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Foods Sold in School Vending Machines are Associated with Overall Student Dietary Intake

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Abstract

Purpose—To examine the association between foods sold in school vending machines and students' dietary behaviors.

Methods—The 2005–2006 US Health Behavior in School Aged Children (HBSC) survey was administered to 6th to 10th graders and school administrators. Students' dietary intake was estimated with a brief food frequency measure. Administrators completed questions about foods sold in vending machines. For each food intake behavior, a multilevel regression analysis modeled students (level 1) nested within schools (level 2), with the corresponding food sold in vending machines as the main predictor. Control variables included gender, grade, family affluence and school poverty. Analyses were conducted separately for 6th to 8th and 9th to 10th grades.

Results—Eighty-three percent of schools (152 schools, 5,930 students) had vending machines which primarily sold foods of minimal nutritional values (soft drinks, chips and sweets). In younger grades, availability of fruits/vegetables and chocolate/sweets was positively related to the corresponding food intake, with vending machine content and school poverty explaining 70.6% of between-school variation in fruit/vegetable consumption, and 71.7% in sweets consumption. In older grades, there was no significant effect of foods available in vending machines on reported consumption of those foods.

Conclusions—Vending machines are widely available in US public schools. In younger grades, school vending machines were related to students' diets positively or negatively, depending on what was sold in them. Schools are in a powerful position to influence children's diets; therefore attention to foods sold in them is necessary in order to try to improve children's diets.

Keywords

Schools; Vending Machines; Foods of Minimal Nutritional Value

Introduction

Children's food choices and eating habits are impacted by a variety of individual and environmental factors (1). The school environment is one important influence that plays a significant role in teaching and modeling eating behaviors to children (2). With demonstrated inadequacies in children's diets (3–5) and the rising rates of overweight children in the US (6), the school food environment is a potentially modifiable factor that has received attention in recent years (7).

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Students have a wide variety of eating options and opportunities in schools, and foods and beverages consumed during the school day provide a significant portion of children's daily nutrient intake (2). The three main sources of foods and beverages consumed in schools are federally reimbursable USDA school nutrition programs (the National School Lunch Program [NSLP] and the School Breakfast Program [SBP]); food and beverages sold in a la carte lines, snack bars, school stores, vending machines or school activities (e.g., fundraisers, classroom parties); and foods brought from home (7). Foods and beverages sold in schools outside of the NSLP or SBP are referred to as "competitive foods". In contrast to NSLP or SBP meals, competitive foods are not required to follow any federal nutrition guidelines and are frequently Foods of Minimal Nutritional Value (FMNV), defined as "those that provide low amounts per portion of specified nutrients (e. g., soft drinks, candy, chips)" (8). Competitive foods are widely available in middle and high schools in the US, and vending machines are the most common provider of these foods with 82% of middle schools and 97% of high schools having vending machines (9). There have been recent measures to try to improve the school food environment. In the Child Nutrition and WIC Reauthorization Act of 2004 (Public Law 108-265), the US Congress established a new requirement that all school districts with a federally-funded school meals program develop and implement wellness policies that address nutrition and physical activity by the start of the 2006-2007 school year. However, it is left to the schools to determine specifically what will be addressed in their wellness policies and how they will implement the policies.

Although it is well-documented that the majority of US schools sell FMNV (9), few studies have examined the association between foods sold in schools and student outcomes. In the Teens Eating for Energy and Nutrition at School (TEENS) study of Minnesota middle school students, a la carte food availability was negatively associated with fruit and fruit/vegetable consumption and positively associated with total and saturated fat intake (10). In addition, having vending machines in schools was negatively associated with fruit consumption. Another study of 8th graders (n=3,088) from the TEENS study examined the relationship between body mass index (BMI) and school-wide food practices (e.g., allowing snacks in the hallways, using food as incentives) (11). For every additional unhealthy food practice that was permitted in the school, BMI of the students increased by 10%. Recently, a study of 9,151 students from 64 middle schools in WA found that sugar sweetened beverage exposure (SSB) at school significantly predicted total SSB consumption ($\beta=0.157$, $p<0.001$) (12). Although these studies provide important data they were each conducted in a single geographic location and included children in a limited age range. More recent data on the availability and consumption of competitive foods in 287 US public schools (grades 1 through 12) from the 3rd School Nutrition Dietary Assessment Study (SNDA-III) (13) indicated that competitive foods were available in 73% of elementary schools, 97% of middle schools and 100% of high schools. In addition, 40% of children consumed one or more competitive foods daily and consumption was highest in high school students. Although the SNDA-III provides important descriptive national data on the school food environment, to date, no national study has examined the relationship of competitive foods available in schools to school-level variation in students' overall dietary intake.

