



Research review

Vending machine assessment methodology. A systematic review



Melissa A. Matthews, Tanya M. Horacek *

Syracuse University, Syracuse, NY, USA

ARTICLE INFO

Article history:

Received 11 July 2014

Received in revised form 12 February 2015

Accepted 6 March 2015

Available online 12 March 2015

Keywords:

Vending machines

Environment

Snacks

Beverages

ABSTRACT

The nutritional quality of food and beverage products sold in vending machines has been implicated as a contributing factor to the development of an obesogenic food environment. How comprehensive, reliable, and valid are the current assessment tools for vending machines to support or refute these claims? A systematic review was conducted to summarize, compare, and evaluate the current methodologies and available tools for vending machine assessment. A total of 24 relevant research studies published between 1981 and 2013 met inclusion criteria for this review. The methodological variables reviewed in this study include assessment tool type, study location, machine accessibility, product availability, healthfulness criteria, portion size, price, product promotion, and quality of scientific practice. There were wide variations in the depth of the assessment methodologies and product healthfulness criteria utilized among the reviewed studies. Of the reviewed studies, 39% evaluated machine accessibility, 91% evaluated product availability, 96% established healthfulness criteria, 70% evaluated portion size, 48% evaluated price, 52% evaluated product promotion, and 22% evaluated the quality of scientific practice. Of all reviewed articles, 87% reached conclusions that provided insight into the healthfulness of vended products and/or vending environment. Product healthfulness criteria and complexity for snack and beverage products was also found to be variable between the reviewed studies. These findings make it difficult to compare results between studies. A universal, valid, and reliable vending machine assessment tool that is comprehensive yet user-friendly is recommended.

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* Corresponding author.

E-mail address: thoracek@syr.edu (T.M. Horacek).

Introduction

According to recent National Health and Nutrition Examination Survey (NHANES) data, in 2011–2012 the percentage of overweight children and adolescents (BMI \geq 85th percentile) between the ages of 2 and 19 was 31.8% (Ogden, Carroll, Kit, & Flegal, 2014). Additionally, the percentage of obese children and adolescents (BMI $>$ 95th percentile) 2 to 19 years old was 16.9% in 2011–2012 (Ogden et al., 2014). Childhood obesity is particularly problematic because it is a predictor of many chronic health conditions, such as obesity, type-2 diabetes, hypertension, and cardiovascular disease in adulthood (Deckelbaum & Williams, 2001). In the US, the increasing percentage of overweight and obese adults, currently 63%, has been associated with the increasing incidence of several chronic health issues, particularly type-2 diabetes and cardiovascular disease (Nguyen, Nguyen, Lane, & Wang, 2011; Ogden et al., 2014; Saydah et al., 2014).

Nutrition and food environments are implicated as contributing factors to the rising obesity and chronic health disease rates seen in the US (Voss, Klein, Glanz, & Clawson, 2012). For children and adolescents, schools are a prominent source of calories, with as much as one third of a child or adolescent's daily caloric intake, regardless of nutritional quality, being consumed at school (United States Department of Agriculture, 2013). Meals provided by the federally assisted school meal programs, the National School Lunch and Breakfast Programs (NSLP and SBP), must satisfy federal nutrition standards (United States Department of Agriculture, n.d.). Children and adolescents also have the option to buy competitive foods and beverages, which as defined by the United States Department of Agriculture (USDA), are items such as those sold in vending machines and schools stores that are offered in schools that are supplemental to school meal programs (United States Department of Agriculture, 2013; United States Department of Agriculture Food and Nutrition Service, 2013). Previous research suggests that the majority of competitive food items offered in vending machines are higher in fat, calories, and sugars than is recommended after the implementation of such policies (Kubik et al., 2013; Pasch et al., 2011). However, an approved amendment to the NSLP and SBP guidelines that are posited to address, regulate, and change the competitive food environment in schools went into effect in July 2014 (United States Department of Agriculture Food and Nutrition Service, 2013). This amendment, referred to as 'Smart Snacks in Schools' was fully implemented in all elementary, middle, and high schools participating in the NSLP and/or SBP, and established inclusive nutrition standards and guidelines for all food and beverage items sold in schools, including competitive items sold a la carte, in school stores, and in vending machines (United States Department of Agriculture Food and Nutrition Service, 2013). According to 'Smart Snacks in Schools' guidelines, food items sold in school vending machines must contain \leq 200 calories, \leq 35% calories from fat (excluding nuts, seeds, and low-fat cheese), $<$ 10% calories from saturated fat, 0 g trans fat, and \leq 230 mg sodium per package and \leq 35% sugar by weight per serving (excluding fresh, frozen, canned, and dried fruits and vegetables, fruits packed in 100% juice or extra light syrup) (United States Department of Agriculture Food and Nutrition Service, 2013). Additionally, beverages permissible in school vending machines that meet 'Smart Snacks in Schools' guidelines vary between elementary, middle, and high schools (United States Department of Agriculture Food and Nutrition Service, 2013). In elementary schools, 8 oz. portions of 100% fruit and vegetable juices may be sold in vending machines and in middle and high schools 12 oz. portions may be sold (United States Department of Agriculture Food and Nutrition Service, 2013). In elementary schools unflavored 1% milk and flavored or unflavored non-fat milk may be sold in vending machines and in middle and high schools 12 oz. portions may be sold (United States Department of Agriculture Food and Nutrition Service, 2013). In all schools water without additives may be sold in vending

machines at any size (United States Department of Agriculture Food and Nutrition Service, 2013). In high schools 20 oz. portions of calorie-free, flavored or unflavored, caffeinated or non-caffeinated, carbonated water may be sold in vending machines, but these beverages cannot be sold in elementary or middle schools (United States Department of Agriculture Food and Nutrition Service, 2013). Additionally, in high schools sports drinks \leq 50 calories per 8 oz. may be sold in vending machines, but these beverages cannot be sold in elementary or middle schools (United States Department of Agriculture Food and Nutrition Service, 2013).

