

Accessibility Over Availability: Associations Between the School Food Environment and Student Fruit and Green Vegetable Consumption

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Abstract

Background: No national studies have examined associations between (1) school food availability and accessibility and (2) secondary student fruit and vegetable (FV) consumption. This article uses 5 years of nationally representative data from secondary school students to examine associations between the school food environment and student fruit and green vegetable consumption.

Methods: From 2008 to 2012, cross-sectional, nationally representative data from US middle and high school students were collected annually on self-reported fruit and green vegetable consumption. Each year, data from administrators at each relevant school were collected on food item availability (any venue) and accessibility (total number of school sources). Data were obtained from 10,254 eighth-grade students in 317 schools and 18,898 tenth- and 12th-grade students in 518 schools. Associations were estimated by multi-level models controlling for student- and school-level characteristics.

Results: Availability showed minimal association with student consumption. Candy/regular-fat snack accessibility was associated negatively with middle school fruit consumption. Salad bar availability and accessibility were positively associated with middle school green vegetable consumption; FV accessibility was associated positively with high school fruit and green vegetable consumption. Significant associations were consistent across student racial/ethnic and socioeconomic groups.

Conclusions: Forthcoming USDA nutrition standards for school foods and beverages sold outside of reimbursable meal programs should result in the removal of school candy/regular-fat snacks. In deciding which items to make available under the new standards, schools should consider increasing the number of FV sources—including salad bars—thereby potentially increasing student FV consumption.

Introduction

The 2010 Dietary Guidelines for Americans call for increased fruit and vegetable (FV) consumption for the following reasons: (1) Fruits and vegetables contribute significant amounts of many nutrients that are currently underconsumed in the United States (including dietary fiber, folate, vitamins, potassium, and phytochemicals); (2) FV consumption has been associated with significantly reduced chronic disease risk; and (3) FV consumption (prepared without added fats or sugars) may help with healthy weight maintenance through displacement of more energy-dense foods.¹ Healthy People 2020 objectives specifically call for increases in not only the variety and contribution of fruits and vegetables to US diets, but also the proportion of school districts requiring schools within district boundaries to make fruits or vegetables available wherever other food is offered or sold on

school grounds.² Research with elementary and middle school students on overall food consumption found that both availability (whether a specific food item is present) and accessibility (whether a food item is available in a form, location, and time facilitating consumption) were associated positively with FV consumption.³

Recent reviews of school-based interventions to increase adolescent FV consumption⁴⁻⁶ indicate that whereas the majority of reviewed studies focused on elementary school populations, a limited number have addressed middle or high school students. Reviews generally indicate that student fruit consumption may be moderately improved by school-based interventions, but student vegetable consumption shows minimal impact.^{4,5} Factors showing significant associations with student FV consumption⁶ include FV availability (positive associations), presence of competitive venues, such as vending machines, stores/snack bars/carts, and à la carte cafeteria sales (negative associations), and school lunch

participation (positive associations). A national study of fifth graders indicated that in schools without snack food restrictions, student FV consumption was significantly lower than in schools with restrictions.⁷ The same national study also indicated that middle school student FV consumption sensitivity to the school competitive food environment may be heightened for low-income students.⁸ None of the reviewed studies compared associations between school food item availability and accessibility across a variety of food groups and venues and student FV consumption using nationally representative samples of both middle and high school students.

The current study used national data to investigate secondary school FV and snack food availability and accessibility and their associations with student self-reported daily FV consumption (including consumption in and out of school) through three research questions: Is school food group availability associated with student FV consumption?; Is accessibility as indicated by the total number of school sources of a given food group associated with student FV consumption?; and If associations are observed, do they hold across racial/ethnic and socioeconomic groups?

Methods

Study Setting and Data Collection

Student data were obtained from the Monitoring the Future (MTF) study using in-school questionnaires from annual nationally representative cross-sectional samples of 8th-, 10th-, and 12th-grade students from 2008 to 2012.⁹ School data were obtained from administrators in MTF schools through the Youth, Education, and Society (YES) study using mailed questionnaires.^{10,11} Both studies were conducted by the Institute for Social Research at the University of Michigan (Ann Arbor, MI; approval obtained from the University of Michigan Behavioral Sciences Institutional Review Board; procedures followed were in accord with institutional and national committee standards).