The aim of the current study was to examine the association between foods sold in school vending machines and students' dietary intake. Data were collected as part of the 2005-2006 US Health Behavior in School-aged Children survey. It was hypothesized that foods and beverages available in school vending machines would positively relate to the corresponding food intake in students.

Methods

Study Population

Health Behavior in School-aged Children (HBSC) is a cross-national research study involving 41 countries (14). The US study was designed to provide a national probability sample of students in grades 6 through 10 with an over-sampling of minorities (Hispanics and African-Americans) large enough to provide accurate population estimates (15). A sample of public, religious, and other private schools was derived from the Quality Education Data's list of US schools. The sample design is a two-stage cluster of classes stratified by grade within nine US Census regions.

Student surveys were conducted in school classrooms during the 2005-2006 school year. Surveys regarding school policies were completed by school administrators; 33% were completed by the principal, 27% by an assistant or vice principal, 8% by another administrator and 32% by school staff designated by the principal. Passive or active consent was obtained from parents and students according to school district policy, and participant responses were anonymous. The Institutional Review Board of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) approved the study.

Student Measures

Measures were obtained from standard self-completion questionnaires, which included questions about personal and social resources, health-related behaviors, health outcomes and demographics.

Dietary intake—As part of a brief food frequency questionnaire (FFQ), participants were asked how many times a week they usually ate fruits, vegetables, sweets (chocolates and candy), soft drinks, and chips. French fries were asked as a separate question and were not included in the vegetable category. The response options for the items were coded 1 to 7 for “never,” “less than once a week,” “once a week,” “2-4 days a week,” “5-6 days a week,” “once a day, every day” and “every day, more than once.” This FFQ was previously validated in a sample of Belgian children participating in HBSC (16). In that study, test-retest reliability of the FFQ was conducted and consumption frequencies were compared with a 24-hour food behavior checklist (FBC) and a 7-day food diary. Reliability (weighted kappa values between test and retest) ranged from 0.43 to 0.70, percentage agreement from 37 to 87%, and Spearman correlations from 0.52 to 0.82. Relative validity, comparison of the FBC with the percentage of respondents who should have consumed the food items on a random day, computed from the FFQ, showed good agreement between the FFQ and the FBC for most items. Results from that validation study indicated that the HBSC FFQ had sufficient reliability and validity to rank children's intake according to food items. To correspond with the school administrator survey, in which the variable of fruits/vegetables offered by vending machine was measured as a single item, the mean fruit and vegetable intake for each student was calculated and used as a single outcome variable.

Sociodemographic characteristics—Students were asked their gender (male, female), grade, race/ethnicity (Hispanic/Latino, non-Hispanic Black, non-Hispanic White, Others), and family affluence. The Family Affluence Scale (FAS) was the sum of four items assessing number of family cars, vacations in the past year, home computers, and whether the respondent had his or her own bedroom. Previous research indicates the scale has good content validity and external reliability and may be a more reliable affluence indicator than parent education or occupation when asked of adolescents (17;18). Scores ranged from four to thirteen, with higher value indicating higher level of family affluence.

School measures

Vending machines—School administrators were asked if students could purchase snacks or beverages from a school vending machine. If they answered “yes”, they were asked whether students could buy the following items from the vending machines: 1) fruits/vegetables, 2) chocolates/other candies, 3) soft drinks, and 4) non low-fat salty snacks. Each vending machine variable was coded as a binary variable (yes, no).

