in 12th grade. Other student outcomes were similarly virtually identical. There were some very minor differences in school characteristics, but these were not sufficient to produce dissimilar student outcomes.

Measures

Descriptive data on all measures can be found in Table 1.

Dependent variables (MTF)

BMI-related outcomes. Students self-reported their height (in feet and inches) and weight (in pounds), using pre-coded close-ended response alternatives. BMI was calculated by dividing weight (in kilograms) by height (in meters) squared. Age- and gender-specific growth curves produced by the Centers for Disease Control and Prevention were used to determine whether each student was categorized as

Table 1
Descriptive characteristics of study population

	Middle school		High school	
	% or Mean	Range	% or Mean	Range
Student-level outcomes				
Overweight ($\geq 85\%$ BMI)	26.9		26.3	
Obese ($\geq 95\%$ BMI)	12.3		11.8	
Eat breakfast nearly every day or every day	47.1		37.3	
Eat fruit nearly every day or every day	53.9		42.4	
Eat green vegetables nearly every day or every day	42.2		37.4	
School-level predictors				
Frequency of offering fruit at lunch ^a	2.2	(0–3)	2.5	(0–3)
Frequency of offering vegetables at lunch ^b	2.1	(0–3)	2.4	(0–3)
Regular sugar/fat food items in vending machines and other competitive food outlets ^c	59.8		85.2	
Regular sugar/fat food items for lunch meal or a la carte ^d	26.5		42.4	
Reduced fat food items in vending machines and other competitive food outlets ^e	60.3		79.9	
Reduced fat food items for lunch meal or a la carte ^f	27.4		37.6	
Breakfast available at school	78.0		87.6	
School start time ^g	8:01–8:15	(7:01–7:15 to 9:16–9:30)	7:45–8:00	(7:00 to 9:31–10:40)
Control measures				
School: % of Students eligible for reduced lunch	36.7	(0–98)	28.0	(0–100)
Student: Gender = female	50.8		50.5	
Student: Race/ethnicity				
White	62.0		67.4	
African-American	9.7		11.2	
Hispanic	12.6		9.5	
Other/missing data	15.7		12.0	
Student: Average parental education ^h	3.2	(1–5)	3.2	(1–5)

Notes: Total possible N (wtd.) with no missing data on control measures for middle school = 29,254; high school = 49,188. Ns (wtd.) for student-level weight-related outcomes equal approximately 22,000 for middle school and 28,000 for high school; for student-level eating outcomes, equal approximately 8300 for middle school and 15,300 for high school.

^a Frequency with which 2+ fruit options are offered as part of school lunch meals (0 = never, 1 = some days, 2 = most or every day) plus offering fruit a la carte during lunch; range of 0–3.

^b Frequency with which 2+ vegetable options are offered as part of school lunch meals (0 = never, 1 = some days, 2 = most or every day) plus offering vegetables a la carte during lunch; range of 0–3.

^c Candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt in vending machines, school/student stores, or snack bars/carts.

^d Candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt provided a la carte during lunch.

^e Low fat varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt/sherbet/yogurt in vending machines, school/student stores, or snack bars/carts.

^f Low fat varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt provided a la carte during lunch.

^g Numeric scale from 1–12 recording time in 15-minute intervals from 7:00 am to 10:40 am.

^h Student-reported average of both father's and mother's education, allowing missing data for one parent.

overweight (equal to or greater than the 85th percentile on BMI) or obese (equal to or greater than the 95th percentile) [14,15].

Student food consumption. Measures of student food consumption were obtained from responses to three questions: (1) “How often do you eat breakfast?” (2) “How often do you eat at least some fruit?” (3) “How often do you eat at least some green vegetables?” Response options were on a scale of 1–6, ranging from never to every day. Data were analyzed using both the original scale of 1–6, as well as a dichotomy of almost every day/every day versus other. No substantive differences in results were found; accordingly, results for only the dichotomous measures are

presented in this article so as to maintain the same analytical modeling used for the dichotomous overweight and obesity measures.

Independent variables (YES)

Independent variables were all measured at the school level, and included items focusing on types of foods offered, locations such foods could be obtained, if the school provided breakfast, and school start time.

Frequency of offering fruits and vegetables at lunch. Separate items for both fruits and vegetables were measured using the question, “As part of school lunch meals

(not a la carte), how often are students offered a choice of two or more different fruits [vegetables]?” with response options of 0 = never, 1 = some days, and 2 = most or every day. In addition, respondents were asked, “During a typical week, are students at your school offered a la carte selections such as fruit [vegetables]?” (response options of yes or no). For fruits and vegetables separately, an overall frequency of 0–3 was calculated by summing the two items.

Food items in vending machines and other competitive food outlets. Respondents were asked to indicate if a variety of food items was available to students from vending machines, school/student stores, or snack bars/carts (not including a la carte foods offered in the cafeteria at lunch). Two dichotomous any/none measures were created based on the nutritional content of the foods listed: (a) regular-sugar/fat food items (including candy; salty snacks that are not low in fat, such as regular potato chips; cookies, crackers, cakes or other baked goods that are not low in fat; ice cream or frozen yogurt that is not low in fat), and (b) reduced-fat food items (including low-fat salty snacks, such as pretzels, baked chips, or other low-fat chips; low-fat cookies, crackers, cakes, pastries, other low-fat baked goods; low-fat or fat-free ice cream, frozen yogurt, sherbet, or low-fat or non-fat yogurt).