Self-completed, optically scanned student questionnaires were administered in classrooms by University of Michigan personnel during a normal class period (detailed MTF methodology information can be found elsewhere^{9,12}). From 2008 to 2012, the overall school response rate (with replacement) averaged 97%; student response rates averaged 90%, 87%, and 82% for 8th, 10th, and 12th grades, respectively. Absenteeism was the primary reason for missing data; less than 1% of students refused participation.

Mailed questionnaires with a monetary incentive were sent to each sampled school's principal in the spring of the same year in which student data were gathered (detailed YES methodology information can be found elsewhere¹⁰). School administrator response rates averaged 83%. Principals or other administrators completed items on general school characteristics. It was suggested that food service personnel complete detailed venue and food item availability questions; this occurred in 47% of schools. To minimize errors, participants providing incomplete or in-

consistent answers were recontacted by research staff to clarify or complete the information requested.

Measures

Student consumption. The MTF survey is intended to monitor student substance use, but it also measures many variables that might help to explain use. A limited number of items are included to assess other health-related behaviors, including dietary behavior. Students were asked, "How often do you... Eat at least some green vegetables? Eat at least some fruit?" (No additional definitions of, or prompts for, fruit or green vegetable responses were provided.) Response options included never, seldom, sometimes, most days, nearly every day, and every day. For both fruits and green vegetables, three measures were coded for analysis: *consumption frequency* (ranging from never [0] to every day [5]); *regular consumption prevalence* (nearly every day/every day vs. other); and *daily consumption prevalence* (every day vs. other). The focus on green vegetable consumption only is a clear limitation; efforts to improve population health have called for increased consumption of dark green as well as red/orange vegetables and legumes.² Though green vegetable consumption is not a proxy for total vegetable consumption, the behaviors likely correlate significantly and positively. Online analyses using 2011 national Youth Risk Behavior Survey data of US 9th–12th-grade students¹³ produced correlations between green salad, carrot, and other nonpotato vegetable consumption frequency ranging from 0.43 to 0.46 ($p < 0.0001$). Though MTF measures were only single-item, calculated reliability estimates were acceptable (0.60 for fruit and 0.64 for green vegetables). Fruit consumption prevalence estimates and trends over time are similar to those observed in other national population studies using similar methodologies, such as the Youth Risk Behavior Surveillance System¹⁴ and the National Youth Physical Activity and Nutrition Study¹⁵ (see online Supplementary Figs. 1 and 2) (see online supplementary material at www.liebertpub.com/chi). (Vegetable consumption measures were not comparable between the studies.)

School food items. Administrators were asked whether students had access to a variety of food items in competitive venues and/or the school lunch meal (see Table 1). Based on individual item correlations,* the following five food item groupings were created: (1) candy/regular-fat snacks (candy, regular-fat salty snacks, regular-fat baked goods, and regular-fat dairy desserts/yogurt); (2) low-fat snacks (low-fat salty snacks, low-fat baked goods, and low-fat dairy desserts/yogurts); (3) fruits and vegetables (fresh fruit, dried/canned fruit, and vegetables excluding

*Correlations between individual food items included Pearson's r (for correlations between total number of possible sources for each specific item) and tetrachoric correlations (for dichotomous any/none school prevalence measures for each specific item).

