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The Dirty Dozen: Assessing the Nutritional Quality of the Twelve Most Purchased Vending Items on a Large University Campus

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Abstract

The poor nutritional quality of snacks in vending machines may contribute to obesogenic food environments. Understanding the obesogenic food environments and accessibility to healthy foods may help policymakers identify approaches for improving the food environment. This study conducted in 2017-2018 assessed the nutrient density and quality of snacks sold in vending machines at a land grant university and examined their spatial proximity to other food sources. The list of vending machines, their location, the revenue generated from each machine, and the most popular snack list were obtained from the campus business services. Researchers evaluated snacks in vending machines independently utilizing two validated assessment tools: Nutritional Environment Measures Survey-Vending assessment tool (NEMS-V) for overall snack healthfulness and Health Density Vending Machine Audit Tool (HDVMAT) for snack nutrient density. There were 81 snack vending machines on campus, and each machine generated varying levels of revenue. A sample of the top 25% revenue generating machines located in buildings with high student traffic were selected for snack healthfulness ($n=20$) and spatial food proximity analyses. Assessment by both tools revealed that most of the snacks in these vending machines were of low nutritional quality. The 12 most popular snacks ("dirty dozen") were comparable in nutritional quality to what was being offered in the campus-wide vending program. The spatial analysis found that significant portions of the campus were more than half a mile from any quality food source, likely contributing to greater consumer use of these vending machines. Based on this sample analysis, snacking options available to college students are of poor nutritional quality and may contribute to the obesogenic environment common to college campuses; policies to address this issue are warranted.

Keywords: Environmental assessment; Obesity prevention; Nutrient density; Vending machines; Snacks; Health promotion

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Introduction

Obesity has increased across many cohorts in the United States and is estimated to affect 42.4% of adults nationally in 2017-2018 [1]. Consequently, there has been great interest in understanding the factors underlying this increasing prevalence. It is well understood that eating behaviors are complex and the role of the *built environment* is a significant component in shaping individual food choices. The *built environment* refers to the anthropogenic aspects of a community including shopping and dining opportunities, contexts for physical activity and opportunities for walking [2]. Moreover, there is increasing evidence that the standard American diet has evolved over the last few decades to

include more energy-dense foods associated with fast food and snack consumption [3].

Recent trends for young adults indicate that they experience the most significant increases in the proportion of overweight and obesity in the United States and, indeed, in all Western Countries. Weight gain and poor nutritional intake are particularly well documented for the cohort of young adults (ages 18-24 years), that predominate on college campuses [4] as the percentage of overweight/obese college students in the United States increased from 31.4% to 36.8% between 2006 and 2016 [5]. Because of these disturbing trends, there has been a great interest of late in the nutritional status of college students and the role that college

campuses play in shaping health and nutrition behaviors.

Whether through preference or because they are ubiquitous on campuses, vending machines are a common source of snacks for students with approximately 6.6% of the 19.3 billion dollar vending industry in the United States derived from university and college sales [6]. In spite of this, by 2018, few campuses had nutrition policies in place providing guidance on what food products should be offered in vending machines [7,8].

Though usually considered to be relatively small intakes of food, a widely-cited survey of eating behaviors found that snacking now accounts for almost 50% of American food consumption and are thus the most widely prevalent eating behavior [9]. Indeed, in the same survey 8% of consumers indicated they had foregone formal meals in favor of snacks; 91% of consumers reported snacking multiple times throughout the day [9]. In the two decades preceding 2006, snacking consumption increased by 25% [10]. Consequently, the amount and quality of snacks consumed makes a significant contribution to the overall consumption patterns in the US and must be considered in any policy approach for addressing obesity.

Currently, there is no formal definition of what constitutes a snack or snacking behavior though it is loosely considered as “eating foods or consuming caloric beverages between regular meals [6]. This pragmatic understanding serves as the working definition of snacking for this analysis. There is interest of late in the health-related aspects of “grazing” in lieu of formal meals but, at present is incompletely understood as a health behavior [11]. A recent study concluded that frequent small snacks in lieu of established meals contributes to increased energy intake [12].

Vending machines are a common source of snacks. Many different metrics have been utilized to assess the nutritional contents of foods offered in vending machines. Some studies have focused exclusively on total energy provided (kcal) [13] or total energy and fat [14]. Other studies have utilized specific instruments to determine overall nutritional quality [15]. Two of the metrics commonly used and most robust are the Nutritional Environment Measures Survey (NEMS) and the Health Density Vending Machine Audit Tool (HDVMAT).

