

The Association of the School Food Environment With Dietary Behaviors of Young Adolescents

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The school environment is recognized as having a powerful influence on students' eating behaviors.^{1,2} Ecological models of health behavior posit that such influence is multilevel and includes not only intrapersonal and social and cultural factors but physical factors as well.^{3–5} Indeed, it is the change in the physical environment of schools that has prompted many nutrition experts and public health advocates to question whether the present-day school environment supports and promotes the development of healthy eating as normative childhood behavior.^{6,7}

In today's schools, students are offered a variety of eating options and opportunities. In addition to government-regulated child nutrition programs, which include the National School Lunch and Breakfast Programs, students may purchase single food items from snack bars, à la carte programs, vending machines, and school stores; in some cases, they are allowed to leave school to buy food. Findings from the second School Nutrition Dietary Assessment study indicated that more than 90% of schools offered an à la carte program at lunchtime; 76% of high schools, 55% of middle schools, and 15% of elementary schools had vending machines available for student use; and 41% of high schools, 35% of middle schools, and 9% of elementary schools had school stores, snack bars, or canteens that sold food or drinks.⁸ Overall, few of the foods offered to students via these venues are lower-fat items, fruit is rarely available, and fruit juice is a less prevalent offering than carbonated or sweetened beverages.^{9–11}

Interestingly, this metamorphosis in the school environment has occurred during a time when deliberate national effort has been expended to improve the nutritional health of the US populace, particularly regarding the consumption of fruits, vegetables, and dietary fat.¹² Most children, however, do not follow the US Department of Agriculture's (USDA's) Dietary Guidelines for Americans, which rec-

Objectives. We examined the association between young adolescents' dietary behaviors and school vending machines, à la carte programs, and fried potatoes' being served at school lunch.

Methods. Using a cross-sectional study design, we measured à la carte availability and the number of school stores, vending machines, and amounts of fried potatoes served to students at school lunch in 16 schools. Grade 7 students (n=598) completed 24-hour dietary recall interviews.

Results. À la carte availability was inversely associated with fruit and fruit/vegetable consumption and positively associated with total and saturated fat intake. Snack vending machines were negatively correlated with fruit consumption. Fried potatoes' being served at school lunch was positively associated with vegetable and fruit/vegetable intake.

Conclusions. School-based programs that aim to promote healthy eating among youths should target school-level environmental factors. (*Am J Public Health*. 2003;93:1168–1173)

ommend 5 or more servings of fruits and vegetables a day and limiting fat intake to no more than 30% saturated fat intake to less than 10% of daily calories consumed.^{12,13} Unhealthy dietary patterns, especially diets low in fruits and vegetables and high in fats, have been cited as the most frequently occurring chronic disease risk behavior among youths aged 12 to 17 years.¹⁴

Clearly, focused efforts to improve the nutritional health of America's young people are still needed, and schools, with their access to an estimated 95% of children and adolescents nationwide,¹⁵ are regarded as optimum settings for such efforts. However, because of the many changes in the school food environment, there is a critical need to examine the association between the food options available to students at school today and the dietary practices of school-aged youths. We therefore undertook this study to assess the influence of certain school-level factors, such as the availability of vending machines and à la carte programs, on the eating behaviors of a sample of middle-school students from the upper Midwest who were participants in the Teens Eating for Energy and Nutrition at School (TEENS) study.¹⁶ TEENS was a school-based dietary intervention trial that sought to promote healthful dietary behaviors

among young adolescents to reduce future cancer risk.¹⁶

METHODS

Design

A cross-sectional design was used to study the association between selected factors in the school environment and young adolescent dietary behavior. School-level data collected from 16 schools in the St Paul–Minneapolis, Minn, metropolitan area and individual-level data obtained from a sample of seventh-grade students attending these schools allowed us to create a “snapshot” of the school food environment and to assess the influence of such factors as fried potatoes' being served at school lunch and the availability of à la carte programs and vending machines on students' consumption of fruits, vegetables, and total and saturated fat. Data collection occurred in the fall of 1998, prior to implementation of the TEENS intervention. All data (school-level measures and 24-hour dietary recalls) were collected over an 8- to 10-week period.