Food items for lunch meal or a la carte. Respondents were asked about the availability of food items through (a) school lunch meals (not a la carte), and (b) a la carte foods offered in the cafeteria at lunch. Again, two dichotomous any/none measures were created based on the nutritional content of the listed foods: (a) regular-sugar/fat food items (pizza; deep-fried French-fried potatoes (includes fries that are just reheated); candy; salty snacks that are not low in fat, such as regular potato chips or cheese puffs; cookies, crackers, cakes, pastries, or other baked goods that are not low in fat; ice cream or frozen yogurt that is not low in fat); (b) reduced-fat food items (low-fat salty snacks, such as pretzels, baked chips, or other low-fat chips; low-fat cookies, crackers, cakes, pastries, or other low-fat baked goods; low-fat or fat-free ice cream or yogurt, frozen yogurt, or sherbet).

Breakfast available at school. School breakfast availability was a dichotomous variable based on the question, “Does your school offer breakfast to students?”

School start time. To measure school start time, respondents were asked: “At what time in the morning are most or all of your [target grade] students normally required to be at school?” Responses were coded into twelve 15-minute intervals, and used as a continuous measure in analytical models.

Control variables

MTF student measures. The present study uses self-reported race/ethnicity, average parental education, and gender as demographic controls. Racial/ethnic background was coded

as African American, Hispanic, White, or Other background (the numbers of cases in other specific racial/ethnic groups were too small to allow separate estimates). Average parental education was coded using reported educational attainment for both father and mother (missing data for one parent permitted). Response categories for the initial question were: 1 = completed grade school or less, 2 = some high school, 3 = completed high school, 4 = some college, 5 = completed college, 6 = graduate or professional school after college). Responses for both father and mother were summed and then multiplied by 5 (if data on only one parent was available, data were multiplied by 10). Values were then recoded into a five-level measure as follows: 1(<25), 2(25–30), 3(35–40), 4(45–50), 5(55+). Parent education was utilized as a proxy for student socioeconomic status (SES), because students are generally unable to provide accurate information on parental income and occupation.

YES school measures. Relevant analyses explored the possible effect of school-level SES by including a continuous measure reflecting the school administrator-reported percentage of students eligible to receive a free or reduced price lunch.

Analysis

Trends in various food item availability, as well as multivariate analyses on relationships between school food item availability and student outcomes, are presented separately for middle schools (8th grade) and high schools (10th and 12th grades). Analyses were conducted separately for middle and high schools because the literature indicates significant differences by school level for both the school food environment [10,16] and relationships between the school food environment and student-level outcomes [17,18]. Weighted sample sizes after removing cases with missing data on control variables were 29,254 for middle school and 49,188 for high school. Data were weighted to adjust for differential probability of school and student selection. Trend analyses were conducted at the school level using the Mantel-Haenszel χ^2 test for significance. Multivariate analyses were conducted to assess the association between the school food environment and student food consumption, with correction for design effects resulting from clustered sampling using the surveylogistic procedure in SAS version 9.1.3.

Results

National trends in the school food environment

Figures 1–3 present trends in food item availability for U.S. middle and high schools. Results show significant declines since 2004 in the availability of regular-sugar/fat food items for students at both middle schools and high schools, whether from vending machines/other competitive food outlets or from lunch meals/a la carte. No clear trends in the availability of reduced-fat food items were seen among

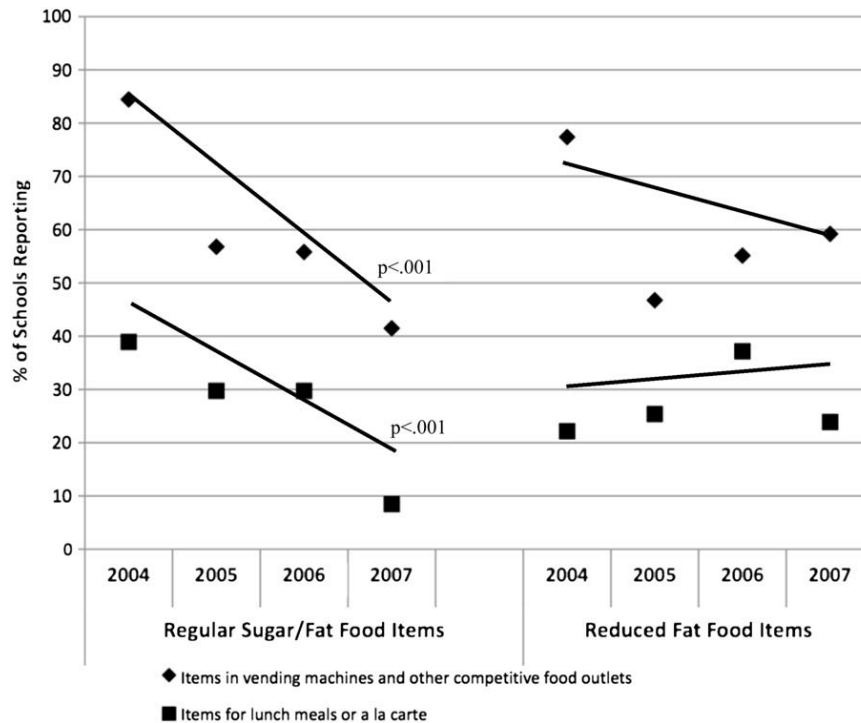


Figure 1. Regular-sugar/fat and reduced-fat food item availability at middle schools, 2004–2007. Percentages, trends, and significance tests presented using school-level data ($N = 260$). Regular sugar/fat food items defined as: candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt. Reduced fat food items defined as: low-fat or fat-free varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt/sherbet/yogurt. Other competitive food outlets include school/student stores and snack bars/carts.

middle schools. Among high schools, a significant increase in reduced-fat food items was observed for lunch meals/a la carte, but not for vending machines/other competitive food outlets. No clear trends in mean fruit or vegetable availability were observed for either middle schools or high schools.