NEMS-V is a validated observational measure that provides an overall grade of vending quality. It is low cost, requires little training to utilize, is readily available due to a dedicated website (and therefore has been used widely [16]. The HDVMAT is a newer tool which incorporates numerous factors for analysis including availability, as well as snack healthfulness, price, and promotion [17]. Unlike NEMS-V, which is calorie driven, HDVMAT’s scoring system addresses nutrient density to determine the overall healthfulness of the snacks. The score is achieved based on analysis of the relationship of calories and macro/micronutrients and addresses both snacks and beverages [17].

A review of 23 studies of vending machine contents undertaken between 1981-2013 found that criteria besides nutritional quality of contents was often utilized including accessibility, portion size, promotion, and scientific practice [15]. Eighty-seven percent of the studies included analysis of healthfulness criteria with variable results across the studies, making comparison

difficult and thus precluding any overall pattern or conclusion [15]. Limited access to dining options for college students due to the location and hours of operation may lead to purchasing from vending machines, a ubiquitous, easily accessible, and convenient source of food [18]. Vending machine prevalence and consumer frequency of use suggest vended snack and beverage products can substantially contribute to daily energy intake.

The social-ecological model emphasizes the importance of integrating the person and environment to promote healthy behaviors [19,20] and is the basis of this analysis. From this perspective, strategies to promote healthful eating should be implemented at both the individual and the institution levels. At the individual level, behavior change strategies may be beneficial since stimulation and reinforcement that occur in the food environment are important in eliciting behavior change. Policy changes directed towards healthy vending options might be more effective at the institutional level [21]. Assessing the current food environment is necessary before creating policy changes or population-based interventions focusing on desirable behavior changes. Therefore, in this study we evaluated i) the nutrient density and quality of snacks sold in the vending machine using validated tools and ii) the spatial proximity to other food sources on campus.

Materials and Methods

Researchers from this study contacted the campus business services of a large land grant institution in the Mid-Atlantic using the directives of the *Freedom of Information Act* to obtain a list of snack vending machines, location and revenue generated from each machine, and the most popular snacks from the highest grossing vending options.

Selection of vending machines for assessment

The vending machine data obtained from the campus business services were sorted by amount of revenue (highest sale volume), ranging from lowest to highest. The top 25% revenue producing machines with the highest sale volume were then selected for the study (n=20). Further assessment of the location of these vending machines on campus revealed that they were in buildings on campus that are most heavily trafficked by students. These buildings include residence halls, academic/classrooms buildings, common areas such as library and recreation centers. Buildings that include mostly or all faculty/staff and/or administrative offices were not identified in this top 25% revenue producing machine list. Additionally, all the snack machines that were analyzed, were of equal size.

Data collection

The data was collected between 2017-2018. Two researchers visited independently the selected vending machines. Using the NEMS-V and HDVMAT tools, two tasks were subsequently undertaken. First, snacks from the selected machines were inventoried and analyzed. Second, the twelve most popular vending items across the entire campus as well as the high grossing vending machines were also analyzed for nutritional content.

The NEMS-V tool assesses nutritional quality based on a variety of metrics including calories, total calories from fat, saturated fat, trans fat, sugar and sodium per package. Based on these parameters, snacks are then categorized into "Red" (not healthy), "Yellow" (minimally healthy) and "Green" (healthiest) categories. The nutrition standards utilized in NEMS-V are based on the Institute of Medicine (IOM) Nutrition Standards for Foods in Schools and have been updated to match the Health and Sustainability Guidelines for Federal Concessions and Vending Operations [22]. In contrast, HDVMAT (though also based on IOM criteria) uses a nutrient density scoring system that considers metrics including fiber, calcium, iron, potassium, vitamins C, D and E in categorizing foods into "unhealthy" (≤ 2), "somewhat healthy" (3-4) and "healthy snacks" ($\geq 5-12$) [17].