Table 1. Food Item Measures and Groupings

Food groupings with questionnaire text ^a	Availability in specific venues ^b				Total possible sources ^c
	Vending	Stores/snack bars/carts	À la carte sales	School lunch meal	
Candy/regular-fat snacks					16
Candy	•	•	•	•	
Salty snacks that are <i>not low in fat</i> , such as regular potato chips	•	•	•	•	
Cookies, crackers, cakes, or other baked goods that are <i>not low in fat</i>	•	•	•	•	
Ice cream or frozen yogurt that is <i>not low in fat</i>	•	•	•	•	
Low-fat snacks					12
<i>Low-fat</i> salty snacks, such as pretzels, baked chips, or other <i>low-fat</i> chips	•	•	•	•	
<i>Low-fat</i> cookies, crackers, cakes, pastries, or other <i>low-fat</i> baked goods	•	•	•	•	
<i>Low-fat</i> or <i>fat-free</i> ice cream, frozen yogurt, sherbet, or <i>low-fat</i> or <i>nonfat</i> yogurt	•	•	•	•	
Fruits and vegetables					12
Fresh fruit	•	•	•	•	
Other fruit (such as dried or canned fruit)	•	•	•	•	
Vegetables (excluding potatoes)	•	•	•	•	
Premade salads					4
Premade, main course salads (such as chef's salad)	•	•	•	•	
Salad bar					2
Salad bar			•	•	

^aFood groupings used in analyses are in bold font; questionnaire wording used for items within food groupings is then provided.

^bIf indicated with a dot, availability of the food item(s) listed was asked about for the venue specified.

^cAccessibility for each food group is indicated by the count of total possible school sources. For example, the candy/regular-fat snack grouping included four item types, and availability of each of the four types was measured in four specific venues ($4 \times 4 = 16$).

potatoes); (4) premade salads; and (5) salad bar.[†] Two measures were created for each food item group (see Table 1): *Availability* indicated any school prevalence; *accessibility* measured the total number of school sources, indicating the degree to which food group items might be available in a form, location, and/or time facilitating consumption. For example, schools with fresh fruit and vegetables in the school lunch meal—but no other sources of these items or of dried/canned fruit—would receive a score of “2” for accessibility. Schools with fresh fruit and vegetables in the school lunch meal, fresh fruit in the school store, and dried/canned fruit available in vending machines, stores, and à la carte lines would receive a score of “6” for accessibility. Accessibility measures did not incorporate hours of vending machine or school/student store operation.

[†]No significant correlation was observed between premade salads and salad bar; thus, these items were neither combined with fruits and vegetables nor with one another to form a combined salad measure.

Control variables. Student-level demographic measures shown to be associated with adolescent dietary consumption^{6,15–17} included self-reported gender, race/ethnicity, two-parent family, and average parental education (used as a proxy for socioeconomic status (SES), because student-level data on free and reduced price lunch eligibility were not available). School-level controls shown to be associated with the school nutrition environment included type and number of competitive venues available, school level (middle vs. high school), grade (10 vs. 12, for high school models), percentage of students eligible for free and reduced-price lunch, majority student race/ethnicity, population density, and region.¹¹

Statistical Analysis

Analyses were conducted using Stata statistical software (v12.1; StataCorp LP, College Station, TX). The GLLMM procedure was used for multi-level modeling. Analyses included appropriately scaled weights to adjust for differential