Associations between the school food environment and student overweight and obesity

After controlling for year as well as student sociodemographics, few relationships between the school food environment and overweight or obesity were observed among middle school students (Table 2). Breakfast availability at school was positively associated with both student overweight and obesity, while school start time was negatively associated with student overweight, but not obesity.

Among high school students, breakfast availability at school also was positively associated with both student overweight and obesity after controlling for year and student sociodemographics. Negative associations were observed between reduced-fat food items (regardless of source location) and student overweight (but not obesity). Contrary to expectations, negative associations were also observed between regular-sugar/fat food items for lunch/a la carte and both overweight and obesity.

Additional analyses added the school-level variable indicating the percentage of students eligible for free or reduced price lunch (FRPL). Inclusion of this variable rendered insignificant

the middle school associations between having breakfast available at school and student overweight/obesity. However, the negative association between school start time and student overweight remained significant ($OR = .97$; $p < .05$). Further, the positive association between regular-sugar/fat food items in vending machines/other competitive food outlets and student obesity reached significance ($OR = 1.14$; $p < .05$). For high school students, after inclusion of percentage of students eligible for FRPL, all associations between the school food environment and student overweight and obesity were not significant.

Associations between the school food environment and students' food consumption

Frequency of breakfast consumption. In models controlling for year and student sociodemographics, the only predictor associated with increased odds of students reporting they ate breakfast nearly every day or every day was school start time (Table 3). The later the start time, the more likely middle school and high school students were to eat breakfast. These findings remained after controlling for percentage of students eligible for FRPL.

Frequency of fruit consumption. Among middle school students, the odds of eating fruit on a daily or near-daily basis was significantly and positively associated with the frequency with which schools reported offering both fruits

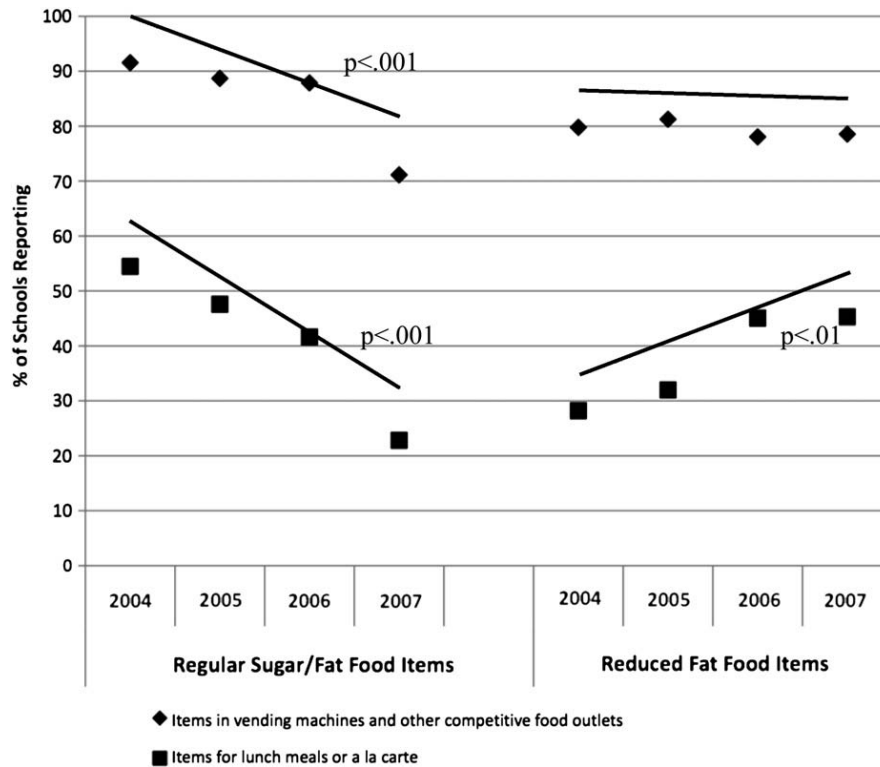


Figure 2. Regular-sugar/fat and reduced-fat food item availability at high schools, 2004–2007. Percentages, trends, and significance tests presented using school-level data ($N = 429$). Regular sugar/fat food items defined as: candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt. Reduced fat food items defined as: low-fat or fat-free varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt/sherbet/yogurt. Other competitive food outlets include school/student stores and snack bars/carts.

and vegetables at lunch (after controlling for year and student sociodemographics; Table 3). In contrast, frequent student fruit consumption was negatively associated with schools having regular-sugar/fat food items in vending machines/other competitive food outlets. After controlling for percentage of students eligible for FRPL, the only change was that the significance level dropped below the $p < .05$ level for the frequency with which schools reported offering fruits at lunch. No significant relationships were observed among high school students.

Frequency of green vegetable consumption. Table 3 shows that for middle school students, two school food environment predictors were positively associated with the odds of students eating green vegetables in models controlling for year and student sociodemographics: the frequency of offering vegetables at lunch, and whether schools reported the availability of reduced-fat food items at lunch. These results held after controlling for percentage of students eligible for FRPL. Among high school students, a positive association was found between the frequency with which fruits were offered at lunch and student consumption of green vegetables in initial models. However, significance for this finding dropped below $p < .05$ after inclusion of the percentage of students eligible for FRPL to the model.