The researchers took photographs of each vending machine and also completed the survey on each of the selected machines using forms provided on the NEMS-V website; data were collected separately to address inter-rater reliability, though elsewhere this has been demonstrated to be high [16]. A data inventory was undertaken of each slot in the vending machine being studied. For this sampling, all face-front items (those snacks that faced outward and were next in line for purchase) were inventoried by product brand with variations noted (e.g., different varieties of potato chips or cookies) as were product size and price. Where the net weight could not be determined due to visual obstruction, the item was purchased so as to ascertain the needed information. When snacks were offered multiple times in the same machine, this was noted as were empty product queues or those selling gum/mints.

A standardized vending snack inventory form was utilized by researchers undertaking this activity and the forms were turned over to another colleague for inventory and formal assessment using online product guides for independent nutritional assessment. Subsequently, each of the items inventoried was then assessed based on both the NEMS-V and HDVMAT scoring system and assigned the appropriate grade or label. The inventory data collected from this survey was then used to assign *green*, *yellow*, or *red* scores to each snack item, based on NEMS-V criteria. Snacks were also categorized into unhealthy" (≤ 2), "somewhat healthy" (3-4), "healthy snacks" ($\geq 5-12$) based on HDVMAT criteria. To examine the spatial context, and the

proximity to other food sources after regular business hours (8 AM to 4:30 PM) from the common area/buildings analyzed in this study, Google Map Marker was used and the distance between vending machines and other food sources was calculated.

Data analysis

Data from each machine was entered into an Excel spreadsheet. Calorie and nutrient content for each vending item was obtained using Nutrition Facts labels, food manufacturers' websites. After data on the contents of the vending machines were collected, the items were categorized by their nutritional value according to the NEMS-V standards. These nutritional values were assigned using the NEMS-V "Red" (not healthy), "Yellow" (minimally healthy) and "Green" (healthiest) category standards. Data were also analyzed using HDVMAT nutrient density scoring system categorizing foods into "unhealthy" (≤ 2), "somewhat healthy" (3-4) and "healthy snacks" ($\geq 5-12$). The twelve most popular vending items across the entire campus were also analyzed for nutritional content utilizing NEMS-V and HDVMAT tools. Descriptive statistics were calculated to describe the nutritional density and quality of snacks.

Results

Campus demographics

The campus of the university being assessed has nearly forty thousand undergraduate and graduate students; approximately 47% are female students and 53% are male. There are 81 snack vending machines on campus devoted exclusively to snacks. An average sale of 2,200 units/items were reported from these machines with the highest number of units sold by a machine reported at 6,276 items annually. The most popular vending item list provided by campus business services are shown in **Table 1**. Both salty and sweet snacks accounted for 50% of the choices vended in the list of most popular snacks.

First, the popular snacks nutritional quality was assessed by both NEMS-V and HDVMAT tools. Results of the nutritional analyses of the twelve most purchased snack items are shown in **Table 2**. NEMS-V categorized all the top 12 snacks as red. Alternatively, the HDVMAT analyses showed that one third of snacks belonged to each one of the three categories: unhealthy snack, somewhat healthy dense snack, and healthy dense snack.

Table 1 Most Popular Vending Items.

Snack	Size of Package/calories	Size of Serving/calories
Snickers Bar	1.86 oz/250 calories	1 bar/250 calories
M&M's (plain)	1.69 oz/240 calories	1 pack/240 calories
Twix Bar (caramel)	1.79 oz/250 calories	1 pack/250 calories
Welch's Fruit Snacks (mixed flavors)	2.25 oz/195 calories	1.5 servings/pack/130 calories per serving
Kellogg's Pop Tarts (strawberry)	3.67 oz/ 400 calories	2 servings/pack/200 calories per serving
Cheetos (crunchy cheddar jalapeno)	2 oz/320 calories	2 servings/pack/160 calories per serving
Cheetos (crunchy)	2 oz/300 calories	2 servings/pack/150 calories per serving
Lay's Class Potato Chips	1.5 oz/240 calories	1.5 servings/pack/160 calories per serving
Doritos Nacho Cheese Chips	1.75 oz/245 calories	1.75 servings per pack/140 calories per serving
Smartfood White Cheddar Popcorn	1 oz/160 calories	1 pack/160 calories
Famous Amos Chocolate Chip Cookies	2 oz/280 calories	1 pack/280 calories
Fritos Bar-B-Q Chips	2 oz/300 calories	2 servings per pack/150 calories per serving

Table 2 Nutritional Analysis of Twelve Most Purchased Items.