Depending on the type of food items available for purchase, vending machines, a major source of competitive foods, can either positively or negatively affect the diets of children, adolescents, and adults (Rovner, Nansel, Wang, & Iannotti, 2011). The presence of vending machines in a multitude of settings influence the food choices of children, adolescents, and adults by providing convenient and easy access to a plethora of unhealthy snacks and beverages (New & Livingstone, 2003). Vending machines are becoming increasingly more common in a wide variety of settings including schools, universities, healthcare facilities, and various worksites. According to the 2011 *State of the Vending Industry Report*, 28.5% of all vending machines in the US were located in offices, 26.8% in manufacturing buildings, 9.1% in retail sites, 8.8% in hospitals and nursing homes, 7.0% in restaurants, bars, and clubs, 6.8% in elementary, middle, and high schools, and 5.9% in universities and colleges (Maras, 2011).

Because vending machines are becoming increasingly more prevalent and available in the US, they are responsible for supplying a growing proportion of an individual's daily energy intake. In 2009, according to the third School Nutrition Dietary Assessment Study, 40% of children and adolescents consumed at least one competitive food daily while at school, with the highest consumption rates seen among high school students (Fox, Gordon, Nogales, & Wilson, 2009). Beyond the primary and secondary school environment, 19% of a sample of staff and faculty ($n = 806$) at a large urban university indicated that they purchase snacks from vending machines (Freedman & Rubenstein, 2010). Additionally, although vending machines are more often used for snacking, a study of 1918 US adults working outside the home (4.4%) indicated vending machines as their primary site for purchasing lunch items during work hours (Blanck et al., 2009). Furthermore, for individuals working long hours, vending machines may be the only available source of food at the worksite, thus demonstrating the importance of healthy product availability in vending machines (Escoto et al., 2010). Similarly, in university, manufacturing, and healthcare facility environments, accessibility to dining options may be limited due to cafeteria location and hours of operation, rendering vending machines the sole source of foods and beverages readily available to individuals in these environments (Byrd-Bredbenner et al., 2012; Lawrence, Boyle, Craypo, & Samuels, 2009).

Because vending machines are becoming increasingly more prevalent and available, and thus supply a growing proportion of individuals' daily energy intake, it is important to accurately assess and monitor the nutritive value of vended products. Diet and eating behaviors are strongly influenced by food availability and accessibility, thus it is important to monitor and measure various aspects of the food and nutrition environment, which includes vending machines. The purpose of this systematic review is to summarize, compare, and evaluate the current available literature on vending machine assessment methodology. The information gathered from this systematic review will be used to earmark the variables important for inclusion in a universal vending machine assessment tool.

Methods

A systematic literature review was conducted to determine the available information on vending machine assessment methodology.

Only published peer-reviewed articles containing detailed methods for evaluating vending machines were reviewed. Specific databases searched included Scopus, PubMed, MEDLINE, and ProQuest. Article titles were searched within these databases for the specific keywords (vending OR vending machine) AND (assessment OR evaluation OR audit) AND (snack OR food OR beverage OR drink). A total of 242 peer-reviewed articles, including duplicates, were retrieved from the databases that matched the search criteria for article title. The search results were all compiled into a master reference list and all duplicate studies were removed.

For all remaining research articles, the full text was read to determine if the research study met the inclusion criteria for this systematic review. Inclusion criteria for this review were as follows. (a) The research article must be peer-reviewed. (b) One of the primary aims or objectives of the research study was to assess vending machines and/or vending machine products and/or the effects of environmental interventions on vending machine use, product availability, and/or purchasing patterns by consumers. (c) The research article provided detailed methodology on how vending machines and/or vending machine products were evaluated and/or the research study evaluated or manipulated at least one key vending machine assessment variable including accessibility, availability, healthfulness, portion size, price, and promotion. All criteria (a–c) had to be met for inclusion in this review. Additionally, abstracts from all references obtained from relevant first tier research articles secured from search engines that met the inclusion criteria were reviewed. Additional second tier research articles were selected if they met the aforementioned inclusion criteria. Research articles that evaluated vending machines in the context of a larger environmental audit were excluded from this study because the purpose of this review is to highlight research studies whose primary focus was to evaluate vending machines. All reviewed studies were graded and selected for inclusion by the primary researcher. In total, 24 articles published between 1981 and 2013 are summarized, compared, and evaluated in this systematic review (Tables 1 and 2). Of note, both the [Winston et al. \(2013a\)](#) and [Winston et al. \(2013b\)](#) studies evaluated healthcare facilities using the Hospital Nutrition Environment Scan for Cafeterias, Vending Machines, and Gift Shops, with the former study establishing validity and the latter study establishing reliability. For this review, both studies were subsequently combined and are referred to collectively as one study for result purposes.

