

Nutritional quality of snacks and beverages sold through vending machines in a large Hispanic-serving urban college campus in the United States: A cross-sectional study

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Abstract

Students from nutritionally-vulnerable neighborhoods face dietary challenges through built environment of college vending machines. In this cross-sectional study, snacks and beverages sold in vending machines for a 4-week period in a Bronx-based Hispanic-serving college were recorded. Nutritional information was recorded from nutrition labels. Proportion of low- and high-sodium foods, “smart snacks” with a limit of 200 kcal and 200 mg of sodium, and foods with added sugar were recorded. Snacks had significantly higher calories and sodium per serving (227 kcal, 208 mg) than beverages (132 kcal, 90 mg) (*t*-test, $p < 0.001$). Almost a third of the snacks (32%) qualified as “smart snacks” for calories and 62% qualified as “smart snacks” for sodium. Beverages contained less than half the number of ingredients as snacks. About 53% of beverages and almost 60% of snacks listed sugar among the first five ingredients. Results underscore the need for colleges to promote less-processed entities with less added sugar.

Keywords

Vending machines, smart snacks, added sugar, nutrition label, snacks, beverages

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Background

Food environment refers to the physical, economic, policy, and sociocultural factors that impact the dietary choices of individuals.¹ As college students transition from home life to college life, the food environment dictates dietary choices that they may make independently for the first time. The change in food options presents dietary challenges that can set the stage for health habits and outcomes that can have lifelong consequences. College students are likely to gain weight during their college life without meeting nutritional guidelines, and weight gains acquired during the emerging adulthood phase of college life are not merely related to normal growth and maturation.^{2–4} Overweight college students are at increased risk of being overweight as adults and associated diet related conditions such as type 2 diabetes.⁵

Vending machines are ubiquitous in American college and university settings, and offer a quick and convenient source of pre-packaged processed foods.⁶ They have often

been overlooked as possible conduits of practical, nutrition intervention strategies to improve the built food environment for student.⁷ Predominant vending machine options are shelf-stable, are high in sugar, sodium, and fats; as exemplified by chips, soft drinks and sweets.⁶ Research attests that students’ selection from vending machines tend to gravitate toward less nutritious snacks than their healthier counterparts.⁸

For the past 10 years, the Bronx has been ranked the worst among all of New York state’s counties for health outcomes.⁹ More than a third of Bronx adults have been diagnosed with hypertension, and 28.5% are obese,⁹ both

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conditions being driven by the food environment. Among the five boroughs of New York City, the Bronx has the highest proportion of youth reporting consumption of at least one sugary drink per week, the lowest proportion of adults who report a daily consumption of five or more servings of fruit and/or vegetables, as well as the highest percent of obese youth and adults.¹⁰ With a poverty level of more than 24%, a high proportion of Black and Hispanic population,¹¹ the Bronx has also witnessed extensive promotion of unhealthy processed foods that are high in added sugars, sodium and saturated fats being promoted through supermarkets.^{12,13} Perceived acceptability, accessibility, affordability and adequacy of food choices are critical parameters that affect food choices made by students in minority-serving educational institutions located in a food desert.¹⁴ Given the proven role of built food environment in increasing risk for onset and accelerated progression of chronic diseases,¹⁵ particularly among Hispanics¹⁶ and African-Americans,¹⁷ as well as the role of behavioral and environmental interventions in mitigating these effects, the goal of this study was to conduct a nutritional analysis of the foods and beverages sold in the vending machines of a Hispanic-serving institution in the Bronx.

Design and methods

The study was conducted for a 4-week period during April-May of 2022. Since this study did not involve participation of human subjects, it was not reviewed by the Institutional Review Board at Lehman College. Researchers obtained an inventory and location of all active vending machines on the campus and visited them on the same pre-determined day each week during the 4-week study period. In order to ensure completeness of inventory, two researchers were present at each vending machine during each trip. During each visit, digital pictures for each spiral rack in a vending machine were captured. Information regarding brand, product description and package weight was transcribed from the picture format into an excel spreadsheet. For each product, nutritional information was obtained from the manufacturer's website. The information was recorded on to a Microsoft Excel spreadsheet and verified by two researchers.