Sample

School districts located within a 30-mile radius of St Paul–Minneapolis and with a minimum of 20% of students approved for the

free/reduced lunch program were eligible to participate in the TEENS study. Schools were required to have both seventh and eighth grades in 1 building and to have at least 30 students enrolled in each of these grades. Fourteen districts (33 schools) were eligible, and 9 districts (20 schools) agreed to participate. Reasons cited for nonparticipation included time constraints, personnel changes, and lack of interest in the environmental component of the intervention. One of the 20 schools was chosen to pilot-test the evaluation and intervention materials, and 3 were judged ineligible owing to scheduling conflicts. The remaining 16 formed the school sample for the study.

At the student level, 4050 seventh-grade students were eligible to participate in the TEENS study. Letters of consent were mailed to parents, and those who did not wish their children to participate in the TEENS student survey or a 24-hour dietary recall interview were asked to call the study's evaluation coordinator. Cases in which letters were returned undelivered and families were known not to read English or any of the translated languages (Spanish, Hmong, Croatian) were treated as though consent had not been given.

The student sample for this research consisted of a random subsample of seventh-grade students who completed a single 24-hour dietary recall interview. This recall was the primary outcome measure for the TEENS study. Because budgetary constraints precluded collection of recalls on the entire study population, power calculations were used to determine the recall sample size. Of the 844 students (21%) selected for recalls, 645 (76%) completed an interview, 5 (0.6%) were excluded owing to parental or student refusal, and 194 (23%) were missed owing to absence or other scheduling conflicts. Another 47 recalls (6%) were eliminated as outliers (cases more than 4 standard deviations from the mean). Valid recall data were provided by 598 students (71%). The majority of the students were White (63%); 51% were male, about 25% participated in the free/reduced lunch program, 70% came from 2-parent households, 43% reported that both parents worked full-time, and 40% had at least 1 parent who had completed college.

School-Level Variables

School lunch program. All schools participated in the USDA's National School Lunch Program and were required to maintain food production records, which included information on participating grades, the number of students served school lunch, and the quantity of food served (note that food served does not equal food consumed). For 14 schools, records were collected and reviewed for 5 consecutive, nonrandomly selected days. Using a standardized protocol, trained nutritionists abstracted the number of school lunches served to students and the number of daily servings of fruits, vegetables (excluding fried potatoes), and fried potatoes. Two schools received meals from a nutrition center and did not keep local records. For these schools, trained evaluation specialists scheduled lunchroom visits for 5 consecutive, nonrandomly selected days and observed and recorded individual students' selections of fruits, vegetables, or both that were offered as part of school lunch. The number of students served lunch was also obtained. Owing to scheduling problems, data for 1 school were collected for only 4 days.

From these data, 3 school-level variables were created representing the mean number of daily servings of fruits, vegetables (excluding fried potatoes), and fried potatoes served to students for every 100 school lunches served.

À la carte programs. Trained evaluation specialists visited schools with à la carte programs and observed and recorded the number of items offered and sold to students on 5 consecutive, nonrandomly selected days. Grams of fat were recorded for snacks. For multivariate analyses, a dichotomous variable was created, with "yes" indicating the availability of a program.

À la carte items were further categorized as either *foods to promote* or *foods to limit*. Foods to promote included snacks containing less than 5 g of fat per serving, 100% fruit juice, bottled water, and 1% and skim milk. This category also included lower-fat versions of high-fat foods, such as baked french fries and school-prepared desserts containing 7 g of fat or less per serving. Foods to limit included all other snacks and sweetened drinks.