Results

Of the articles summarized, compared, and evaluated for this study, 78% (17 articles) evaluated vending machines and/or vending machine products (Table 1). Additionally, 22% (5 articles) investigated the effects of environmental interventions on vending machine use, product availability, and/or vending machine purchasing patterns (Table 2). All studies included in this systematic review evaluated or manipulated at least one key vending machine assessment variable: accessibility, availability, healthfulness, portion size, price, or promotion.

Study location

Of the articles reviewed, 56% (13 studies) were conducted in primary and secondary schools, 17% (4 studies) in universities, 17% (4 studies) in healthcare facilities, and 13% (3 studies) in worksites. The majority of studies were conducted in only one type of environment, but one intervention study was implemented in both schools and worksites. It should be noted that the location categories are not mutually exclusive, as schools, universities, and healthcare facilities can also be considered worksites. The reviewed studies found to meet inclusion criteria for this review were

predominantly conducted in schools, universities, and healthcare facilities. The worksite category was created to encompass all other worksites outside of the school, university, and healthcare environments such as manufacturing, transportation, and office facilities.

Assessment tool design

A wide assortment of different assessment tools have previously been used and developed to evaluate vending machines. In the reviewed literature, the most commonly used method in 52% of all evaluated studies was an environmental assessment, defined as a physical direct observation and review of the actual vending machines. Researchers or research assistants performed the majority of environmental assessments, but food service directors performed the environmental assessment in one study. Researchers in 39% of studies administered questionnaires to a wide variety of respondents including students, child nutrition supervisors, principals, school personnel, worksite employees, and adults to evaluate respective vending machine environments. Additionally, 26% of studies recorded vending machine sales to track purchasing and consumption patterns of consumers. Additionally, 8% of studies utilized qualitative methods, telephone interviews and focus groups, to gather in-depth perceptions when assessing vending machines. Although studies have used similar methodologies to evaluate vending machines and/or vended products, there is wide variability between assessment tools. Each vending machine evaluation or intervention study developed a unique assessment tool to investigate vending machines, each with different evaluation components and criteria. Additionally, some studies utilized one assessment tool type, while others triangulated methodologies and utilized variety of different assessment tools to evaluate vending machines.

Accessibility

Of the articles reviewed, 39% (9 studies) investigated vending machine accessibility. Researchers evaluated and recorded the location of vending machines in 35% of studies. Researchers also evaluated and recorded vending machine hours of operation in 30% of studies.

Availability

Product availability was the most common vending machine assessment variable found in 91% (21 studies) of studies: evaluated in 78% and manipulated in 13%. Of the reviewed studies, 43% recorded the number of all snacks and/or beverages within evaluated vending machines. Similarly, 39% recorded the percentage of 'healthy' snack and/or beverage products within evaluated vending machines based upon each study's respective healthfulness criteria standards (Tables 3 and 4). Additionally, 17% recorded the number of machines, 17% recorded the percentage of specific snack and/or beverage product types, and 13% evaluated consumer perceptions of product availability within vending machines. Furthermore, 13% implemented interventions that increased the availability of 'healthy' snack and/or beverage products in vending machines.

Healthfulness criteria

The majority of reviewed studies, 96% (22 studies), previously established healthfulness criteria to evaluate the nutritional quality of vended snacks and/or beverages in order to classify products as healthy or unhealthy (Tables 3 and 4). Healthfulness criteria were established for snack products in 87% (20 studies). Combinations of three different types of classification methods have been employed to establish the healthfulness of vended snacks; 65% used macro- and/or micronutrient content as a basis for healthfulness,

Table 1
Comparison of vending machine environmental assessment studies.

Study	Location	Assessment tool	Variables evaluated during assessment						Validity and reliability
			Accessibility	Availability	Healthfulness criteria	Portion size	Price	Promotion	
Adachi-Mejia et al. (2013)	Schools	Environmental assessment (researchers)	Yes Hours of operation Location	Yes Number of machines Percentage of beverage types	Yes Beverages	No	No	Yes Machine front advertisements	No
Alaimo et al. (2013)	Schools	Environmental assessment (food service directors)	Yes Hours of operation Location	Yes Recorded all snacks and beverages Percentage of 'healthy' products	Yes Snacks	Yes Package size	Yes Recorded prices of all snacks and beverages	No	No
Aljadir, Biggs, and Misko (1981)	University	Environmental assessment (researchers) Questionnaire (students) Vending machine sales	No	Yes Recorded number of 'healthy' products Perceptions	Yes Snacks	Yes Serving size	Yes Recorded prices of all snacks and beverages Perceptions	No	No
Bell et al. (2013)	Healthcare facilities	Environmental assessment (researchers) Telephone interviews (parents and food service managers)	No	Yes Recorded all snacks and beverages Percentage of 'healthy' products Perceptions	Yes Snacks Beverages	Yes Package size	No	Yes Signage Identification labels Perceptions	No
Byrd-Bredbenner et al. (2012)	Universities	Environmental assessment (researchers)	Yes Location	Yes Recorded all snacks and beverages Percentage of 'healthy' products	Yes Snacks Beverages	Yes Package size	No	No	Yes Inter-rater reliability
Callaghan et al. (2010)	Schools	Focus groups (students) Vending machine sales	No	Yes Perceptions	Yes Snacks	Yes Package size	Yes Perceptions	Yes Identification labels Student perceptions	No
French et al. (2003)	Schools	Environmental assessment (researchers)	Yes Hours of operation Location	Yes Number of machines Recorded all snack products Percentage of 'healthy' products	Yes Snacks	Yes Serving size	No	No	No
Gemmill and Cotugna (2005)	Schools	Questionnaire (child nutrition supervisors)	Yes Location	Yes Percentage of product types	Yes Snacks Beverages	Yes Serving size	No	No	Yes Face validity
Jensen, Sato, McMurty, Hart, and Jelalian (2012)	Schools	Environmental assessment (researchers) Questionnaire (students)	No	Yes Recorded all beverages Percentage of 'healthy' products	Yes Beverages	No	No	No	No
Kelly et al. (2012)	Train stations	Environmental assessment (researchers)	No	Yes Recorded all snacks and beverages Percentage of 'healthy' products	Yes Snacks Beverages	Yes Serving size	Yes Recorded average prices of 'healthy' and 'unhealthy' products	Yes Machine front advertisements Advertisements	No
Kubik, Lytle, and Farbakhsh (2011)	Schools	Environmental assessment (researchers) Questionnaire (principals)	Yes Hours of operation	Yes Recorded all snacks and beverages	Yes Snacks Beverages	Yes Serving size	No	No	Yes Content validity