For each vending machine, data for duplicate products were eliminated and the consolidated data was analyzed for calorie, sodium, and dietary fiber content per serving. Data was recorded onto a data collection tool that had been refined by visits to vending machines off-campus. The list of ingredients was also reviewed for each product to identify the number of ingredients as well as the presence of added sugar among the first five ingredients. Added sugar was identified as sucrose, dextrose, high fructose corn syrup, cane sugar.¹⁸

We also used calorie and sodium limits of 200 kcal and 200 mg per serving to identify snacks as "smart snacks."¹⁹

Low-sodium snacks were identified as those which contained 5% or less of the daily value for sodium, and high sodium snacks were those that contained 20% or more of the daily value for sodium.²⁰ The number of ingredients were identified from the ingredients list. Products were coded dichotomously ("0"=absent, "1"=present) for these characteristics. A second researcher recoded randomly selected 10% of the sample; a high value of Cohen's unweighted Kappa (0.89) confirmed inter-rater reliability of the manual coding.

Data analysis for averages, standard deviation and proportion of different categories was done on Microsoft Excel. Independent *t*-test was conducted to analyze the difference in calories, sodium content, and number of ingredients between snacks and beverages.

Results

We analyzed a total of 3068 snacks and 1667 beverages during the 4-week study period. Nutritional characteristics are summarized in Table 1. Mean calorie (per serving) was significantly higher for snacks (227kcal) than for beverages (132kcal) ($p < 0.001$). The maximum calories in snacks (590kcal) was more than twice of its counterpart in beverages (290kcal).

Per serving sodium content was more than twice the amount in snacks (208 mg) than in beverages (90 mg) ($p < 0.001$), with the highest levels in the former category (900 mg) exceeding thrice their counterparts in beverages (270 mg). Further, the snacks indicated high level processing with an average of 18 ingredients, and a maximum of 37 ingredients. Almost 60% of this group had sugar listed among the first five ingredients (59%, $n = 1821$) and 8% were categorized as high-sodium products ($n = 248$). A little over a third of the snacks (36%, $n = 1103$) were low in sodium, and almost two-thirds fulfilled the criteria of sodium content not exceeding 200 mg (per serving) to be categorized as smart snacks (62%, $n = 1901$). Almost a third of the snacks had a calorie content within the ceiling limit of 200 kcal for a smart snack.

The beverages comprised an average of eight ingredients, significantly lower than the snacks ($p < 0.001$), and were mostly low-sodium (81%, $n = 1345$). More than half the beverages listed sugar among the first five ingredients (53%, $n = 888$).

Discussion

This study fills a gap in the literature of nutritional quality of vending options available in a Hispanic serving institution located in a food swamp. As college students transition to an independent college life, the food environment that they are exposed to, plays a significant role in establishing dietary practices that can have long-term health outcomes. Their new-found dietary independence is

Table 1. Proportion of snacks and beverages with different nutritional characteristics.

Nutritional characteristic	Snacks (N= 3068)	Beverages (N= 1667)
Kcal/serving ^a		
Mean ± Std. dev.	227.1 ± 86.2	131.8 ± 96.2
Range	70–590	0–290
Sodium (mg)/serving ^a		
Mean ± Std. dev.	207.9 ± 174.4	90.0 ± 90.1
Range	0–900	0–270
No. of ingredients ^a		
Mean ± Std. dev.	18.4 ± 9.0	8.2 ± 6.3
Range	3–37	1–22
Proportion of low-sodium items	36% (1103)	80.8% (1345)
Proportion of high-sodium items	8.1% (248)	0
Proportion of items with sugar listed among the first five ingredients	59.4% (1821)	53.3% (888)
Proportion of smart snacks with ≤200kcal/serving	31.8% (977)	-
Proportion of smart snacks with ≤200mg Sodium/serving	62% (1901)	-
Proportion snacks high in fiber	2.5% (76)	
Proportion of plain or carbonated water	-	26.6% (433)