Table 2. Descriptive Statistics

	Range ^a	Middle school ^b		High school ^c	
		Mean ^d	(SE)	Mean	(SE)
Student consumption					
Fruit consumption					
Frequency ^e	0–5	3.667	(0.023)	3.359	(0.018)
Regular prevalence ^f	0,1	0.591	(0.008)	0.477	(0.006)
Daily prevalence ^g	0,1	0.360	(0.008)	0.261	(0.005)
Green vegetable consumption					
Frequency	0–5	3.158	(0.030)	3.060	(0.020)
Regular prevalence	0,1	0.455	(0.009)	0.399	(0.006)
Daily prevalence	0,1	0.258	(0.007)	0.209	(0.005)
School food items					
Candy/regular-fat snacks ^h					
Availability ⁱ	0,1	0.799	(0.026)	0.827	(0.020)
Accessibility ^j	0–15	3.345	(0.214)	4.682	(0.195)
Low-fat snacks ^k					
Availability	0,1	0.938	(0.015)	0.965	(0.009)
Accessibility	0–12	4.519	(0.175)	5.729	(0.141)
Fruits and vegetables ^l					
Availability	0,1	0.993	(0.004)	0.997	(0.001)
Accessibility	0–12	5.026	(0.131)	5.936	(0.108)
Premade salads					
Availability	0,1	0.837	(0.022)	0.894	(0.015)
Accessibility	0–4	1.435	(0.055)	1.778	(0.049)
Salad bars					
Availability	0,1	0.386	(0.032)	0.494	(0.026)
Accessibility	0–2	0.614	(0.055)	0.774	(0.045)
Competitive venue availability measures					
Any vending machines	0,1	0.734	(0.028)	0.960	(0.009)
Any stores/snack bars/carts	0,1	0.424	(0.033)	0.611	(0.024)
Any à la carte	0,1	0.766	(0.028)	0.862	(0.017)
Competitive venue density					
No competitive venues	0,1	0.067	(0.016)	0.008	(0.004)
Vending only	0,1	0.090	(0.018)	0.065	(0.011)
Store/snack bar/cart only	0,1	0.041	(0.013)	0.008	(0.004)
À la carte only	0,1	0.102	(0.019)	0.010	(0.004)
Vending and stores/snack bars/carts	0,1	0.039	(0.014)	0.059	(0.012)
Vending and à la carte	0,1	0.318	(0.032)	0.308	(0.023)
Store/snack bar/cart and à la carte	0,1	0.055	(0.014)	0.014	(0.006)
All competitive venues	0,1	0.287	(0.030)	0.528	(0.026)
Student controls					
Male	0,1	0.492	(0.007)	0.494	(0.005)

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Table 2. Descriptive Statistics *continued*

	Range ^a	Middle school ^b		High school ^c	
		Mean ^d	(SE)	Mean	(SE)
Race/ethnicity					
White	0,1	0.572	(0.019)	0.603	(0.015)
African American	0,1	0.107	(0.010)	0.105	(0.008)
Hispanic	0,1	0.140	(0.014)	0.138	(0.010)
Other	0,1	0.181	(0.010)	0.153	(0.006)
Average parental education	1–6	4.123	(0.039)	3.975	(0.030)
Two-parent household	0,1	0.754	(0.008)	0.710	(0.007)
School controls					
Race/ethnicity					
≥ 66% white	0,1	0.564	(0.033)	0.578	(0.026)
> 50% African American	0,1	0.046	(0.012)	0.054	(0.010)
> 50% Hispanic	0,1	0.094	(0.021)	0.076	(0.014)
All other	0,1	0.296	(0.031)	0.292	(0.024)
Percentage of students eligible for free and reduced-price lunch					
Less than 15% eligible	0,1	0.195	(0.024)	0.210	(0.021)
15–39% eligible	0,1	0.286	(0.032)	0.370	(0.025)
40% or more eligible	0,1	0.519	(0.033)	0.420	(0.025)
Population density					
Urban	0,1	0.228	(0.029)	0.213	(0.021)
Suburban	0,1	0.505	(0.033)	0.520	(0.026)
Rural	0,1	0.267	(0.028)	0.267	(0.022)
Region					
South	0,1	0.373	(0.032)	0.334	(0.024)
Northeast	0,1	0.161	(0.022)	0.171	(0.018)
Midwest	0,1	0.237	(0.026)	0.267	(0.022)
West	0,1	0.229	(0.031)	0.229	(0.023)

Total possible *N* for middle school: 10,254 students in 317 schools; total possible *N* for high school: 18,898 students in 518 schools. For student consumption and school food item measures, *N*s ranged from 10,025 to 10,204 for middle school and from 18,549 to 18,846 for high school.

^aDichotomous measures are indicated by a range of 0,1.

^bMiddle school = grade 8.

^cHigh school = grades 10 and 12.

^dMeans for dichotomous measures (those with a range of 0,1) are expressed as proportions.

^eConsumption frequency categories included never (0), seldom (1), sometimes (2), most days (3), nearly every day (4), and every day (5).