(continued on next page)

Table 1 (continued)

Study	Location	Assessment tool	Variables evaluated during assessment							Validity and reliability
			Accessibility	Availability	Healthfulness criteria	Portion size	Price	Promotion		
Lawrence et al. (2009)	Healthcare facilities	Environmental assessment (researchers)	Yes Hours of operation Location	Yes Recorded all snacks and beverages Percentage of 'healthy' products	Yes Snacks Beverages	Yes Package size	Yes Recorded price of all snacks and beverages	Yes Signage	No	
Minaker et al. (2011)	Schools	Questionnaire (students)	No	Yes Number of machines	No	No	No	Yes Machine front advertisements	No	
Park, Sappenfield, Huang, Sherry, and Bensyl (2010)	Schools	Questionnaire (students)	No	Yes Percentage of product types	Yes Snacks Beverages	No	No	No	No	
Pasch et al. (2011)	Schools	Questionnaire (school personnel)	Yes Hours of operation	Yes Recorded all snacks and beverages	Yes Snacks Beverages	Yes Serving size	Yes Recorded prices of all snacks and beverages	No	No	
Voss et al. (2012)	Universities	Environmental assessment (students)	Yes Hours of operation location	Yes Percentage of 'healthy' products	Yes Snacks Beverages	Yes Serving size	Yes recorded prices of all snacks and beverages	Yes Signage	Yes Inter-rater reliability Test–retest reliability	
Whately Blum et al. (2007)	Schools	Environmental assessment (researchers)	No	Yes Number of machines Recorded all snacks and beverages Percentage of 'healthy' products	Yes Snacks Beverages	Yes Package size	No	No	No	
Winston et al. (2013a); Winston et al. (2013b)	Healthcare facilities	Environmental assessment (researchers)	No	Yes Recorded presence of certain snacks and beverages	Yes Snacks Beverages	No	No	Yes Signage Identification labels	Yes Face and content validity Inter-rater reliability	

Table 2
Comparison of vending machine environmental intervention studies.

Study	Location	Assessment tool	Variables evaluated during intervention			Variables manipulated during intervention			Validity and reliability
			Healthfulness criteria	Portion size	Accessibility	Availability	Price	Promotion	
French, Jeffery, Story, Hannan, and Snyder (1997)	Universities	Vending machine sales	Yes Snacks	Yes Package size	No	No	Yes Reduced prices of low-fat options	Yes Information labels on products to indicate low-fat options Signage encouraging low-fat options	No
French et al. (2001)	Schools and worksites	Vending machine sales	Yes Snacks	Yes Package size	No	No	Yes Reduced prices of low-fat options	Yes Information labels on products to indicate low-fat options Signage encouraging low-fat options	No
French et al. (2010)	Bus garages	Vending machine sales Questionnaire (employees)	Yes Snacks Beverages	Yes Package size	No	Yes Increased availability of 'healthy' options	Yes Reduced prices of 'healthy' options	No	No
Kocken et al. (2012)	Schools	Vending machine sales	Yes Snacks Beverages	Yes Package size	No	Yes Increased availability of lower calorie options	Yes Reduced prices of lower calorie options	Yes Information labels on products to indicate lower calorie options	No
Van Hulst, Barnett, Dery, Cote, and Colin (2013)	Healthcare facility	Questionnaire (adults)	Yes Snacks Beverages	No	Yes Location	Yes Increased availability of healthier beverages, meals, and snacks	No	Yes Healthy habits signage and posters Interactive displays	No

34% used caloric content, and 9% used snack type. However, exact healthfulness criteria used to classify products as healthy or unhealthy was unspecified in 13%. Among the reviewed studies, the established healthfulness criteria for vended snack products have varied from simple to complex (Table 3).

Beverage products have been evaluated less extensively, with healthfulness criteria established in 70% (16) of the studies. Similar to snacks, combinations of several different types of classification methods have been employed to establish the healthfulness of vended beverages: 43% used beverage type, 17% used added sweetener content, 13% used caloric content, and 13% used macro- and/or micronutrient content. Among the reviewed studies evaluating beverage healthfulness, the specific healthfulness criteria for vended beverage products were variable.