^ap-Value <0.001 by independent t-test.

juxtaposed with the practical limitations of time and resources and abundant exposure to food deserts and swamps, making them vulnerable to unhealthy dietary changes that can result in acute and chronic behavioral and health outcomes.¹⁴ The exposures are compounded by the disparate effect of predatory marketing and promotion of unhealthy, processed snacks and beverages in minority, and low-income communities.

Vending machines are a ubiquitous part of the college food environment. As a convenient and easily accessible source for a wide variety of foods and beverages, they can be a wide-ranging, influential source to foster a health-promoting food environment for college students.⁷ However, research indicates that majority of snack and beverage options in college-based vending machines are of poor nutritional quality, thereby necessitating a need for practical and affordable nutrition interventions.²¹ In our study sample, even though majority of the foods and beverages were highly processed, 62% of snacks could be categorized as “smart snacks” for sodium. However, the presence of added sugar among the first five ingredients was predominant in both snacks and beverages.

Ultra-processed foods are industrial formulations that generally contain more than five ingredients, which mostly includes additives, sugars, salt and refined flours, and oils. These foods have been estimated to comprise up to 58% of the caloric intake and almost 90% of added sugars in the American diet.²² Analyses of barcoded purchasing data attests that ultra-processed foods have higher median contents of sodium, added sugars and saturated fats.^{23–25} American youth and college students have a high frequency of consumption of ultra-processed foods, as mostly characterized by energy and soft drinks, snacks, industrial bakery,

cereal, and energy bars.^{26,27} Consumption of ultra-processed foods has been associated with increased risks for obesity, cardiometabolic diseases, metabolic syndrome, cancers, and all-cause mortality.²⁸ Some of the snacks sold at vending machines analyzed in this study had as many as 37 ingredients, sodium content that was as high as 39% of the daily value, and majority of them (59%, $n=1821$) had sugar listed among the first five ingredients. The built environment of the present food system assertively promotes overconsumption of ultra-processed foods among the youth, through targeted strategies such as promotional pricing, marketing strategies, and product placement.²⁹ Food insecurity among college students can trigger coping mechanisms such as purchasing inexpensive foods of poor nutritional quality,³⁰ that are easily accessible from the vending machines.

Frequent snacking can result in increased intake of calories.³¹ While physiological maturation up to 20 years of age can result in weight gain,⁴ it is not clear how to delineate this weight gain from that which is associated with unhealthy lifestyle and dietary habits.³ Studies confirm that an increased proportion of college students become overweight or obese during their college life. Cross-sectional studies among college students indicate that a vast proportion consume a daily snack and more than 93% consumed an unhealthy snack at least once a week.^{32,33} Evidence-based nutrition standards for snacks and beverages, called as “Smart Snacks in School” have been established in schools.¹⁹ These guidelines focus of calorie density, sodium content, dietary fiber and added sugar and address general guidelines for healthy eating. Based on these standards, 32% ($n=977$) met the criteria for a calorie limit of 200 kcal per serving, and 62% ($n=1901$) met the sodium limit of 200 mg per serving.

The 2020–2025 Dietary Guidelines for Americans recommend that Americans restrict their daily sodium consumption to less than 2300 mg per day.³⁴ By current estimates, Americans consume more than 3400 mg sodium per day.³⁵ Excessive sodium intake is associated with hypertension, which in turn increases risks for cardiovascular conditions.³⁶ Interventions to reduce sodium intake such as nutrition education as well as involving stakeholders such as the food industry have been successful in reducing population salt intake.³⁷ In our study sample, 36% of the snacks ($n=1103$) and 81% of the beverages ($n=1345$) were low in sodium. Only 8% of the snacks ($n=248$) contained sodium levels exceeding 20% of the daily value to categorize them as high-sodium. More than 60% of the snacks complied with the limit of 200 mg sodium per serving to be categorized as “smart snacks.”