Snack and beverage vending and school stores. A trained evaluation specialist met with a school representative on a single, nonrandomly selected day to ascertain the availability of a school store and the location of vending machines accessible to students. The number of machines and store and vending items were observed and recorded. Fat grams for snacks were also recorded. Items were categorized into 3 groupings. "Promote" and "limit" categories were the same as for à la carte. A third category, "items to neither promote nor limit," included lower-fat candies, pastries, nuts, and diet drinks. Two vending variables were used in multivariate analyses. One represented the number of snack machines, school stores, or both; the other represented the number of beverage machines.

Outcome Variables

Five measures from 24-hour dietary recall data were used as outcome measures: total fruit servings per day, total vegetable servings per day, total fruit and vegetable servings per day, and percentage of total energy from total fat and saturated fat. Although intraindividual variability in diet precludes use of a single recall as an accurate representation of individual dietary intake, recalls provide a valid assessment of group-level mean intake.^{17–19} Numerous studies support the validity of this methodology in school-aged children.^{19,20}

Recall interviews were conducted during school hours by trained, certified interviewers following a standardized protocol. Information regarding all foods eaten on the day preceding the interview were obtained and directly entered into the Nutrition Data System (version 2.6/8a/23) at the University of Minnesota's Nutrition Coordinating Center. The Nutrition Data System, an interactive computer-based system, is a comprehensive nutrient database, equipped to report findings at the nutrient level, as well as in servings of fruits and vegetables.²¹

Statistical Analysis

Descriptive statistics were calculated for several variables, including fruits and vegetables served to students at school lunch, foods offered and sold to students à la carte, and snacks and beverages offered in vending machines and school stores.

To evaluate the association between students' dietary behaviors and group-level variables representing the school food environment, mixed-model analysis-of-variance techniques were used. By including school in the model as a random effect, this statistical method accounts for the additional component of variance anticipated when a cluster sampling design is employed and observations obtained from subjects in the same group are likely to be correlated.²² This methodology also incorporates hierarchical linear analysis techniques, which allow school-level predictors to be accurately modeled as group-level covariates, with the denominator degrees of freedom determined from the school component of variance.²³ The linearity of predictor variables modeled as continuous measures was assessed by visual inspection of scatterplots of univariate models.

General linear mixed modeling was used to test all multivariate associations. Each outcome variable was entered into a model together with the 4 hypothesized school-level predictor variables (amounts of fried potatoes served to students at school lunch, number of snack machines/school stores, number of

beverage machines, and presence of an à la carte program). All models included adjustment for potential confounders (sex, race/ethnicity, participation in the free/reduced lunch program, number of parents at home, highest level of education for mother and father, and number of parents working full-time) and for all 2-way interactions between potential confounders. Using a backward stepwise selection method, we removed non-significant predictor variables one at a time until each predictor retained in the model had a *P* value below .05. All analyses were conducted with version 6.12 of SAS/STAT.²⁴

RESULTS

Table 1 presents selected characteristics of the 16 schools. Most were middle schools, and student enrollment ranged from 209 to 1758. Thirteen schools had à la carte programs; the median number of items offered and sold to students per week was 75 (range: 17–233) and 1306 (range: 276–6505), respectively. The overwhelming majority of the foods offered (84%) and sold (93%) were foods to limit.

Snack vending machines were present in 7 schools; the number of machines per school ranged from 1 to 5. One school had a school store. About 80% of snacks offered were from the limit category. All but 1 school had beverage vending machines; the number of machines per school ranged from 1 to 11. The large majority of beverages offered (84%) were from the limit category.

The median number of school lunches served daily to students was 500 (range: 55–738). For every 100 school lunches served, the median number of servings was 49 for fruit (range: 4–113), 30 for vegetables (excluding fried potatoes) (range: 5–135), and 38 for fried potatoes (range: 12–99). Fried potatoes represented 37% of all fruit and vegetable servings and more than half (56%) of all vegetable servings. The most common alternative to school lunch was a “bag lunch” brought from home. The schools studied did not permit students to leave campus to eat.