Previous conclusions on vended product healthfulness and vending environment

Of all reviewed articles, 87% (20 studies) reached conclusions that provided insight into the healthfulness of vended products and/or vending environment (Table 5). Only 30% of all reviewed studies reached conclusions regarding the healthfulness of both snack and beverage products. Furthermore, one study reached conclusions regarding the healthfulness of snacks alone and one study reached conclusions regarding the healthfulness of beverages alone. Collectively, results from these studies indicated that the majority of snacks and beverages available in vending machines were unhealthy and did not meet respective healthfulness criteria.

Additionally, 22% (5) of all reviewed articles reached conclusions regarding the effectiveness of previously implemented nutrition policies, programs, and interventions that were targeted at improving the vending machine environment. Results from 4 out of these 5 studies indicated that nutrition policies, programs, and interventions were effective at improving healthy product availability and consumption within the vending machine environment healthy

product availability. However, one out of the aforementioned 5 studies indicated that the sales of healthy vending machine products did not increase when healthy product availability was increased.

Similarly, 22% (5) of all reviewed studies reached conclusions regarding the effects of environmental interventions that increased healthy product availability, increased healthy product promotional signage, and/or reduced healthy product price. Collectively, results from these studies indicated that healthy product sales increased following environmental interventions on vending machines, although one study indicated that a low percentage of consumers actually purchased healthy products from vending machines, despite their presence.

Portion size

Among the reviewed studies, when assessing the healthfulness of vended snacks and/or beverages, 70% (16 studies) differentiated product evaluation based on package size versus serving size. Of the reviewed studies, 43% evaluated snack and beverage healthfulness based on package size, while 30% evaluated snack and beverage healthfulness based on serving size.

Price

Prices of vended snack and beverage products have also been commonly evaluated and/or manipulated in 48% (11 studies) of the reviewed studies. Of the reviewed studies, 22% recorded the prices of all snacks and beverages within the evaluated vending machines, with one study recording the average price of 'healthy' and 'unhealthy' products. Additionally, only 9% of all reviewed studies evaluated consumer perceptions regarding the prices of healthy and unhealthy products sold in vending machines. Furthermore, 17% of all reviewed studies implemented interventions to investigate the effects of 'healthy' product price reductions on vending machine sales.

Table 3
Comparison of snack healthfulness criteria.

Study	Snack type	Calories	Fat	Saturated fat	Sugar	Protein	Sodium	Fiber	Cholesterol	Vitamin A	Vitamin C	Niacin	Thiamine	Riboflavin	Iron	Calcium
Alaimo et al. (2013) ^a																
Aljadir et al. (1981) ^b						X				X	X	X	X	X	X	X
Bell et al. (2013) ^c																
Byrd-Bredbenner et al. (2012) ^d		X		X	X	X	X	X	X	X	X				X	X
Callaghan et al. (2010)			X ^e	X ^f			X ^g									
French et al. (1997)			X ^h													
French et al. (2001)			X ^h													
French et al. (2003)			X ⁱ													
French et al. (2010)		X ^j	X ^k		X ^l											
Gemmill and Cotugna (2005) ^b						X				X	X	X	X	X	X	X
Kelly et al. (2012)		X ^m														
Kocken et al. (2012)		X ⁿ														
Kubik et al. (2011)		X ^o	X ^p													
Lawrence et al. (2009)		X ^q	X ^r	X ^s	X ^l											
Park et al. (2010)	X ^t															
Pasch et al. (2011)		X ^p	X ^r													
Van Hulst et al. (2013) ^u																
Voss et al. (2012)		X ^p	X ^v	X ^w	X ^x		X ^y									
Whately Blum et al. (2007)			X ^k		X ^l											
Winston et al. (2013a);Winston et al. (2013b)		X ^p	X ^v	X ^w	X ^x		X ^y									

^a Exact criteria unspecified within study. Healthfulness criteria standards described as virtually identical to the new proposed *USDA Nutrition Standards for All Foods Sold in Schools* with some slight modifications. Snacks were considered healthy if nutrient content fell within 10% of the specified nutritional standards.

^b Healthy products supplied at least 5% of the USRDA for 2 of 8 critical nutrients.

^c Exact criteria unspecified within study. Healthfulness criteria standards were adapted from the 'traffic light' nutrition classification system created as part of a NSW Healthier Choices program.

^d Nutrient Adequacy Ratios (NARs) calculated for each nutrient by dividing the amount in vended food item by its DV. A quality score was determined by dividing a Nutrients to Maximize Score (average of vitamin A, vitamin C, protein, dietary fiber, iron, and calcium NARs) by a Nutrients to Minimize Score (average of saturated fat, cholesterol, sodium, and total sugar NARs).

^e Healthier products contain ≤6 g fat/package.

^f Healthier products contain ≤2 g saturated fat/package.

^g Healthier products contain ≤2 g sodium/package.

^h Healthier products contain ≤3 g fat/package.

ⁱ Healthier products contain ≤5 g fat/serving.

^j Healthier products contain ≤150 calories/package.

^k Healthier products contain ≤30% calories from fat/package.

^l Healthier products contain ≤35% sugar by weight/package.

^m Healthier products contain ≤600 kJ/serving.

ⁿ Healthier products contain ≤100 kcals/package.

^o Healthier products contain ≤3 g fat/serving.

^p Healthier products contain ≤200 kcals/serving.

^q Healthier products contain ≤250 kcals/package.

^r Healthier products contain ≤35% calories from fat/package.

^s Healthier products contain ≤10% calories from saturated fat/package.

^t Healthier products include trail mix, nuts, and granola bars.