^fRegular consumption prevalence defined as nearly every day and every day versus other.

^gDaily consumption prevalence defined as every day versus other.

^hIncludes candy as well as any regular-fat items: salty snacks; baked goods; and frozen dairy desserts/yogurt.

ⁱAvailability indicates any school prevalence (regardless of number of school sources).

^jAccessibility indicates total number of school sources; possible scores varied based on food grouping. For example, the candy/regular-fat snack grouping included four item types, and availability of each of the four types was measured in four specific venues ($4 \times 4 = 16$). In contrast, premade salads included only one item that could be available in each of the four school venues ($1 \times 4 = 4$), and salad bars could be available only in à la carte sales or the school lunch meal ($1 \times 2 = 2$).

^kIncludes any low-fat items: salty snacks; baked goods; and frozen dairy desserts/yogurt.

^lIncludes fresh fruit, other fruit, and vegetables (excluding potatoes).

SE, standard error.

selection probability. Availability models controlled for competitive venue availability type. Accessibility models controlled for both the type and number of competitive venues. All models included year dummy variables. Results are presented separately for middle school (eighth grade) and high school (10th and 12th grades). Analytical sample sizes were 10,254 eighth-grade students in 317 schools and 18,898 tenth- and 12th-grade students in 518 schools. Analyses indicated similar results for consumption frequency and prevalence measures; for brevity, results focus only on consumption prevalence.

Results

Table 2 presents descriptive statistics for all measures. Overall, 59% of middle and 48% of high school students reported eating fruit regularly (nearly every day/every day); 36% of middle and 26% of high school students reported eating fruit daily (every day). Overall, green vegetable consumption was somewhat lower; regular consumption was reported by 46% of middle and 40% of high school students; daily consumption was reported by only 26% of middle and 21% of high school students. (Readers are reminded that student fruit and green vegetable measures were for consumption both in and out of school.)

Additional bivariate analyses (see Supplementary Table 1) (see online supplementary material at www.liebertpub.com/chi) indicated significant differences in fruit and green vegetable consumption rates by student race/ethnicity and student SES, as indicated by average parental education. Daily fruit and green vegetable consumption was reported by significantly more white than African American or Hispanic middle and high school students ($p < 0.01$). High-SES students reported significantly higher daily fruit and green vegetable consumption prevalence than mid- or low-SES students at both the middle and high school levels ($p < 0.001$ for all comparisons).

As reported by previous studies,¹¹ middle school students had lower competitive venue availability than their high school peers. In the current analytical sample, vending machines were available to 73% of middle and 96% of high school students; respective rates for stores/snack bars/carts were 42% and 61%, and rates for à la carte were 77% and 86%. Twenty-nine percent of middle school students attended schools with all three competitive venues, whereas 53% of their high school peers did so.

As shown in Table 2, FV availability (any school prevalence) was almost universal—over 99%. The high availability was driven primarily by the school lunch meal; competitive venue FV availability was 66% for middle and 84% for high school students. There was significant variation in FV accessibility (total number of school sources indicating the degree to which food group items might be available in forms, locations, and/or times facilitating student consumption). The mean number of FV sources was 5 for middle school and 6 for high school students, but ranged from 0 to 12.

Models examining school food availability and student fruit or green vegetable consumption simultaneously included candy/regular-fat snacks, low-fat snacks, premade salads, and salad bars (school FV availability not included because of the almost universal availability noted previously). No availability measures were significantly associated with student fruit consumption or high school student green vegetable consumption. For middle school students, salad bar availability was associated with significantly higher regular consumption of green vegetables (adjusted odds ratio, 1.12; 95% confidence interval, 1.01–1.25; $p = 0.028$; data not shown). No other significant associations were observed.