School poverty index—The school poverty index was determined by the percent of students who fell below the 2005 federal government poverty guidelines (19).

Statistical Analyses

A separate model was used for consumption of each food, with the corresponding food provided by school vending machine as the main predictor. Control variables included in the models were: gender, grade, and family affluence (student-level), as well as school poverty index (school-level). Due to the hierarchical structure of the data with students (level 1) nested within schools (level 2), multilevel regression models were applied to account for the possible intra-school correlation. To estimate how well the school-level variables (i.e., vending machine and poverty variables) explained between-school variation in student dietary behaviors, the intraclass correlation (ICC) was calculated and compared with the ICC in a reduced model (without these school-level variables). A decline in the ICC coefficient indicates that the between-school differences in student dietary behavior have been reduced by the inclusion of the two school-level explanatory variables.

Analyses were conducted separately for younger (grades 6 to 8) and older grades (grades 9 and 10) since previous studies have reported differences in vending machine availability among grades (13). Descriptive statistics were conducted using SAS (version 9) survey procedures to take into account the sampling design and weights (20). Multilevel analyses were conducted with Mplus (version 5) to account for other complex survey features including stratification and weighting (21). This statistical approach has the advantage of being able to adjust for all three complex survey data features (stratification, clustering, and weighting) in HBSC in order to obtain unbiased estimates and their corresponding standard errors.

Results

Data were collected from students in 222 public schools and 5 private schools. Eighty-five percent ($n=9,016$) of the eligible students participated in the HBSC study. The current analyses are limited to only the public schools ($n = 222$ schools, 8,743 students) because poverty index information was not available for the private schools. Thirty schools (13.5%) were excluded because they did not complete the administrative survey. Of the 192 schools with completed surveys, 9 were missing information about vending machine or school poverty (4.7%). From the remaining 183 schools, 107 of the 7,255 students were missing data on gender, grade, or FAS (1.5%). Of the 183 schools, 152 (83.1%) had vending machines (5,930 students). The percentages of schools with vending machines were 69.8%, 81.1%, 80.9%, 98.2%, and 98.3% for grades 6 through 10, respectively. The difference between the prevalence of vending machines between schools with older grades (grades 9 and 10) and younger grades (grades 6 to 8) was statistically significant (76.0% vs. 98.3%, chi-square statistics = 14.5, $p < 0.001$). Subsequent analyses were restricted to the 152 schools with vending machines (5,930 students).

Table 1 reports the student and school characteristics for younger and older grades separately. Foods and beverages sold in vending machines were frequently FMNV [soft

drinks (76.8% for younger grades and 93.2% for older grades), chips (76.8% for younger grades and 93.2% for older grades), sweets (44.2% for younger grades and 78.0% for older grades)] and less commonly healthy foods [fruits/vegetables (36.8% for younger grades and 47.5% for older grades)].

Table 2 presents data on descriptive statistics of students' dietary behavior, by gender, grade, race and vending machine availability. For example, a mean of 4.66 for fruits/vegetables intake among younger students represents a response between 2 to 4 days a week and 5 to 6 days a week.

Multilevel Regression Analyses

Estimates of regression coefficients in the multilevel regression analyses are presented in Table 3.

Student-level Variables—In the younger age group, there was a significant gender difference in sweets consumption; females reported consuming sweets more frequently than males ($b = 0.369$, $p < 0.001$). FAS also had a significant effect on fruit/vegetable intake, with students reporting higher FAS eating more fruits/vegetables ($b = 0.096$, $p < 0.05$).

In the older age group, females reported less frequent soft drink consumption than males ($b = -0.419$, $p < 0.001$). Students in Grade 10 ate chips less frequently than those in Grade 9 ($b = -0.407$, $p < 0.001$). Higher FAS was associated with more frequent fruit/vegetable consumption ($b = 0.056$, $p < 0.05$) and less frequent soft drink consumption ($b = 0.109$, $p < 0.001$).