^u Exact criteria unspecified within study. Food and beverage options were selected according to *Eating Well with Canada's Food Guide*, Institute of Medicine, and American Heart Association guidelines.

^v Healthier products contain ≤35% calories from fat/serving.

^w Healthier products contain ≤10% saturated fat/serving.

^x Healthier products contain ≤35% sugar by weight/serving.

^y Healthier products contain ≤200 mg sodium/serving.

Table 4
Comparison of beverage healthfulness criteria.

Study	Beverage TYPE	Calories	Fat	Saturated FAT	Sugar	Protein	Sodium	Fiber	Cholesterol	Vitamin A	Vitamin C	Iron	Calcium	Niacin	Thiamine	Riboflavin	Added sweeteners
Adachi-Mejia et al. (2013)	X ^a																
Bell et al. (2013) ^b																	
Byrd-Bredbenner et al. (2012) ^c		X		X	X	X	X	X	X	X	X	X	X				
French et al. (2010)		X ^d	X ^e		X ^f												
Gemmill and Cotugna (2005) ^g						X				X	X	X	X	X	X	X	
Jensen et al. (2012) ^h	X																X
Kelly et al. (2012)	X ⁱ																
Kocken et al. (2012)		X ^j															
Kubik et al. (2011)	X ^k																
Lawrence et al. (2009)	X ^l																X
Park et al. (2010)	X ^m																X
Pasch et al. (2011)	X ⁿ																X
Van Hulst et al. (2013) ^o																	
Voss et al. (2012)	X ⁿ																X
Whately Blum et al. (2007)	X ^p																
Winston et al. (2013a); Winston et al. (2013b)	x ⁿ																X

^a Beverage classifications included the following categories: sugar-sweetened beverages (regular soda, sports drinks, fruit drinks, non-diet iced teas, lemonades, and other sweetened drinks), diet soda, other diet beverages, plain water/zero-calorie seltzer waters, flavored/vitamin water, 100% fruit or vegetable juice, milk, and others.

^b Exact criteria unspecified within study. Healthfulness criteria standards were adapted from the 'traffic light' nutrition classification system created as part of a NSW Healthier Choices program.

^c Nutrient Adequacy Ratios (NARs) calculated for each nutrient by dividing the amount in vended food item by its DV. A quality score was determined by dividing a Nutrients to Maximize Score (average of vitamin A, vitamin C, protein, dietary fiber, iron, and calcium NARs) by a Nutrients to Minimize Score (average of saturated fat, cholesterol, sodium, and total sugar NARs).

^d Healthier products contain ≤150 calories/package.

^e Healthier products contain ≤30% calories from fat/package.

^f Healthier products contain ≤35% sugar by weight/package.

^g Healthier products supplied at least 5% of the USRDA for 2 of 8 critical nutrients.

^h Healthier products include water, including carbonated water and water flavored or sweetened with 100% fruit juice and no added sweetener; nonfat milk, 1% fat milk, and dairy alternatives; and 100% fruit or vegetable juice that are composed of no less than 50% fruit juice and have no added sweetener.

ⁱ Healthier products include water (plain, mineral, or soda), diet soft drinks, 100% fruit or vegetable juice, and diet energy drinks.

^j Healthier products contain ≤100 kcals/package.

^k Unhealthy products include soft drinks (regular and diet), fruit drinks that were not 100% fruit juice, sports drinks, and reduced-fat or whole milk (plain or flavored).

^l Healthier products include fruit juice with ≥50% juice and no added sweeteners, milk with ≤2% fat, water with no added sweeteners, and sports drinks with ≤42 g of added sweetener per 20 oz. serving.

^m Healthier products include 100% fruit juices, milk, chocolate milk, water, and diet soda.

ⁿ Healthier products include water without additives, carbonation, caffeine, or flavoring; low-fat and nonfat milk; flavored milk with ≤22 g of total sugar/serving; and 100% fruit juice.

^o Exact criteria unspecified within study. Food and beverage options were selected according to *Eating Well with Canada's Food Guide*, Institute of Medicine, and American Heart Association guidelines.

^p Healthier products include nonfat or 1% low-fat milk (including flavored milk), 100% juice, and water.

Table 5
Comparison of previous conclusions regarding vended product healthfulness.