Discussion

As Davison and Birch [19] note, the factors that place any specific child at risk for overweight extend beyond child-specific and familial characteristics to the school, community, and larger social environments. Nutritional intake among U.S. school children is significantly affected by the school food environment. Among all students, more than one quarter of daily energy is consumed while at school; among those who participate in school meals, the level reaches almost 50% [16]. However, significant variation exists in the nutritional content of food items available at schools, whether through competitive food outlets or via school lunch and breakfast programs. Crepinsek et al [20] found that in 2005, only 60% of schools provided lunches with total fat levels within the range recommended by the 2005 Dietary Guidelines. Further, while schools can provide a variety of food options to students, the students' selections obviously affect the overall nutrition obtained from any school lunch or breakfast menu. As Crepinsek et al [20] note, all high schools and virtually all middle schools report using an “offer-vs.-serve” approach to food provision in School Lunch or Breakfast programs, where students can refuse some items (the goal being a reduction in food waste). Crepinsek et al further observed that across the nation, food energy and energy from total fat were higher in school

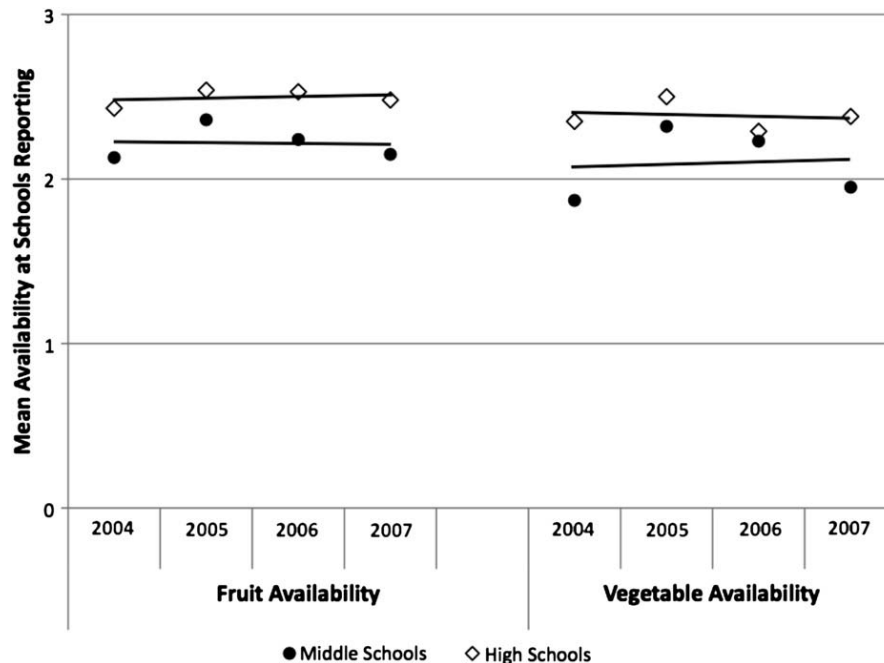


Figure 3. Fruit and vegetable availability during lunch in middle and high schools, 2004–2007. Percentages, trends, and significance tests presented using school-level data ($N_s = 253$ and 254 for middle school fruit and vegetable availability, respectively; 418 for high school for both fruit and vegetable availability). Fruit and vegetable availability coded on a score of 0–3 based on the sum of the following: frequency with which 2+ fruit (or vegetable) options are offered as part of school lunch meals (0 = never, 1 = some days, 2 = most or every day) plus offering fruit (or vegetables) a la carte during lunch (0,1).

breakfasts actually served than in the breakfast menu as offered due to student choices. However, the results of the current study indicate that the U.S. secondary school environment is making positive strides in reducing the availability of regular-sugar/fat food items. Overall relationships with the school food environment and student BMI-related outcomes and food intake largely remain unclear.

Trends in the school food environment

The findings point to a significant decrease in the availability of regular-sugar/fat food items to students in U.S. middle and high schools over the 2004–2007 time period. These results are quite encouraging in that they positively reflect the serious efforts many schools are making to improve the nutrition of foods offered to students. These trends may reflect the positive impact of local, state, and national policies (e.g., 2004 School Wellness Policy provision of the National School Lunch Act), although policy-specific analyses are needed to further investigate this issue. However, given that 2007 data showed approximately 40% of middle schools and more than 70% of high schools still had regular-sugar/fat food items available in vending machines and other competitive food outlets, it is important to continue to monitor and support societal change in this area of the school food environment.

In contrast to the clear declines in regular-sugar/fat food item availability in both middle and high schools, increased availability of reduced-fat food items was seen only for high school lunch meals/a la carte. Figure 1 shows that the 2005

data point for middle school availability of reduced-fat food items in vending machines/other competitive food outlets is sharply lower than 2004, and a corresponding strong drop was seen in regular-sugar/fat food item availability for middle schools in vending machines/other competitive food outlets (however, later years continued the decline for regular-sugar/fat food items). Additional analysis shows that while all regions of the U.S. saw some level of decline in middle school food item availability from vending machines/other competitive food outlets, decreases were especially strong in the West region. These decreases may be related to the July 1, 2004, implementation of the California Childhood Obesity Prevention Act of 2003 [21], which prohibited the sale of unhealthy beverages from vending machines or other sources at any time for elementary schools, and during the school day for middle schools. It may be that this ban significantly affected overall vending machine use for a time, and thus lowered food item availability until new contracts could be arranged with vending machine companies.