School-level Variables

School Poverty: In both younger and older grades, school poverty was negatively associated with fruit/vegetable consumption, and positively related to consumption of soft drinks and chips. In the younger grades, school poverty was also positively related to intake of sweets.

School Vending machine: In the younger grades, availability of food in school vending machines had a significant influence on consumption of both fruits/vegetables ($b = 0.243$, $p < 0.05$) and sweets ($b = 0.344$, $p < 0.01$). That is, students from schools that sold fruits/vegetables in the vending machines consumed more fruits/vegetables than those from schools in which vending machines did not offer fruits/vegetables. Likewise, students from schools selling sweets in the vending machines consumed more sweets than those from schools in which sweets were not offered in the vending machines. There was no significant effect of foods available in vending machines on reported consumption of those foods in students in older grades.

Intraclass Correlations (ICCs)—The amount of within-school and between-school variation in each of the four student dietary behaviors and ICCs were reported in Table 4. To examine how well the school-level variables explained between-school variations of student dietary behaviors, ICCs were compared with those in the models without between-school variables (the reduced model in Table 4). The percentage of decrease in ICC was also reported for each dietary behavior. In the younger grades, the percentages of between-school variation explained by vending machine and school poverty variables were 71%, 72%, 31%, and 28% for student dietary intake of fruits/vegetables, sweets, soft drinks, and chips, respectively. In the older grades, the two school-level variables explained 89% of between-school variation in fruits/vegetables, 42% in soft drinks, and 25% in chips, but effectively none of the between-school variance for sweets.

DISCUSSION

Vending machines are widely available in public schools throughout the US and primarily sell FMNV including soft drinks, chips and sweets (7;13;22,23). Of the public schools that participated in the 2005-2006 HBSC survey, 83% had vending machines and soft drinks were the most common item found in them. Schools with older grades were more likely to have vending machines than those with younger grades which is consistent with previous surveys (9,23).

In this study, the relationship of foods sold in school vending machines to the overall consumption of those foods differed by grade. In younger grades, students from schools that sold fruits/vegetables in vending machines consumed more fruits/vegetables than those from schools in which vending machines did not offer fruits/vegetables. Similarly, students from schools that sold sweets in the vending machines consumed more sweets than those from schools in which sweets were not offered in the vending machines. In older grades, there was no significant effect of foods available in vending machines on reported consumption of those foods. This finding was not anticipated. Among the older grades, the great majority of schools had vending machines selling these items. It is not known how the small number of schools in which these foods were not sold in vending machines may have differed in ways not measured by this study. The difference in effect by grade may be related to differences in parental control of food choices, which is likely greater for younger children. Therefore, when younger students have access to different foods in school vending machines it gives them an opportunity to make their own decisions about what they eat. Another possible explanation for this finding is that FMNV might be more readily available to the older youth in other venues at school (e. g., school stores, snack bars and a la carte sales), and thus intake is less likely to be associated with vending machine availability. Also, teenagers typically have greater access to food outside of school, such as purchases made in convenience stores or fast food restaurants, so vending machines may contribute to a smaller proportion of their daily intake compared to that of younger children.

This study provides a unique contribution, using multilevel analysis of a nationally representative sample to determine whether foods available in school vending machines explained school-level variation in dietary behaviors. Previous studies have examined school vending machines in single geographic locations or have examined student-level means and proportions in larger samples without controlling for or modeling the sampling design. In the current study, when combined with an indicator of school poverty, the types of foods offered in vending machines explained 71%, 72%, 31%, and 28% of between-school variation in younger students dietary intake of fruits/vegetables, sweets, soft drinks, and chips. These results demonstrated that the contents of school vending machines relate to diets positively or negatively, depending on what is sold in them. Therefore, it is important that schools address the quality of foods sold in vending machines in their wellness policies. The Centers for Disease Control and Prevention's School Health Policies and Programs study (SHPPS), which is conducted every 6 years, reported that between the 2000 and 2006 survey years (before and after the wellness policy requirement) there was an increase in the percentage of states and districts that required schools be prohibited from offering "junk food" in vending machines (from 8.0% to 32.0% among states and from 4.1% to 29.8% among districts) (23). Our study was conducted prior to the 2006 requirement to implement school wellness policies so it would be interesting to examine more recent HBSC data to determine if improvements have been made in what foods schools typically sell in their vending machines and, if so, how this has impacted students' dietary intake since this was not examined in SHPPS. It is particularly important to focus on the quality of foods sold in vending machines in less affluent schools since school poverty was negatively associated with fruit/vegetable consumption, and positively related to consumption of soft drinks and