Table 2 presents the results of the multivariate analysis. In this sample of seventh-grade students, a school à la carte program was significantly and negatively associated with total daily intake of fruits and of fruits and vegetables. On average, students from schools without à la carte programs consumed more than half a serving more of fruits per day than did students in schools with these programs (1.95 vs 1.30 servings; *P* = .005). This difference was more pronounced for total daily servings of fruits and vegetables. Students not exposed to à la carte programs consumed, on average, nearly an entire serving more of fruits and vegetables than did students from schools with such programs (4.23 vs 3.39 servings; *P* = .02).

Availability of a school à la carte program was positively associated with students' mean percentage of daily calories obtained from total and saturated fat. Notably, youths from schools without à la carte programs reported a mean percentage of daily calories from total fat that met the USDA dietary recommendations, whereas those from schools with these programs exceeded the recommendations (28.49% vs 31.08%; *P* = .02). For saturated fat, the difference between the mean percentages for the 2 groups was slightly greater than 1%, with both groups exceeding the rec-

TABLE 1—Selected Characteristics of Schools (n = 16) Participating in Study of School Food Environment and Adolescent Dietary Behaviors: St Paul–Minneapolis, Minn, 1998

Type of District	Grade Levels	1998–1999 Enrollment	No. of Snack Machines	No. of Beverage Machines	Total No. of Machines	À la Carte Program
Urban	6–8	209	0	2	2	No
Suburban	7–8	231	0	3	3	Yes
Urban	K–8	625	0	0	0	No
Suburban	7–8	645	0	1	1	Yes
Suburban	6–8	665	2	2	4	Yes
Urban	6–8	710	5	5	10	Yes
Urban	7–8	717	1	1	2	Yes
Suburban	6–8	784	0	1	1	Yes
Urban	6–8	827	1	2	3	Yes
Suburban	6–8	833	1	2	3	No
Suburban	6–8	909	0	3	3	Yes
Suburban	6–8	937	1 ^a	4	5	Yes
Suburban	6–8	1009	0	2	2	Yes
Suburban	6–8	1061	3	5	8	Yes
Suburban	6–8	1072	0	4	4	Yes
Suburban	7–12	1758	4	11	15	Yes

Note. K = kindergarten.

^aRepresents a school store.

TABLE 2—Association Between School-Level Environmental Factors (n = 16) and Fruit, Vegetable, Total Fat, and Saturated Fat Intake in Young Adolescents (n = 598): St Paul–Minneapolis, Minn, 1998

	Total Daily Servings of Fruit ^a		Total Daily Servings of Vegetables ^a		Total Daily Servings of Fruits and Vegetables ^a		Percentage Daily Calories From Total Fat ^a		Percentage Daily Calories From Saturated Fat ^a	
	Estimate (95% CI)	P	Estimate (95% CI)	P	Estimate (95% CI)	P	Estimate (95% CI)	P	Estimate (95% CI)	P
À la carte										
No	1.95		NS		4.23		28.49		10.41	
Yes	1.30				3.39		31.08		11.47	
Difference	0.65 (0.24, 1.07)	.005			0.84 (0.13, 1.54)	.02	-2.59 (-4.71, -0.47)	.02	-1.06 (-2.02, -0.09)	.03
Snack vending ^b (no. of machines)	-0.11 (-0.20, -0.01)	.03	NS		NS		NS		NS	
Beverage vending (no. of machines)	NS		NS		NS		NS		NS	
Fried potatoes served with SLP (no. of servings)	NS		0.02 (0.006, 0.026)	.004	0.02 (0.006, 0.03)	.009	NS		NS	

Note. CI = confidence interval; NS = nonsignificant at $P > .05$ in preliminary multivariate models; SLP = school lunch program. Values are estimates derived from general linear mixed models.

^aAdjusted for race, sex, socioeconomic status (SES), and race × sex, race × SES, and sex × SES interactions.