Snack	NEMS-V Rating	HDVMAT Rating
Snickers Bar	Red	Unhealthy Snack
M&M's (plain)	Red	Unhealthy Snack
Twix Bar (caramel)	Red	Unhealthy Snack
Welch's Fruit Snacks (mixed flavors)	Red	Healthy Dense Snack
Kellogg's Pop Tarts (strawberry)	Red	Somewhat Healthy Dense Snack
Cheetos (crunchy cheddar jalapeno)	Red	Somewhat Healthy Dense Snack
Cheetos (crunchy)	Red	Healthy Dense Snack
Lay's Class Potato Chips	Red	Healthy Dense Snack
Doritos Nacho Cheese Chips	Red	Healthy Dense Snack
Smartfood White Cheddar Popcorn	Red	Somewhat Healthy Dense Snack
Famous Amos Chocolate Chip Cookies	Red	Unhealthy Snack
Fritos Bar-B-Q Chips	Red	Somewhat Healthy Dense Snack

Table 3 Comparison of NEMS-V and HDVMAT Snack Scores from the Top 25 Percent Revenue Earning Vending Machines.

NEMS-V Scoring		HDVMAT Scoring	
Label	Percent	Label	Percent
Red	93	Not Healthy (≤ 2)	53
Yellow	4.1	Somewhat Healthy snack (3 or 4)	34
Green	2.9	Healthy Dense snack (≥ 5)	13

Next, the snacks in the top 25% (n=20) revenue producing machines were analyzed using both NEMS-V and HDVMAT tools (**Table 3**). The NEMS-V analysis of the entire vending inventory categorized 93% of snacks as unhealthy/red and 4.1% as healthiest/green. The use of the alternative assessment, HDVMAT, listed 53% of the same snacks as unhealthy and 13% as healthy.

While NEMS-V was more consistent in the assessment process, both tools demonstrated idiosyncrasies. For example, NEMS-V did not judge the packaged nuts to be a healthy snack based solely on the total calorie (>200 kcal per package) and fat content ($>35\%$ kcal per package). The HDVMAT scoring system was even more problematic, however, in that items such as *Welch's Fruit Snack*, and *Cheetos Oven Baked Crunchy Cheese Curls* were both characterized as healthy. The Welch's fruit snack earned a healthy dense snack label because of the high vitamin C and Vitamin E content (despite a high sugar content). *Cheetos* were also labeled a healthy dense snack since the Calcium and Iron content meet the percent Daily Value (%DV) per serving, though they contribute no fiber and have a significant quantity of saturated fat and salt.

Spatial proximity analysis revealed that 22.2% of the buildings in the survey had no access to food sources on campus other than on-site vending machines, suggesting a strong impetus for students to purchase from these vending options. A majority of the 22.2% buildings that had no access to other food resources were academic buildings. While 77% of buildings comprising of residence halls and academic buildings had access to other food source within 0.5 miles, most were not accessible after regular business hours. Indeed, only 11.1% of buildings were found to have access to a food source after regular business hours. The category of buildings surveyed for snacks in vending machines are shown in **Table 4**.

Table 4 Category of Buildings Surveyed with Vending Machines.

Category	Number	Percent
Academic Buildings	9	45
Residence Halls	8	40
Common Areas	3	15

Discussion

The study provides insights into the topic of snack consumption via vending on college campuses in several regards. First, it evaluates two of the most broadly circulated assessment tools for a comparative view of how they evaluate snack quality; in so doing it shows the strengths and weaknesses of both tools. Based on the scores provided to the most popular 12 items by both tools, it is reasonable to conclude that these items are really a "dirty dozen" of very low-quality food options.

Second, this study provides insight into the snacking choices made by college students as well as what foods are offered within the built environment of a college campus. The sampling of vending machines makes apparent that the 'dirty dozen' is not random and that the nutritional quality of all available vending snacks is poor. Even using HDVMAT, the less restrictive assessment tool, very few foods were deemed healthful in the analyses. It should be noted that the analysis of the snacks was complicated by the fact that product size and serving size can vary. For example, the version of trail mix that was stocked in the vending machines was offered in a 2-ounce package despite the fact that a serving size of this product is actually composed of 1.5 ounces. NEMS-V considers nutritional information by the actual package, not by the serving size, but HDVMAT is based on the manufacturers listing of serving size.