chips in all grades (and positively related to sweets in younger grades). It would also be interesting to determine if improving the quality of the foods available in school vending machines has any effect on school performance since a recent case study reported an association between school performance indicators with the implementation of a program aimed at improving the school food environment. (24)

The study methods have some limitations. A key limitation is that the measure of dietary intake used was a brief FFQ, necessitated by the nature of the HBSC study, which measures a broad spectrum of constructs in a single self-report questionnaire. It is known that people tend to misreport food intake with underreporting being the greatest among females and those who are overweight (25). However, brief FFQ's have shown utility for ranking samples and testing associations with other variables, even if the estimate of individual dietary intake is imprecise (26). Also, the HBSC survey is cross-sectional which precludes drawing any conclusions about causality.

In summary, data from this study as well as other studies have demonstrated that the school food environments in US schools need improvements. Schools are in a powerful position to influence children's dietary intake during a substantial portion of their day; therefore attention to what foods they sell is necessary in order to try to improve children's diets.

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Characteristics of Students and Public Schools with Vending Machines from the 2005-06 Health Behavior in School-aged Children Survey

Table 1

Category/Variable	Younger Grades (Grades 6 to 8)			Older Grades (Grades 9 to 10)		
	N	Percent	Mean (SE)	N	Percent	Mean (SE)
Student-Level						
Total N of Students	3692			2238		
Gender						
Male	1761	48.7%		1117	49.8%	
Female	1931	51.3%		1121	50.2%	
Grade						
Grade 6	1299	28.9%				
Grade 7	1215	37.9%				
Grade 8	1178	33.2%				
Grade 9				1079	51.0%	
Grade 10				1159	49.0%	
Race						
White	1566	42.2%		1113	46.2%	
African	783	15.8%		474	19.4%	
Hispanic	848	25.7%		447	24.5%	
Other	470	16.3%		201	9.9%	
FAS			9.78(0.14)			9.78 (0.13)
School-Level						
Total N of Schools	95 ^a			59 ^a		
School Poverty			40.1 (23.4)			36.2 (23.4)
Vending Machine						
Fruits	35	36.8%		28	47.5%	
Sweet	42	44.2%		46	78.0%	
Soft drinks	73	76.8%		55	93.2%	
Chips	54	56.8%		47	79.9%	

Two schools were selected for both younger grades and older grades in the 2005-06 HBSC survey.

Table 2

Descriptive Statistics of Students' Dietary Behavior ($N = 5930$)

Grades 6 to 8 ($N = 3692$)		Fruits/ Vegetables		Sweets		Soft Drinks		Chips	
Categories	<i>M^a</i>	<i>SE^b</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>
Total	4.66	0.06	4.37	0.05	4.38	0.07	4.26	0.07	
Gender									
Male	4.67	0.06	4.21	0.07	4.50	0.08	4.28	0.07	
Female	4.66	0.08	4.52	0.07	4.26	0.09	4.24	0.09	
Grade									
Grade 6	4.77	0.13	4.27	0.10	4.28	0.16	4.31	0.12	
Grade 7	4.67	0.08	4.39	0.07	4.35	0.08	4.22	0.10	
Grade 8	4.56	0.06	4.44	0.09	4.50	0.12	4.26	0.11	
Race									
White	4.84	0.07	4.27	0.06	4.19	0.11	3.92	0.06	
African	4.51	0.06	4.92	0.10	4.88	0.10	5.10	0.10	
Hispanic	4.44	0.08	4.13	0.08	4.36	0.07	4.27	0.09	
Other	4.71	0.13	4.53	0.10	4.46	0.12	4.35	0.12	
Vending Machine									
No	4.57	0.07	4.30	0.05	4.27	0.15	4.08	0.07	
Yes	4.84	0.08	4.47	0.10	4.42	0.08	4.39	0.06	