^bRepresents 1 school store and 7 vending machines.

ommendations. However, students from schools without à la carte programs exceeded recommendations by less than 0.5%, whereas students exposed to these programs reported mean intakes 1.5% higher than recommended levels ($P = .03$).

School-based snack vending machines were negatively related to the average total daily servings of fruit consumed by the young adolescents in our sample. With each snack vending machine present in a school, students' mean intake of fruit servings declined by 11% ($P = .03$). Fried potatoes' being served to students at school lunch was positively associated with average total daily vegetable intake ($P = .004$) and fruit and vegetable intake ($P = .009$). Beverage vending machines were not associated with fruit or vegetable consumption. Our data also did not support an association between dietary fat intake and snack and beverage vending machines or fried potatoes' being served to students at school lunch.

DISCUSSION

The results presented here support an association between certain factors in the school environment and the dietary behaviors of young adolescents. Perhaps the most striking finding was the significant association between school à la carte programs and students' average daily consumption of

fruits, fruits and vegetables, and total and saturated fat. For each of these food or nutrient groups, students from schools without an à la carte program reported intakes that met or came near to meeting dietary recommendations, whereas students exposed to these programs reported lower intakes of fruits and vegetables and a higher percentage of calories from total and saturated fat. Our results suggest that the primarily high-fat snacks and calorie-dense beverages offered and sold to students via à la carte programs are displacing fruits and vegetables in the diets of young teens and contributing to total and saturated fat intakes that exceed recommended levels.

These results draw attention to an urgent need to evaluate the variety and nutrient quality of the food and beverages offered and sold to students through school à la carte programs. This urgency is compounded by the likelihood that such programs will continue to be offered, given the increasing financial dependence of school food service on revenues generated by à la carte sales, as well as student preference for convenient, tasty fast foods.^{8,9} Our findings, like those of others, indicate that the à la carte items offered to students are disproportionately high-fat snacks and sweetened beverages.^{9–11} Efforts to reverse this ratio so that healthful items are the more plentiful option are sorely needed. If

they are to be successful and sustainable, such efforts will require both creativity and consideration of the revenue-generating needs of school food service. Meaningful policy initiatives at both an organizational and a legislative level, pricing strategies to promote healthy food choice, and limiting availability of such "preferred foods" as sweetened drinks and high-fat snacks are but a few ways to effect such a change.^{1,25–31} Efforts will also be more effective when they are overseen by an advisory group representative of the broader school community.^{1,2,25}

The number of snack vending machines present in a school was negatively correlated with fruit consumption for the seventh graders in our study. As with à la carte foods, the large majority of vending snacks were high-fat items, and most students probably purchased these items. Our results support the notion that more machines at school represent more low-nutrient snack selections and more opportunity to purchase such items. Our findings also suggest that students with access to snack vending machines at school are choosing low-nutrient vending snacks instead of fruit, a practice that undoubtedly contributes to the habituation of unhealthy dietary behavior. Interestingly, snack vending machines did not contribute to dietary fat intake in this sample of young teens, although such an association seems

likely and worth reevaluating, especially if snack vending machines become more common in schools.

Consistent with other studies, our results support the popularity of fried potatoes as a “preferred” vegetable choice by adolescents,^{32,33} and they suggest that when the fruit and vegetable selections offered to students at school lunch include fried potatoes, many choose the fried potatoes. It was not surprising, then, that a majority of our schools offered fried potatoes as a daily lunch item, a practice that is likely to reinforce student preference for high-fat foods. School food service should, instead, be encouraged to adopt practices that support the development of healthy eating patterns, such as limiting how often fried potatoes are offered at school lunch, substituting baked for fried potatoes, and offering more choices of tasty, appealing fruits and vegetables. Although fried potatoes were a popular lunch choice among our student sample, our results did not support an association between fried potatoes and students’ fat intake. Others have suggested that adolescents continue to ingest fat at higher-than-recommended levels in part because of an increased consumption of higher-fat potatoes.³³

Beverage vending machines were not a significant correlate of any of the dietary behaviors we studied. Nevertheless, our findings add to a growing list of similar results indicating that beverage vending machines are common in schools and that most items offered are sweetened beverages.^{8–11} Given the increasing number of youths who are overweight and obese,³⁴ as well as the emergence of type 2 diabetes mellitus in young people,³⁵ the association between adolescent dietary behavior and school-based beverage vending machines deserve further research attention.