Efforts to reduce fat content (especially saturated fat) in school foods is clearly indicated by the USDA guidelines for both the School Breakfast and School Lunch programs that stipulate that no more than 30% of calories are to come from fat, and less than 10% from saturated fat [6]. However, little is known about the ramifications of efforts to increase the availability of the reduced or low-fat foods included in the present study (low-fat or fat-free varieties of the following: salty snacks; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt/sherbet/yogurt). A

Table 2
Relationships between school food environment and student overweight and obesity for middle and high school students, 2004–2007

Outcome	Predictor	Middle school		High school	
		OR	<i>p</i>	OR	<i>p</i>
Overweight ^a	Frequency of offering fruit at lunch ^b	.97		1.00	
	Frequency of offering vegetables at lunch ^c	.99		1.00	
	Regular sugar/fat food items in vending machines and other competitive food outlets ^d	1.01		.92	
	Regular sugar/fat food items for lunch meal or a la carte ^c	.96		.92	*
	Reduced fat food items in vending machines and other competitive food outlets ^f	.99		.90	*
	Reduced fat food items at lunch ^g	.98		.90	**
	Breakfast available at school	1.24	***	1.20	**
	School start time ^h	.97	*	1.01	
Obese ^a	Frequency of offering fruit at lunch	.95		.96	
	Frequency of offering vegetables at lunch	.97		1.00	
	Regular sugar/fat food items in vending machines and other competitive food outlets	1.12		.96	
	Regular sugar/fat food items for lunch meal or a la carte	1.00		.86	**
	Reduced fat food items in vending machines and other competitive food outlets	1.05		.92	
	Reduced fat food items at lunch	.95		.93	
	Breakfast available at school	1.31	**	1.19	*
	School start time	1.00		.99	

Notes: Outcomes measured at the student level. Predictors measured at the school level. School-level predictors entered separately in analytical models. Results obtained from models controlling for year and student-level gender, race/ethnicity, average parental education. OR = odds ratio.

^a Overweight defined as $\geq 85\%$ BMI; obese defined as $\geq 95\%$ BMI.

^b Frequency with which 2+ fruit options are offered as part of school lunch meals (0 = never, 1 = some days, 2 = most or every day) plus offering fruit a la carte during lunch; range of 0–3.

^c Frequency with which 2+ vegetable options are offered as part of school lunch meals (0 = never, 1 = some days, 2 = most or every day) plus offering vegetables a la carte during lunch; range of 0–3.

^d Candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt in vending machines, school/student stores, or snack bars/carts.

^e Candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt provided a la carte during lunch.

^f Low fat varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt/sherbet/yogurt in vending machines, school/student stores, or snack bars/carts.

^g Low fat varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt provided a la carte during lunch.

^h Numeric scale from 1–12 recording time in 15-minute intervals from 7:00 am to 10:40 am.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

study of secondary schools in Minnesota indicated that targeted efforts to promote and increase a la carte low-fat food availability were successful in increasing student purchases [22]. However, concerns have been raised that low-fat food items are not necessarily low-calorie, and individuals may consume larger quantities of low-fat foods thinking that such foods are ‘safer’ for increased consumption [23]. Thus, the implications for student health of a lack of trend in reduced-fat food item availability are not clear.

The high school availability of fruits and vegetables indicated virtually no change over the time period studied. For middle schools, both fruit and vegetable availability seemed to exhibit a possible curvilinear relationship with time. Additional years of data collection will be needed to determine if and how fruit and vegetable availability is changing over time.

School food environment and student outcomes

School fruit and vegetable availability. No relationships were found between school fruit and vegetable availability

and student BMI-related outcomes. Studies have been mixed when comparing fruit and vegetable consumption with adolescent adiposity [24]. The definition of vegetable consumption could be a contributing factor to the lack of findings. Condon et al [25] found that school menus provided starchy vegetables (such as potatoes) more often than dark green or orange vegetables or legumes. Vegetable type has been shown to have differing relationships with adult health-related outcomes including weight management [26] and chronic disease such as diabetes [27]. Specifically, green leafy vegetables were found to relate to healthier outcomes.

Results did indicate the possibility of a positive relationship between the frequency with which a school offered fruits and vegetables and the likelihood of students reporting frequent fruit and vegetable consumption. These findings are in line with previous data from U.S. public schools, such as reports from the 2005 National School Nutrition Dietary Assessment Study, where students participating in School Lunch were more likely to consume both fruit and vegetables [25]. Importantly, the School Nutrition Dietary

Table 3
Relationships between school food environment and student food consumption outcomes for middle and high school students, 2004–2007

Outcome	Predictor	Middle school		High school	
		OR	<i>p</i>	OR	<i>p</i>
Eat breakfast nearly every day or every day	Frequency of offering fruit at lunch ^a	1.02		1.02	
	Frequency of offering vegetables at lunch ^b	1.02		1.00	
	Regular sugar/fat food items in vending machines and other competitive food outlets ^c	.91		1.03	
	Regular sugar/fat food items for lunch meal or a la carte ^d	.93		.98	
	Reduced fat food items in vending machines and other competitive food outlets ^e	.99		1.04	
	Reduced fat food items for lunch meal or a la carte ^f	.95		1.03	
	Breakfast available at school	.92		.98	
	School start time ^g	1.07	***	1.03	*
Eat fruit nearly every day or every day	Frequency of offering fruit at lunch	1.07	*	1.04	
	Frequency of offering vegetables at lunch	1.07	*	1.02	
	Regular sugar/fat food items in vending machines and other competitive food outlets	.86	*	1.02	
	Regular sugar/fat food items for lunch meal or a la carte	.97		.99	
	Reduced fat food items in vending machines and other competitive food outlets	.95		.96	
	Reduced fat food items at lunch	1.10		1.02	
	Breakfast available at school	.99		1.00	
	School start time	1.02		.99	
Eat green vegetables nearly every day or every day	Frequency of offering fruit at lunch	1.07		1.08	*
	Frequency of offering vegetables at lunch	1.07	*	1.05	
	Regular sugar/fat food items in vending machines and other competitive food outlets	.95		.95	
	Regular sugar/fat food items for lunch meal or a la carte	1.01		1.00	
	Reduced fat food items in vending machines and other competitive food outlets	1.00		1.01	
	Reduced fat food items at lunch	1.15	*	1.03	
	Breakfast available at school	.95		.94	
	School start time	1.01		.98	

Notes: Outcomes measured at the student level. Predictors measured at the school level. School-level predictors entered separately in analytical models. Results obtained from models controlling for year and student-level gender, race/ethnicity, average parental education.