Models examining school food accessibility and student fruit or green vegetable consumption simultaneously included all five food group types. Multivariate results are presented in Table 3. Higher accessibility of candy/regular-fat snacks was associated with *lower* regular fruit consumption among middle school students. Predicted probabilities of regular fruit consumption dropped from 61% in middle schools with no candy/regular-fat snacks to 57% in schools with nine or more[‡] sources of candy/regular-fat snacks. Among high school students, higher FV accessibility was associated with *higher* fruit consumption (regular and daily consumption prevalence) and *higher* green vegetable consumption (regular consumption prevalence). In high schools with three or fewer FV sources, compared with schools with nine or more sources, the following predicted probabilities were observed: 45% versus 51% for regular fruit consumption; 25% versus 29% for daily fruit consumption; and 38% versus 43% for regular green vegetable consumption. Among middle school students, higher salad bar accessibility was associated with higher green vegetable consumption (regular and daily consumption prevalence). For regular green vegetable consumption, predicted probabilities rose from 44% for students in schools with no salad bars to 47% in schools with salad bars offered in both school lunch meals and à la carte lines; predicted probabilities for daily green vegetable consumption rose from 24% to 27%.

For all significant associations noted above, additional models were run to investigate any evidence for differences by either student race/ethnicity or SES (separately) using interaction terms. No significant interactions were observed.

Discussion

This article investigated associations between school food group availability and accessibility and student fruit and green vegetable consumption (including consumption in and out of school) in a nationally representative sample

[‡]Because of comparatively low Ns in either the upper or lower range of various accessibility scores, predicted probabilities were averaged for these values to obtain more stable estimates.

Table 3. Multivariate Associations Between US School Food Item Accessibility and Student Fruit or Green Vegetable Consumption, 2008–2012

Outcome	Food accessibility ^a predictors	Middle school ^b			High school ^c		
		AOR	(95% CI)	p value	AOR	(95% CI)	p value
Fruit consumption							
Regular prevalence ^d	Candy/regular-fat snacks ^e	0.979	(0.962–0.997)	0.021	0.998	(0.987–1.009)	0.766
	Low-fat snacks ^f	1.004	(0.980–1.029)	0.735	0.993	(0.978–1.008)	0.343
	Fruits and vegetables ^g	0.992	(0.957–1.028)	0.662	1.033	(1.009–1.058)	0.007
	Premade salads	0.952	(0.887–1.023)	0.179	0.981	(0.925–1.040)	0.522
	Salad bar	1.024	(0.962–1.089)	0.458	1.020	(0.974–1.068)	0.406
Daily prevalence ^h	Candy/regular-fat snacks	0.986	(0.969–1.003)	0.106	1.001	(0.988–1.015)	0.826
	Low-fat snacks	0.996	(0.973–1.020)	0.750	0.988	(0.972–1.005)	0.167
	Fruits and vegetables	0.994	(0.962–1.028)	0.733	1.039	(1.010–1.068)	0.007
	Premade salads	0.969	(0.911–1.031)	0.320	0.972	(0.907–1.042)	0.423
	Salad bar	0.986	(0.926–1.051)	0.673	1.014	(0.963–1.068)	0.589
Green vegetable consumption							
Regular prevalence	Candy/regular-fat snacks	0.986	(0.969–1.002)	0.093	0.989	(0.977–1.001)	0.082
	Low-fat snacks	1.017	(0.991–1.043)	0.214	1.002	(0.985–1.019)	0.835
	Fruits and vegetables	0.981	(0.944–1.020)	0.340	1.034	(1.008–1.061)	0.011
	Premade salads	1.008	(0.936–1.086)	0.827	0.958	(0.897–1.022)	0.195
	Salad bar	1.071	(1.008–1.137)	0.027	1.027	(0.977–1.079)	0.296
Daily prevalence	Candy/regular-fat snacks	0.991	(0.973–1.010)	0.338	0.991	(0.976–1.006)	0.226
	Low-fat snacks	0.996	(0.972–1.021)	0.749	0.998	(0.980–1.017)	0.873
	Fruits and vegetables	0.997	(0.960–1.036)	0.884	1.031	(0.999–1.065)	0.061
	Premade salads	0.990	(0.923–1.063)	0.787	0.977	(0.913–1.045)	0.496
	Salad bar	1.073	(1.006–1.145)	0.033	1.020	(0.962–1.081)	0.506