Grades 6 to 8 ($N = 2238$)		Fruits/ Vegetables		Sweets		Soft Drinks		Chips	
Categories	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>
Total	4.41	0.05	4.47	0.06	4.42	0.08	4.00	0.09	
Gender									
Male	4.37	0.06	4.27	0.09	4.60	0.09	4.02	0.09	
Female	4.44	0.06	4.67	0.11	4.25	0.10	3.98	0.12	
Grade									
Grade 9	4.34	0.06	4.56	0.08	4.47	0.08	4.17	0.09	
Grade 10	4.48	0.07	4.37	0.08	4.38	0.11	3.82	0.12	

Grades 6 to 8 (N = 2238)		Fruits/ Vegetables		Sweets		Soft Drinks		Chips	
Categories	M	SE	M	SE	M	SE	M	SE	
Race									
White	4.57	0.05	4.41	0.08	4.18	0.11	3.62	0.07	
African	4.15	0.07	5.17	0.07	5.06	0.11	4.97	0.15	
Hispanic	4.09	0.09	4.12	0.10	4.59	0.09	4.08	0.11	
Other	4.95	4.95	4.19	4.19	3.88	3.88	3.64	3.64	
Vending Machine									
No	4.35	0.08	4.47	0.12	4.24	0.24--	4.13	0.25	
Yes	4.45	0.07	4.47	0.08	4.44	0.08	3.95	0.11	
Note:									

Note:

^a Scales of response categories are (1) *Never*, (2) *Less than once a week*, (3) *Once a week*, (4) *2-4 days a week*, (5) *5-6 days a week*, (6) *once daily*, and (7) *more than once daily*.

^b SE = Standard Error of the Mean: Analyses of the complex survey data gave the standard error of the mean.

Table 3

Estimates of Regression Coefficients in the Multilevel Regression Analyses

Predictors	Younger Group (Grade 6 to 8) (N = 3692)				Older Group (Grade 9 to 10) (N = 2238)			
	Fruits/ Vegetables	Sweets	Soft Drinks	Chips	Fruits/ Vegetables	Sweets	Soft Drinks	Chips
<i>N</i>	3631	3613	3621	3604	2207	2207	2207	2212
Level 1								
Female	.152	.369***	-.152	.145	-.081	.194	-.419***	.055
Grade	-.088	.153	.089	.074	.009	-.253	-.050	-.407***
FAS	.096*	.010	-.025	.014	.056*	-.037	-.109***	-.090
Level 2								
Vending Machine	.243*	.344**	.109	.215	.072	-.218	.098	-.169
School Poverty	-.011***	.009***	.012***	.011*	-.008***	.003	.011***	.015*

Note.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 4

Within and Between School Variances and ICCs in the Full and Reduced Models

Predictors	Younger Group (Grade 6 to 8) (N = 3692)				Older Group (Grade 9 to 10) (N = 2238)			
	Fruits/ Vegetables	Sweets	Soft Drinks	Chips	Fruits/ Vegetables	Sweets	Soft Drinks	Chips
Full Model								
Within	2.405	3.218	3.503	3.014	2.173	3.091	3.962	2.987
Between	0.048	0.042	0.206	0.196	0.004	0.102	0.147	0.341
ICC	0.020	0.013	0.056	0.061	0.002	0.032	0.036	0.102
Reduced Model^a								
Within	2.428	3.256	3.516	3.025	2.192	3.131	4.032	3.055
Between	0.178	0.156	0.311	0.281	0.041	0.101	0.267	0.481
ICC	0.068	0.046	0.081	0.085	0.018	0.031	0.062	0.136
Full Model								
Decrease in ICC	70.6%	71.7%	30.9%	28.2%	88.9%	-3.2%	41.9%	25.0%

Note:

^aThe full model includes school-level variables (i.e., vending machine and poverty variables); the reduced model does not.