^a Frequency with which 2+ fruit options are offered as part of school lunch meals (0 = never, 1 = some days, 2 = most or every day) plus offering fruit a la carte during lunch; range of 0–3.

^b Frequency with which 2+ vegetable options are offered as part of school lunch meals (0 = never, 1 = some days, 2 = most or every day) plus offering vegetables a la carte during lunch; range of 0–3.

^c Candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt in vending machines, school/student stores, or snack bars/carts.

^d Candy; regular fat salty food items; regular fat cookies, crackers, cakes, or other baked goods; regular fat ice cream/frozen yogurt provided a la carte during lunch.

^e Low-fat or fat-free varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt/sherbet/yogurt in vending machines, school/student stores, or snack bars/carts.

^f Low-fat or fat-free varieties of the following: salty food items; cookies, crackers, cakes, or other baked goods; ice cream/frozen yogurt provided a la carte during lunch.

^g Numeric scale from 1–12 recording time in 15-minute intervals from 7:00 am to 10:40 am.

* $p < .05$.

*** $p < .001$.

Assessment Study also indicated a relationship between the percentage of students eligible for FRPL and fruit and vegetable availability. Specifically, higher percentages of students eligible for FRPL were associated with lowered school availability of daily fresh fruit or raw vegetables [10]. Such a relationship likely results from financial resources available in schools with economically disadvantaged student populations. In the current study, models controlling for the percentage of students eligible for FRPL still showed some degree of positive relationship between school provision of fruit and vegetables and student consumption. It should be noted that in the current study, a strong correlation was observed between students' fruit consumption and green

vegetable consumption (middle school students, $r = .61$; $p < .001$; high school students, $r = .57$; $p < .001$). Further, significant correlations were also observed between school-level frequencies of offering fruits and offering vegetables (middle schools, $r = .78$; $p < .001$; high schools, $r = .67$; $p < .001$). Thus, it is perhaps not too surprising that school-level provision of vegetables related significantly to student fruit consumption among middle school students, although school-level provision of fruit related significantly to student vegetable consumption among high school students.

In addition, further analyses indicated a possible mediating effect of school availability of frequent fruit consumption on high school student overweight and obesity. In multivariate

models controlling for student sociodemographics, high school students who reported eating fruit nearly every day or every day had lower odds of overweight (OR = .90; $p < .05$), and approached traditional significance levels for lower odds of obesity (OR = .89; $p = .09$) (data not shown). Frequent fruit consumption was not related to overweight/obesity for middle school students, and neither middle nor high school students showed significant relationships between frequent green vegetable consumption and overweight/obesity. If school fruit/vegetable availability is related to increased fruit consumption, and fruit consumption in turn relates to BMI-related outcomes, the need to strengthen school provision of and student willingness to consume fruit is underscored.

School availability of regular-sugar/fat and reduced-fat food items. Controlling for student sociodemographics, none of the regular-sugar/fat or reduced-fat items was significantly related to middle school student overweight or obesity. Among high school students, the availability of reduced-fat food items was associated with lower odds of overweight (but not obesity), whereas the availability of regular-sugar/fat food items for lunch meal or a la carte surprisingly was associated with reduced odds of both overweight and obesity. However, in two separate state-specific studies, school-level percentages of students eligible for FRPL were found to relate to both student-level BMI [28] and to the nutrition level of snacks available for purchase at school [29]. Additional models were run controlling for the percentage of students reported to be eligible for FRPL, and results indicated no remaining significant relationships for high school students. After controlling for the percentage of students eligible for FRPL, the availability of regular-sugar/fat food items in vending machines and other competitive food outlets was related to increased odds of obesity among middle school students.

Policy recommendations for school food environments have included the removal of vending machines and school stores, or to allow only approved food items in such competitive food outlets [30]. In one follow-up study in southeast Texas, movement from school environments offering only School Lunch to competitive food outlet access via school snack bars was associated with lower consumption of fruits, regular vegetables and milk, and higher consumption of high-fat vegetables and sweetened beverages for middle school students [31]. In general, both access to and consumption of competitive foods has been found to increase significantly as students move from elementary school to middle school and on to high school [10,18]. Results from the 2005 National School Nutrition Dietary Assessment Study showed that consumption of low-nutrient, energy-dense competitive foods provided 171 and 219 calories daily for middle and high school students, respectively [18], and that participation in School Lunch was related to lower caloric intake from low-nutrient, energy-dense competitive foods among middle school students (no differences were observed for high school

students based on School Lunch participation). Importantly, some research indicates that an average reduction in caloric intake of 110–165 calories daily might have helped prevent the increase in body weight among U.S. children [32].

School breakfast. Results from the current study indicate that the availability of breakfast at school was related to increased odds of student overweight and obesity before controlling for the percentage of students eligible for FRPL. This finding appears counterintuitive at first, given that in general, research indicates that skipping breakfast is associated with overweight among children [33]. Indeed, multivariate models using the current study's data relating student overweight and obesity to student-reported frequent breakfast consumption also showed a significant and negative relationship for both middle school students (OR .65 for overweight; OR .68 for obesity) and high school students (OR .73 for both overweight and obesity) (all results significant at $p < .001$ after controlling for student-level sociodemographics; data not shown). However, it is important to point out that, in the current analyses, school provision of breakfast did not significantly relate to the odds of students reporting eating breakfast on a regular basis (Table 3). A summary of research studies on the subject by Brown et al [34] indicates that positive relationships with school provision of breakfast may be limited to youth who do not obtain breakfast at home, and that only among low-income children is school breakfast associated with improved nutrition and overall diet. While breakfast is provided at the majority of schools, data indicate that school breakfast participants are much more likely to be low-income than are school lunch participants [20,35]. Additional models were run controlling for the percentage of students reported to be eligible for FRPL. Results showed that the relationship between school provision of breakfast and student overweight/obesity no longer reached traditional significance levels.