These findings have limitations. The cross-sectional nature of our study precludes assumptions related to temporality and causality. However, this design, with its ecological focus, affords a population-level view of the school food environment and its influence on adolescent dietary behavior.^{3–5} Because TEENS was primarily an intervention trial, resources for testing the validity and reliability of school-level measures were not available. To our knowledge, valid and reliable measures of the school food environment do

not exist.³⁶ Our small school sample limited our ability to adequately test certain associations, and replication of this research with a larger sample is warranted. Our schools also formed a convenience sample and may not be representative of most schools attended by middle school–aged youth. Student-level data were self-reported and subject to recall and response bias.

Some may question our use of 24-hour dietary recalls as an outcome measure, as recalls include more than foods consumed at lunchtime or during school hours. We contend that the school food environment and its influence on dietary behavior extend beyond the school lunchroom. Students are exposed to food throughout the school day,^{6,7} and this repeated exposure, especially to less healthful foods and less healthful food choices, is likely to influence food selection outside the school as well.^{3–5} Indeed, our use of 24-hour recalls as the outcome measure yielded findings that suggest that students do *not* compensate for less healthful food choices made at school by choosing more healthful foods when away from school.

In summary, this study is one of the first to examine and demonstrate a negative and adverse association between physical factors in the school food environment—such as à la carte programs, snack vending machines, and fried potatoes’ being served to students at school lunch—and young adolescents’ consumption of fruits, vegetables, and dietary fat. Our findings have important implications for school-based intervention research that aims to promote healthy eating among youthful populations, and they indicate a need to develop and test strategies that target school-level environmental factors, including not only the school lunch program but also other common food venues, such as vending machines and à la carte programs. Young people spend considerable time at school, and attention to the food options and opportunities available to students at school is clearly warranted if healthy eating is to become normative childhood behavior. ■

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Contributors

M. Y. Kubik conceived of the research; was responsible for study design, data analysis, and data interpretation; and wrote the article. L. A. Lytle supervised the study and assisted with study design. P. J. Hannan assisted with study design and supervised the data analysis process. C. L. Perry and M. Story provided advice on school-based dietary interventions and adolescent nutrition.

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Human Participant Protection

This study was approved by the University of Minnesota committee on the use of human subjects in research.

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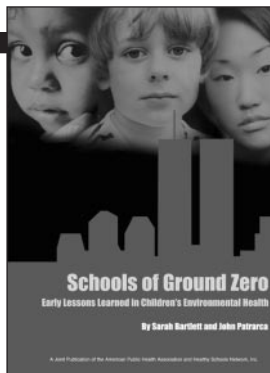
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The Schools of Ground Zero: Early Lessons Learned in Children's Environmental Health

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The *Schools of Ground Zero* is the story of how public school districts in Lower Manhattan dealt with the events of Sept. 11, 2001, and their aftermath. Written by the parents of two children who attend public school in lower Manhattan, this book focuses on the effect that the Sept. 11 attacks had on the physical and mental health of New York City schoolchildren and their parents.

The *Schools of Ground Zero* uses the example of the World Trade Center attacks to illustrate how school officials may be unprepared to cope with emergencies, and uncertain how to proceed after the event. Drawing on interviews with parents, teachers, New York Board of Education officials and environmental consultants, the authors make practical recommendations for safeguarding the health and safety of schoolchildren in times of crisis.



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