More than 53% of the beverages ($n=888$) listed sugar among the first five ingredients and a little over a quarter was represented by plain or carbonated water (27%, $n=433$). Within the snack category, more than 59% ($n=1821$) listed sugar among the first five ingredients. Excess added sugar in both snacks and beverages can trigger the inflammation cascade leading to hypertension and increased risk for cardiovascular diseases. The increased calories from added sugars especially in beverages blunt the satiety cues thus contributing to weight gain.³⁸ College students are among the highest consumers of sugar-sweetened beverages (SSBs),³⁹ increased consumption of which has been associated to obesity, type 2 diabetes and cardiometabolic risks.⁴⁰ Almost half of Americans’ added sugar intake is in the form of SSBs.⁴¹ In terms of intake patterns, almost half of American adults consume at least one SSB daily on a given day,⁴² and their consumption is high among young adults, men, Hispanics and non-Hispanic Blacks.⁴² Given the high proportion of Hispanics in the institution where the study was done, our results suggest the need for decrease offerings for SSBs in the vending machines to improve the built food environment in the campus. Intervention strategies in college campuses such as phasing out sugar-sweetened beverages,⁴³ placement of warning labels on these beverages⁴⁴ have gained attention, with results confirming the positive effect of such interventions in decreasing consumption of SSBs in college campuses.⁴⁴ With respect to the snacks analyzed in this study, none of the snacks were a good source of fiber. Whole grains are nutrient dense, provide satiety, and stimulate gut microbiome diversity.⁴⁵ Our results allude to the need for greater advocacy in offering products that are more whole-grain based and without added sugar, with the intent of decreasing the risk of overweight and obesity and improving overall health outcomes. Research attests that since students gravitate toward vending machines due to their affordability and grab-and-go convenience, they can be an effective point of nutritional and behavioral intervention by increased offerings of healthier, flavorful

snacks that could improve the built food environment and nudge students toward healthier purchases.⁴⁶

Our study was not without limitations. The cross-sectional design limited our study to products promoted in the vending machines, without looking at purchasing trends such as the proportion of snacks and beverages with specific nutritional attributes actually purchased by students. We did not account for pricing and thus failed to capture the association between cost and nutrient density. Nonetheless, our results complement previous findings in similar studies and underscore the need for greater advocacy with stakeholders to offer healthier options, as well as soliciting student feedback in deciding snack and beverage options. Students are mostly undecided consumers when purchasing from a vending machine. Vending machines can be used as active portals of health promotion through nutrition education by incorporating nutrition interventions such as choice architecture and traffic light labeling to equip students to make nutritionally-wise choices.

Significance for public health

The built environment of vending machines in colleges located in nutritionally vulnerable neighborhoods exacerbate the dietary challenges for students by offering highly processed snacks and beverages with high amounts of added sugar. This study indicates that while majority of the snacks in a Bronx-based Hispanic-serving college had sodium levels less than 200 mg/serving, they were highly processed. Majority of snacks and beverages also listed sugar among the first five ingredients. Since dietary habits instilled during college years have lifelong impacts, our findings underscore the need for stakeholders in neighborhoods with poor health outcomes to improve nutritional quality of vending machine options.

Author contributions

LS conceptualized, designed and led the study and data analysis, EO, SJL, CB contributed to data collection. All the authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Declaration of conflicting interests

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Disclosure of financial and non-financial relationships and activities

None

Ethical considerations

Since this study did not involve participation of human subjects, it was not reviewed by the Institutional Review Board at Lehman College.

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Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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