School start time. In 2002, a study was published indicating several positive relationships with a later start time for high school students [36], including improved attendance and enrollment, as well as lower rates of student-reported depression. More recent research has connected lack of sleep with obesity rates among middle school students in Japan [37]. The current study indicates that later school start time is negatively related to middle school student odds of overweight, and positively relates to the odds of both middle and high school students eating breakfast regularly. Given the previously discussed relationship between regular breakfast consumption and student overweight/obesity, later school start times may be an additional component to consider in efforts to reduce student weight-related problems.

Limitations

These findings should be viewed within the context of the study's limitations. First, student overweight and obesity are based on BMI values calculated using self-reported height

and weight data. Self-reported height and weight for adolescents and adults from a variety of countries and population groups have been shown to correlate strongly with actual measurements [38–40]; however, slightly lower prevalence rates of obesity and overweight may result. Given that the current study focuses on relational analyses (versus prevalence), self-report data are believed to be appropriate. Second, neither MTF nor YES items provided the opportunity for detailed analysis of caloric or food group intake; neither did they specify a specific recall time period nor provide a standardized definition of terms (i.e., students were not provided with a definition of what was included in ‘green vegetables’ or ‘eating breakfast’). Third, questions about the school environment relied on reports by school principals or by other school personnel. More comprehensive data could be obtained if assessments of the school food environment could be made using direct observation, but the cost of such an effort would be prohibitive given the scale of data collection. Finally, there is limited between-school variability on both the dependent and independent variables. In the present study, the intra-cluster correlation coefficients (ICC) were .04, .03, and .03 for the dependent variables frequency of eating green vegetables, fruits, and breakfast, respectively. This means, for example, that four percent or less of the differences in students’ consumption of green vegetables, fruits, and breakfast can be explained by differences between schools and that 96% of the variance in student behaviors are due to non-school related factors.

Conclusion

The results from this study point to a decreasing trend in the availability of regular-sugar/fat food items in U.S. middle and high school food environments. Further, the results indicate that factors such as the frequency with which fruits and vegetables are provided, food availability in vending machines and other competitive food outlets, and school start time are all policy avenues that may be used to affect student BMI and food consumption. Continued monitoring of food environment trends and the development of greater between school differences may help clarify if and how such factors relate to youth health outcomes.

Acknowledgments

The Youth, Education, and Society (YES) project (part of a larger research initiative, entitled Bridging the Gap: Research Informing Policy and Practice for Healthy Youth Behavior) is funded by the Robert Wood Johnson Foundation. The Monitoring the Future study is funded by the National Institute on Drug Abuse (DA01411). The views expressed in this article are those of the authors and do not necessarily reflect the views of the funders.

References

- [1] Chaloupka FJ, Johnston LD. Bridging the gap: Research informing practice and policy for healthy youth behavior. *Am J Prev Med* 2007;33:S147–61.
- [2] Centers for Disease Control. Competitive foods and beverages available for purchase in secondary schools—selected sites, United States, 2004. *MMWR* 2005;54:917–21.
- [3] General Accounting Office. School meals programs: Competitive foods are available in many schools; actions taken to restrict them differ by state and locality [Online]. GAO-04–673. General Accounting Office, Washington DC, 2004. Available at: <http://www.gao.gov/new.items/d04673.pdf>. Accessed March 24, 2009.
- [4] General Accounting Office. School lunch program: Efforts needed to improve nutrition and encourage healthy eating [Online]. GAO-03–506. General Accounting Office, Washington DC, 2003. Available at: <http://www.gao.gov/new.items/d03506.pdf>. Accessed March 24, 2009.
- [5] General Accounting Office. School meals programs: Competitive foods are widely available and generate substantial revenue for schools. GAO-05–563. General Accounting Office, Washington, DC, 2005. Available at: <http://www.gao.gov/new.items/d05563.pdf>. Accessed March 24, 2009.
- [6] U.S. Department of Agriculture. Food and nutrition service. USDA, Washington, DC, 2005. Available at: <http://www.fns.usda.gov/cnd/>.
- [7] Institute of Medicine (IOM). Nutrition standards for foods in schools: Leading the way toward healthier youth. Committee on Nutrition Standards for Foods in Schools—Food and Nutrition Board. Washington DC: National Academy Press, 2007.
- [8] Story M, Hayes M, Kalina B. Availability of foods in high schools: Is there cause for concern? *J Am Diet Assoc* 1996;96:123–6.
- [9] Delva J, Johnston LD, O’Malley PM. The epidemiology of overweight and related lifestyle behaviors: Racial/ethnic and socioeconomic status differences among American youth. *Am J Prev Med* 2007;33:S178–86.
- [10] Finkelstein DM, Hill EL, Whitaker RC. School food environments and policies in US public schools. *Pediatrics* 2008;122:e251–9.
- [11] O’Toole TP, Anderson S, Miller C. Nutrition services and foods and beverages available at school: Results from the School Health Policies and Programs Study 2006. *J Sch Health* 2007;77:500–21.
- [12] Wechsler H, Brener N, Kuester S, et al. Food service and foods and beverages available at school: Results from the School Health Policies and Programs Study 2000. *J Sch Health* 2001;71:313–24.
- [13] Johnston LD, O’Malley PM, Bachman JG, et al. Monitoring the Future: national survey results on drug use, 1975–2007, Volume I: Secondary school students (NIH Publication No. 08-6418A). Bethesda, MD: National Institute on Drug Abuse, 2008.
- [14] Hammer LD, Kraemer HC, Wilson DM, et al. Standardized percentile curves of body-mass index for children and adolescents. *Am J Dis Child* 1991;145:259–63.
- [15] Pietrobelli A, Faith MS, Allison DB, et al. Body mass index as a measure of adiposity among children and adolescents: A validation study. *J Pediatr* 1998;132:204–10.
- [16] Briefel RR, Crepinsek MK, Cabili C, et al. School food environments and practices affect dietary behaviors of US public school children. *J Am Diet Assoc* 2009;109(2 Suppl. 1):S91–107.
- [17] Fox MK, Dodd AH, Wilson A, et al. Association between school food environment and practices and body mass index of US public school children. *J Am Diet Assoc* 2009;109(2 Suppl. 1):S108–17.
- [18] Fox MK, Gordon A, Nogales R, et al. Availability and consumption of competitive foods in US public schools. *J Am Diet Assoc* 2009; 109(2 Suppl. 1):S57–66.
- [19] Davison KK, Birch LL. Childhood overweight: A contextual model and recommendations for future research. *Obes Rev* 2001;2:159–71.
- [20] Crepinsek MK, Gordon AR, McKinney PM, et al. Meals offered and served in US public schools: Do they meet nutrient standards? *J Am Diet Assoc* 2009;109(2 Suppl. 1):S31–43.