All food item accessibility measures entered simultaneously. All models controlled for student characteristics (gender, race/ethnicity, parental education, and number of parents in the home), school characteristics (presence of each of the three types of competitive venues and number of venues using competitive venue density category dummy terms, student body majority race/ethnicity, percent of students eligible for free and reduced price lunch), population density, region, and year. High school models also controlled for grade. Missing data for student control measures handled by imputing means (for continuous measures) together with the use of missing data indicators; no substantive differences were found, when compared with results from complete-case analysis. Estimates for missing data indicators not shown. Fruit consumption model Ns: 9836 middle school students in 310 schools; 18,060 high school students in 504 schools. Green vegetable consumption model Ns: 9969 middle school students in 310 schools; 18,208 high school students in 504 schools. Bold font indicates statistical significance ($p < 0.05$ or less).

^aAccessibility indicates total number of school sources for each food type (regardless of venue).

^bMiddle school = grade 8.

^cHigh school = grades 10 and 12.

^dRegular consumption prevalence defined as nearly every day and every day versus other.

^eIncludes candy as well as any regular-fat items: salty snacks; baked goods; and frozen dairy desserts/yogurt.

^fIncludes any low-fat items: salty snacks; baked goods; and frozen dairy desserts/yogurt.

^gIncludes fresh fruit, other fruit, and vegetables (excluding potatoes).

^hDaily consumption prevalence defined as every day versus other.

AOR, adjusted odds ratio; CI, confidence interval.

of secondary students. Results indicated that availability showed few significant associations with secondary student fruit and green vegetable consumption. Instead, accessibility was more likely to relate significantly to student consumption and—where associations were found—do so consistently across student racial/ethnic and socioeconomic groups.

School FV availability was virtually universal, but as FV accessibility increased, the likelihood of high school students consuming fruits and green vegetables on a regular basis also increased. Salad bars showed significant associations with middle school student green vegetable consumption in both availability and accessibility analyses. Increasing the total number of school FV sources increases the likelihood that these items will be available in both locations and times facilitating consumption. Several studies reviewed by Krølner and colleagues¹⁸ reported that students often made choices between eating healthfully and time, either to be able to sleep longer or to not spend time waiting in cafeteria lines during short lunch periods. Qualitative studies of determinants of adolescent FV consumption have found that children routinely complain about the quality and appearance of fruits and vegetables served in school¹⁸ and state a preference for salads, salad bars, and bite-sized/sliced fruit options that are as visible and promoted as much as unhealthy food items.^{19–21} The current study found that whereas salad bars were associated with significantly increased middle school green vegetable consumption, premade salads were not. The difference in observed associations may be related to marked differences in availability of premade salads, compared to salad bars for middle school students (84% vs. 39%). Differences may also be related to the element of individual choice provided by salad bars over premade salads.

A detrimental association between candy/regular-fat snacks and middle school fruit consumption was observed in the current study, and results approached traditional significance levels for detrimental associations with candy/regular-fat snacks and both middle and high school green vegetable consumption. Qualitative research has indicated that students themselves identify pervasive exposure to unhealthy foods in the school environment as a reason for low FV consumption.¹⁸

The fact that associations were observed with salad bars for middle school students (but not high school students) and with fruits and vegetables for high school students (but not middle school students) is of interest. Salad bars are available through the school lunch meal and à la carte cafeteria sales. Thus, student salad bar access is part of the mid-day meal and likely paid for using lunch meal funds. A higher percentage of middle than high school students are estimated to (1) be eligible for free and reduced price lunch and (2) eat the school lunch meal.¹¹ Thus, items available in school cafeterias may have a stronger impact on middle than high school students. In contrast, high school students are more likely than middle school students to have the disposable income needed to purchase items through school competitive venues, which

were the primary source of variance in FV accessibility levels in the current study. Access to competitive venues of any type consistently has been higher for high school than middle school students.¹¹