Study	Study conclusions
Adachi-Mejia et al. (2013)	Common beverages found in evaluated vending machines were flavored water (34.8% of slots), sugar-sweetened beverages (23.6% of slots), and plain water (21.8% of slots).
Alaimo et al. (2013)	In schools where nutrition policies were implemented to improve the nutritional quality of vended food items, the nutritional quality of students' dietary intake improved.
Aljadir et al. (1981)	An almost exclusive selection of high calorie and/or low nutritional value snacks were found in evaluated vending machines.
Bell et al. (2013)	Following an intervention to improve the nutritional value of snacks and beverages in vending machines in a hospital, the percentage of healthy snacks and healthy beverages increased from 29% to 51% and 0% to 26%, respectively.
Byrd-Bredbenner et al. (2012)	The majority of snacks and beverages found in evaluated vending machines were not nutrient dense.
Callaghan et al. (2010)	Overall vending machine sales declined after implementation of an intervention that replaced 50% of vending machine slots with healthier snacks.
French et al. (1997)	During a price reduction and increased promotional signage intervention, low-fat snack sales increased 80%.
French et al. (2001)	During a price reduction and promotional signage intervention, low-fat snack sales significantly increased.
French et al. (2003)	The median percentage of low-fat snacks found in evaluated vending machines was 35%, but mostly due to a large number of hard candy items.
French et al. (2010)	During a price reduction and increased healthy snack and beverage availability intervention, healthy product sales significantly increased.
Gemmill and Cotugna (2005)	The majority of snacks and beverages sold in vending machines were of minimal nutritional value.
Jensen et al. (2012)	Following an implementation of a healthy beverage policy in vending machines in schools, 78.8% of evaluated beverages were found to be in compliance with the policy.
Kelly et al. (2012)	Of all evaluated vending machines, 84% of slots contained high-energy snacks and beverages.
Kocken et al. (2012)	During a price reduction, increased promotional signage, and increased healthy product availability intervention, proportional sales of healthy snacks and beverages increased.
Kubik et al. (2011)	Low-nutrient energy dense snack and beverage prevalence was high in evaluated vending machines.
Lawrence et al. (2009)	Across all evaluated vending machines, 81% of snacks and 75% of beverages were classified as unhealthy.
Park et al. (2010)	Only 3.6% of surveyed students reported purchasing healthier snacks and beverages from vending machines.
Pasch et al. (2011)	The majority of snacks and beverages offered in evaluated vending machines were high in calories and fat.
Van Hulst et al. (2013)	During an increased promotional signage and healthy product availability intervention in a hospital participant perception and knowledge regarding healthy vended products improved and increased, respectively.
Whately Blum et al. (2007)	Following an intervention to improve the nutritional value of snacks and beverages in vending machines in schools, the percentage of healthy snacks and healthy beverages increased from 22.5% to 84% and 48% to 98.9%, respectively.
Winston et al. (2013a)	Evaluated vending machines received an average of 33% of total possible points for healthfulness, indicating that vending machines are not conducive to a healthy nutrition environment.

Promotion

Product promotion was also a commonly assessed variable in vending machines, evaluated and/or manipulated in 52% (12 studies) of the reviewed studies. However, only 22% recorded the presence of promotional signage and advertisements on or surrounding vending machines within the environment. Additionally, 13% recorded the presence of machine front advertisements and logos, 13% recorded the presence of healthy and unhealthy identification labels on individual snack and/or beverage products within vending machines, and 8% evaluated consumer perceptions regarding product promotion regarding vending machines and vending machine products. Furthermore, 17% implemented interventions to investigate the effects of increased healthy production promotional signage and identification labels on vending machine sales.

Quality of scientific practice

Although many vending machine assessment tools have been developed and implemented in a variety of settings, only 22% (5 studies) of the reviewed studies established validity and/or reliability for their assessment tools. Only 13% implemented assessment tools that were validated, with only one study establishing face validity and one study establishing content validity. Additionally, only 13% evaluated the reliability of their respective assessment tools, with 2 studies establishing inter-rater reliability only, and one study establishing inter-rater and test-retest reliability.

Discussion

Through a summary, evaluation, and comparison of the current literature on vending machine assessment methodologies, several key variables were identified as important to accurately evaluate the vending machine environment; price, promotion, accessibility,

availability, package size, and healthfulness criteria. Product price is an important variable to evaluate because price can have a strong influence over the purchasing behaviors of consumers (Callaghan, Mandich, & He, 2010). Generally, energy-dense products are perceived to be less expensive than healthier nutrient-dense products, which can influence an individual's dietary choices from vending machines (Callaghan et al., 2010). Price is also commonly cited as a barrier to purchasing healthier products (Callaghan et al., 2010). Additionally, a pricing intervention study in Minnesota schools and worksites found that when the prices of low-fat snacks were reduced the sales of low-fat items increased (French, Story, Fulkerson, & Gerlach, 2003). Although research demonstrates that the price of vended products is an important factor to consider during an evaluation of vending machines, only about 50% of the articles reviewed in this study included product price as an assessment variable.

Product promotion of both healthy and unhealthy vended snacks and beverages is also an important variable to include because brand logos and product advertisements are known to have an influential effect on snack and beverage consumption. A survey of nearly 5000 Canadian adolescents revealed that the presence of snack and beverage logos was positively associated with student purchase of vended snacks and beverages, particularly of unhealthy items such as salty snacks, candy, and sugar sweetened beverages (Minaker et al., 2011). Additionally, front of package nutrition claims and labels have also been shown to have an effect on product knowledge and consumption. Following an intervention at four schools in Ontario where healthier vended products were promoted to students and staff via promotional materials, nutrition information, and product flagging students indicated through focus groups that promotional signage and information raised their awareness of healthy products in vending machines (Callaghan et al., 2010). Although research demonstrates that the promotion of vended products is an important factor to consider during an evaluation of vending machines,

only 52% of the articles reviewed in this study included product promotion as an assessment variable.

Machine accessibility is also an important factor to consider because if vending machines are not accessible or open to children, adolescents, and adults they cannot purchase vended snacks and beverages. Research has shown that students consume more sweets in schools when vending machines are more readily open and accessible (Rovner et al., 2011). However, only one third of the research studies included in this review evaluated machine accessibility as an assessment variable.

Similarly, product availability is an important factor to evaluate because if healthy food and beverage items are not readily available or present in vending machines, it is difficult for individuals to make healthy dietary choices. Surrounding food and nutrition environments have a strong influence on an individual's eating habits, thus if healthy snacks and beverages are available, individuals are capable of improving dietary intake. Following an intervention in bus garages where the availability of healthy vended products was increased, the sales of healthy vended products also increased (French et al., 2010). In order to determine healthy product availability within vending machines, healthfulness criteria for vended snacks and beverages must be established. Vended product healthfulness should also be evaluated based on the product's package size instead of the product's serving size, because research has shown that consumers have a tendency to consume the entire package of a vended product rather than just consuming the recommended serving size (Antonuk & Block, 2006).