- [21] California Center for Public Health Advocacy. California SB 677: Summary of provisions. 2003 [Online]. Available at: http://www.publichealthadvocacy.org/PDFs/SB677_Summary.pdf. Accessed March 24, 2009.
- [22] French SA, Story M, Fulkerson JA, et al. An environmental intervention to promote lower-fat food choices in secondary schools: Outcomes of the TACOS study. *Am J Public Health* 2004;94:1507–12.
- [23] Wansink B. *Mindless eating*. New York, NY: Bantam Books, 2006.
- [24] American Dietetic Association. Fruit and vegetable intake and childhood overweight [Online]. Available at: <http://www.adaevidencelibrary.com/topic/cfm?cat=1054>. Accessed March 23, 2009.
- [25] Condon EM, Crepinsek MK, Fox MK. School meals: Types of foods offered to and consumed by children at lunch and breakfast. *J Am Diet Assoc* 2009;109(2 Suppl. 1):S67–78.
- [26] Brunt A, Rhee Y, Zhong L. Differences in dietary patterns among college students according to body mass index. *J Am Coll Health* 2008;56:629–34.
- [27] Bazzano LA, Li TY, Joshupura KJ, et al. Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. *Diabetes Care* 2008;31:1311–7.
- [28] Marshall J, Poiners A, Drisko J, et al. Obesity surveillance in Colorado children. Paper presented at the Public Health in the Rockies Conference (Colorado Public Health Association), September, 2008 [Online]. Available at: http://www.uchsc.edu/rmpcr/documents/CPHA_BMI_2008.ppt. Accessed March 23, 2009.
- [29] Nanney MS, Bohner C, Friedrichs M. Poverty-related factors associated with obesity prevention policies in Utah secondary schools. *J Am Diet Assoc* 2008;108:1210–5.
- [30] Villianatos M. Healthy school food policies: A checklist. Version 1.5: June 2005. A working paper of the Center for Food and Justice, Urban and Environmental Policy Institute [Online]. Available at: http://departments.oxy.edu/uepi/cfj/publications/healthy_school_food_policies_05.pdf. Accessed March 23, 2009.
- [31] Cullen KW, Zakeri I. Fruits, vegetables, milk, and sweetened beverages consumption and access to a la carte/snack bar meals at school. *Am J Public Health* 2004;94:463–7.
- [32] Wang YC, Gortmaker SL, Sobol AM, et al. Estimating the energy gap among US children: A counterfactual approach. *Pediatrics* 2006;118:2528–9.
- [33] American Dietetic Association. Breakfast skipping and childhood overweight [Online]. Available at: <http://www.adaevidencelibrary.com/topic/cfm?cat=1047>. Accessed March 23, 2009.
- [34] Brown JL, Beardslee WH, Prothrow-Stith, D. Impact of school breakfast on children's health and learning: An analysis of the scientific research. Gaithersburg, MD: Sodexo Foundation, 2008 [Online]. Available at: http://www.sodexofoundation.org/hunger_us/Images/Impact%20of%20School%20Breakfast%20Study_tcm150-212606.pdf. Accessed March 23, 2009.
- [35] Henchy G, Levin M. Hunger and obesity: Implications for school meal patterns. Paper presented for the Institute of Medicine, July 2, 2008 [Online]. Available at: <http://www.iom.edu/Object.File/Master/56/390/5-FRAC%20Hunger%20and%20Obesity.pdf>. Accessed March 23, 2009.
- [36] Wahlstrom K. Changing times: Findings from the first longitudinal study of later high school start times. *NASSP Bull* 2002;86:3–21.
- [37] Yuasa K, Sei M, Takeda E, et al. Effects of lifestyle habits and eating meals together with the family on the prevalence of obesity among school children in Tokushima, Japan: A cross-sectional questionnaire-based survey. *J Med Invest* 2008;55:71–7.
- [38] Craig BM, Adams AK. Accuracy of body mass index categories based on self-reported height and weight among women in the United States. *Matern Child Health J* 2009;13:489–96.
- [39] Dekkers JC, van Wier MF, Hendriksen IJ, et al. Accuracy of self-reported body weight, height and waist circumference in a Dutch overweight working population. *BMC Med Res Methodol* 2008;8:69.
- [40] Elgar FJ, Stewart JM. Validity of self-report screening for overweight and obesity: Evidence from the Canadian Community Health Survey. *Can J Public Health* 2008;99:423–7.