The relevance of the current study's findings are heightened as a result of the USDA's nutrition standards for all foods and beverages sold in schools outside of the meal programs (hereafter referred to as the USDA standards).²² As of the beginning of school year 2014–2015, all US elementary, middle, and high schools participating in the National School Lunch and/or School Breakfast Programs are required to serve only competitive food items meeting strict caloric, fat, sugar, and sodium requirements. Further, all items eventually must be either whole-grain rich or have as a first ingredient (or first after water) fruits, vegetables, dairy, or protein foods. Combination foods containing $\frac{1}{4}$ cup of fruit and/or vegetable are also allowed. The USDA standards (if implemented fully) are intended to result in dramatic decreases in student access to unhealthy foods in school nutrition environments and may result in increased FV consumption through reduced exposure to competing unhealthy options. However, school decision makers will need to determine what will take the place of currently available unhealthy options. The present study indicates that increasing school FV accessibility may significantly increase student total FV consumption.

The current study echoes the findings of previous research indicating (1) secondary school availability of unhealthy items is high, whereas competitive venue FV availability is comparatively lower,²³ and (2) overall adolescent FV consumption is low,²⁴ especially among minority students and those in lower socioeconomic households.^{6,15} Though efforts are being made to increase daily adolescent FV consumption,¹ more remains to be done. The USDA standards do not require that fruits or vegetables be available wherever other food is offered or sold in schools, as recommended by the Healthy People 2020 objectives.² The USDA standards have been designed to align closely with existing guidelines, such as those developed by the Alliance for a Healthier Generation.²⁵ One of the National Automatic Merchandising Association's FitPick[®] programs provides a listing of snack foods meeting Alliance standards.²⁶ Though the listing clearly includes some fruit options, such as fruit cups and dried fruits, the majority of items are baked or salty snacks. The USDA standards do not pre-empt more stringent local or state policies related to school competitive venue nutrition standards.²² School and district decision makers should consider meeting the Healthy People 2020 objectives and require that fruits or vegetables be available wherever other food is offered or sold in schools.²

Limitations

This study benefited from nationally representative samples of middle and high school students and their respective administrators. However, results are subject to

limitations. The data are cross-sectional, thus precluding causal interpretation. Student consumption data were obtained by self-report from only two measures utilizing a food frequency questionnaire (FFQ)-type format. FFQ-type surveys have been shown to provide reasonable population estimates of habitual dietary patterns²⁷ and cost-effective estimates for ranking individuals by FV intake,²⁸ but use of such data collection methodologies likely results in under-reporting among older adolescents, such as the middle and high school students included in the present study.²⁷ The measures used do not measure intake frequency *per day* nor do they measure actual intake. Given that the aim of the current study was not to provide precise national estimates of FV consumption among adolescents, but to examine associations between the school food environment and student consumption, use of the self-report measure data available are reasonable. No data were available documenting student FV consumption frequency in the school environment versus outside of school or source location of FV consumed. Further, school nutrition environment data were based on school administrator responses to self-administered questionnaires, raising the possibility of social desirability bias and reporting error. To minimize social desirability bias, respondents were guaranteed that neither they nor their schools would be identified. To minimize response error, as noted previously, questionnaire directions called for different segments of the questionnaire to be completed by personnel most knowledgeable about the subject matter. In addition, the paper-and-pencil questionnaire data collection format allows respondents to bring the questionnaire to various venues to more accurately record food item availability.

Conclusions

Results from the current analyses indicate that school food accessibility was significantly associated with student self-reported total daily fruit and green vegetable consumption. Schools should not only remove competitive venue unhealthy foods and beverages under implementation of the USDA standards,²² but also consider expanding the use of salad bars as well as providing FV access wherever other foods are sold. Such actions—as well as participation in programs aimed at increasing school FV availability, such as HealthierUS School Challenge, Let's Move Salad Bars to Schools, and the USDA Farm to School Program—may well result in increased FV consumption among students, including among racial/ethnic and socioeconomic subgroups.

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Author Disclosure Statement

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