The majority of vending machine assessment and intervention studies have been targeted to evaluate and determine healthy product availability in vending machines. The nutritional quality of food and beverage products sold in vending machines has been implicated as a contributing factor to an obesogenic food environment. Findings from previous vending machine assessment studies provide support for this claim. An audit of vending machines in train stations in Australia found that only 8 out of the 3048 identified snack items were considered to be healthier choices (Kelly, Flood, & Bicego, 2012). Similarly, an assessment of vending machines at secondary institutions in the US found that the majority of snacks in vending machines were high in fat and calories and the majority of beverages were high in calories and sugar (Byrd-Bredbenner et al., 2012). Overall, the majority of food and beverage products sold in vending machines are considered to be of low nutritional value.

Substantial variability was found between the reviewed studies with regards to the healthfulness criteria established to classify products as healthy. In previous studies the established healthfulness criteria for vended snack products have varied from simple to complex. Evaluating products using criteria that are too simplistic or lenient could result in overestimations of the presence of healthy products in vending machines. In a study that evaluated snack product healthfulness solely on fat content, 35% of vended products were classified as healthy products, the majority of which were identified as hard candies (French et al., 2003). Hard candies, although low in fat and calories, have no real nutritive value and cannot really be considered healthy snacks. Similarly, evaluating products using criteria that are too inclusive or strict could result in underestimations of the presence of the healthy products in vending machines. The likelihood that a snack product will meet a substantive list of strict healthfulness criteria is relatively low.

Generally, combinations of three different types of classification methods have been employed to establish the healthfulness of vended snacks: macro/micronutrient content, caloric content, and snack type. However, the variability in established healthfulness criteria makes it difficult to compare results regarding healthy product availability between studies. If studies did not use the same healthfulness criteria to classify products, healthy product availability findings are not comparable between the studies. The majority of

reviewed studies have focused primarily on the fat, sugar, sodium, and/or caloric content of snacks, which are all important criteria to consider as they are all food components that should be reduced in the American diet as outlined by the *2010 Dietary Guidelines for Americans* (United States Department of Agriculture and United States Department of Health and Human Services, 2010). However, in order to comprehensively evaluate the healthfulness of snacks, perhaps the content of beneficial nutrients that should be increased in the American diet in snacks should also be assessed.

Additionally, according to qualitative research, among the general public, many different cognitive definitions of healthy food and healthy eating practices exist (Bisogni, Jastran, Seligson, & Thompson, 2012). For instance, some individuals classify healthy and unhealthy foods based on food type (fruit, vegetables, etc.), others based on nutrient content (fat, sugar, fiber, etc.), and some based on eating behaviors (balance, variety, moderation, etc.) (Bisogni et al., 2012). Individuals also interpret healthy foods differently based on their age, psychosocial experiences, and cultural backgrounds. Therefore, since healthfulness definitions and categorizations are largely personalized among the general population, it is unlikely that the healthy food definitions and classifications held by all individuals match professional and federal healthy food stipulations perfectly. Furthermore, nutrition guidelines and recommendations are constantly evolving and changing, and it may be difficult and overwhelming for the general public to remain informed about the most current recommendations, especially if they contain strict nutrient guidelines. Since there are a wide variety of ways to define foods as healthy, it may not be necessary or realistic for individuals to keep all of those definitions in mind when selecting food items, whereas it may be more worthwhile to investigate the healthfulness of vended food and beverage items, rather than if each vended item meets every dietary guideline criteria.

A simple, comprehensive, and user-friendly vending machine assessment tool that evaluates caloric content, fat content, sugar content, sodium content, and key indicator micronutrient content of vended products should be developed. Healthfulness criteria standards should be partially derived from well-established nutritional guidelines disseminated by organizations such as the United States Department of Agriculture (USDA) and the Institute of Medicine (IOM), but nutritional criteria requirements should be individualized and evaluated separately. A food or beverage product should not have to meet every nutritional requirement to be considered healthy. A standardized approach that also evaluates healthfulness using the nutrient daily value (DV) percentages listed on the food label may be the simplest way to assess product healthfulness. Using DV percentages would also serve as an indication of a product's contribution to an individual's overall diet. A standard healthfulness criteria classification approach is just one component that should be included in a comprehensive vending machine assessment tool. A comprehensive vending machine assessment tool should also evaluate machine accessibility, product availability, portion size, promotion, and price.

Conclusions

A wide range of assessment tools and methodologies were found to be currently available to measure and evaluate different aspects of the vending machine environment. However, the substantial variability in methodologies and established healthfulness criteria make it difficult to compare results between studies. Additionally, the majority of vending machine evaluation and intervention studies have been focused on the primary and secondary school environments. However, vending machines are becoming increasingly more prevalent in a wide variety of settings including healthcare facilities, universities, and worksites (Maras, 2011). Furthermore, few previous vending machine assessment tools have been validated or

tested for reliability. The development of a universal, valid, and reliable vending machine assessment tool that is both comprehensive and user-friendly is recommended. The development of such a tool would help to support and implement public health policies and environmental changes that could improve healthy food and beverage access and availability in vending machines.

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