The overabundance of unhealthy snacks in the areas most convenient to college students, along with a failure to promote

"better-for-you" items, is especially troubling considering that the university's own vending contractor offers healthier options termed "Choice Plus" snacks. These snacks have been selected by vending contractor's dietitians and experts, and meet specific criteria regarding calories, fat, salt, and added sugar. None of the machines surveyed in this study stocked the healthier snack options categorized under "Choice Plus".

Additionally, no university policy exists to encourage stocking or marketing better-for-you snacks in vending machines on campus. In fact, according to an email from the manager of Corporate Services at this land-grant university, the selection of items stocked in campus vending machines is driven by "customer buying patterns" and this process is managed by the vending supplier.

The spatial analyses included in this study also indicates that students at this large public university have limited access to other food sources after hours and, thus, must rely on unhealthy snacks available from vending machines for snacking options. A recent study [23] examining college students' perceptions of snacks sold in vending machine suggested that students prefer to choose snacks from vending machine as this is convenient, readily accessible and offers a faster solution to alleviate hunger. Students suggested that making healthier snacks available and accessible by, placing snacks in high traffic areas are some of the ways to improve the quality of snacks on campus.

Understanding how the built environment contributes to obesity is a complex and nested issue [2] and one of the limitations of this study is that it explores in isolation one component of the campus environment. The reality is that vending is part of an overall food environment; adjustments to one element are likely to alter other factors. However, even small changes can strongly influence consumption behavior. A study in Ireland examined the effects of a healthier vending policy in a health care setting where 60% of stocked snacks were comprised of healthier options. Other adjustments included placement of snacks at eye-level and providing written cues on the vending machines. The researchers concluded that availability and promotion of healthier options positively influenced healthy snack purchasing behavior [24].

Similarly, in another college campus study, stocking half of all products in compliance with federal guidelines for smart snacks in K-12 school nutrition standards resulted in a decrease in unhealthy food sales. The study concluded that adapting a healthier snack vending choice may be a feasible option for universities striving towards a healthier campus environment [25]. While a majority (62%) of the vending machine-based nutrition interventions in a university setting showed a positive change in outcomes, there are also studies that reported neutral outcomes or no changes. Authors in a recent systematic review concluded that strategies to improve vending options are needed and further research with a strong intervention design is warranted [26].

A limitation of this study is that only 25% of the total snack vending machines were assessed. While this may seem like a

small number, the repetition of products in the machines and data saturation allows for the generalization of the evaluation to the entire campus vending environment. Another constraint of this report is the assumption that the high revenue generated from the machines are due to products purchased by students though these same machines are also available to faculty and staff. However, the machines chosen were based not only on the high total sales but also because they were located in high student traffic areas.

The strength of this study is the snacks being analyzed were examined both for quality but also for nutrient density. Another strength was the spatial analyses of the nutrition environment and food proximity to students during and after regular business hours. Work on improving nutrition environment in college campus is an evolving area. There are great opportunities for campus administrators to consider and create policies for model environments that support healthy lifestyles aimed at prevention of obesity and other chronic diseases. While this study only evaluated the snack environment on the college campus, further research incorporating assessment of all levels of the socio ecological framework might be beneficial for sustainable improvements to the food environment.

Implications for Policy, Practice and Research

The results of this study show the types and quality of snacks that are generally available via vending options. We anticipate that these findings will provide an understanding and garner attention from university administrators towards adopting a school-based policy to guide stocking of vending machines and contribute to a healthier food environment on campus. Likewise, assessment of the campus in a food context helps in the development of population-based interventions focusing on shaping desirable behavior changes. It should not be a surprise that vending machines are implicated as a contributing factor to the obesogenic environment on college campuses because the overall nutritional quality of the products provided is quite low. Notwithstanding the assessment tool utilized, the quality of the most popular snacks at this large land grant university was generally poor suggesting that there is much that can be done to improve the nutritional quality of available options for college students.

Local and state policy makers have demonstrated that regulatory action can help shape vending options, though this likely promotes a piecemeal approach to a systemic problem. National directives are clearly needed to shape all the varied and interacting factors that contribute to obesogenic environments. This paper isolated and analyzed one of these variables: vending options on college campuses and finds that most snack options are of poor nutritional quality and few snack options are nutrient dense and healthy. Findings such as these should be utilized by stakeholders on campus to adopt and enforce healthy vending policies. Likewise, assessment of food environments helps in the development of population-based interventions focusing on desirable behavior changes.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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