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Measuring the Food Environment: Shelf Space of Fruits, Vegetables, and Snack Foods in Stores

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ABSTRACT *Dietary patterns may be influenced by the availability and accessibility within stores of different types of foods. However, little is known about the amount of shelf space used for healthy and unhealthy foods in different types of stores. We conducted measurements of the length of shelf space used for fruits, vegetables, and snack foods items in 419 stores in 217 urban census tracts in southern Louisiana and in Los Angeles County. Although supermarkets offered far more shelf space of fruits and vegetables than did other types of stores, they also devoted more shelf space to unhealthy snacks (mean 205 m for all of these items combined) than to fruits and vegetables (mean 117 m, $p<0.001$). After supermarkets, drug stores devoted the most shelf space to unhealthy items. The ratio of the total shelf space for fruits and vegetables to the total shelf space for these unhealthy snack items was the lowest (0.10 or below) and very similar in convenience stores, drug stores, and liquor stores, was in a middle range (0.18 to 0.30) in small food stores, and was highest in medium-sized food stores (0.40 to 0.61) and supermarkets (0.55 to 0.72). Simple measurements of shelf space can be used by researchers to characterize the healthfulness of the food environment and by policymakers to establish criteria for favorable policy treatment of stores.*

KEYWORDS *Obesity, Food, Environment, Nutrition, Urban*

INTRODUCTION

In recent years, advocates of healthy eating have become increasingly interested in the impact of the availability of different types of foods on diet.[1] Studies have shown positive associations between proximity to supermarkets and consumption of healthier foods, as well as inverse associations between proximity to supermarkets and body mass index.[2–7] In general, these studies have relied on existing databases to identify food stores and have not assessed the foods actually offered for sale in them. Thus, the actual availability of healthy and unhealthy items to people in these studies is not known.

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If foods such as fruits and vegetables are not available at all, certainly people cannot buy them and will consume fewer of them. But studies indicate that even when stores make available healthy items, their accessibility and prominence, as measured by the length of shelf space allotted to them, can have a large impact on sales. One marketing study demonstrated that sales of fruits and vegetables increased by approximately 40% with a doubling of the shelf length.[8] Other marketing studies demonstrate that shelf length can have a profound impact on the sales of a very wide range of items, suggesting that the in-store accessibility and prominence of inherently unhealthy items such as sugar-sweetened beverages and salty snacks may also have an impact on the healthfulness of customers' diets.[9–12] Thus, to understand the relationship between the "food environment" and consumption, quantitative measures are needed for both healthy and unhealthy foods in various types of food stores.

Racial and ethnic minorities and persons of lower socioeconomic status consume fewer fruits and vegetables and are more likely to suffer from diet-related diseases such as diabetes and heart disease.[13–15] Persons in these groups tend to live in neighborhoods with poor access to supermarkets and greater-than-average access to convenience stores and small grocery stores.[16–20] One study has shown that neighborhood-level measures of socioeconomic status are associated with fruit and vegetable intake independent of individual-level socioeconomic status, suggesting that the foods available in neighborhoods may be contributing to socioeconomic and racial health disparities in the USA.[13] If the "food environment" does have an important influence on purchases and consumption, one possible approach to promoting healthy diets in disadvantaged groups would be to provide incentives to stores that sell a healthier mix of foods to locate in or near the neighborhoods in which they live. For such an approach to be effective, incentives must be tied to criteria that the stores meet for the availability and accessibility of both healthy and unhealthy foods, such as minimum shelf lengths for healthy items and maximum shelf lengths for unhealthy items. Before these criteria can be established, a better understanding is needed of the current availability, accessibility, and prominence of foods in stores of different types.

We conducted in-store measurements of the shelf length of food items that are particularly important to health in food stores within 217 urban residential census tracts.

METHODS

This analysis is part of a project conducted in southeastern Louisiana and in Los Angeles County, California, that was designed primarily to assess the relationship between access to and consumption of alcoholic beverages. In this study, we sampled urban residential census tracts, identified all stores that sold alcohol in those census tracts, and conducted measurements in those stores.

Census Tract Sampling

We identified all census tracts with a residential population of greater than 2,000 persons per square mile within two geographic areas: a contiguous 26-parish region of southeastern Louisiana that contained the cities of New Orleans, Baton Rouge, and Lafayette, and a section of Los Angeles County within 20 miles of Charles R. Drew University of Medicine and Science. From these, we randomly selected 114 census tracts in each site in which to conduct store observations. Observations,

which were conducted in 2004–2005, were completed in all 114 tracts in Los Angeles County and in 103 census tracts in Louisiana, after which work on the project was stopped because of damage from Hurricane Katrina.

Store Identification

Stores were identified from alcohol outlet databases maintained by the alcohol beverage control agencies in California and Louisiana, supplemented by systematic direct observation. Addresses of stores permitted to sell any alcoholic beverages (beer, wine, or spirits) for off-premise consumption were geocoded; those stores that fell within the sampled census tracts were included. In addition, observers drove along every street in every census tract to identify additional stores that sold alcohol or food and stores in the database that had closed. Observers went to all open stores that sold any form of alcohol and requested permission from store staff to conduct measurements of shelf length. When permission was not given, observers recorded basic information about the store but did not conduct shelf length measurements.

Store Measurements

Shelf length measurements were taken of six types of healthy foods—fresh fruit, fresh vegetables, canned fruit, canned vegetables, frozen fruit, and frozen vegetables—and four types of unhealthy snack foods—carbonated beverages, salty snacks, cookies and pastries, and candy. Artificially sweetened "diet" beverages were included in the measurements, but non-carbonated beverages, including sugar-sweetened beverages, were not. Salty snacks included chips, popcorn, pretzels, salted nuts, and salted meat snacks such as beef jerky. The category of cookies and pastries included all types of prepackaged cookies, crackers (salty or sweet), doughnuts, pastries, and small fruit-filled pies, but did not include items baked by the store and sold in the bakery section. Candy included chocolates, hard candy, gum, and "energy bars".

Each site had a single team of two observers that conducted all measurements in that site following a standard protocol. The two teams were trained in joint training exercises held in both New Orleans and Los Angeles. In addition, a quality control supervisor conducted parallel measurements for a sample of stores in both sites. Comparisons of these showed inter-observer reliability, as measured by intraclass correlation coefficient, of 0.96 to 0.99.[21]

Observers measured the shelf length of each type of food item using a measuring wheel that they rolled along the shelves or the floor below them. These measurements did not take into account the height, depth, number of shelves, or whether other item types were also available within the interval measured. When an item type (e.g., carbonated beverages) was available in several places in the stores, measurements were summed to produce a total shelf length. Measurements were designed to parallel the accessibility of foods to shoppers, so they were taken in store aisles, around item "islands" (displays placed in centers of aisles that customers could access from all sides), and along the shelves placed next to shoppers when they queued for cash registers.

Observers measured the stores' total floor space devoted to sales by measuring the interior length and width using the measuring wheel and counted the number of cash registers. They characterized stores by type based on their size, items for sale, and status as independent or chain stores. For this analysis, we categorized stores into one of the six types, using the following definitions:

- Small food store—independent (non-chain) store in which the primary items sold are foods and beverages and that has less than 200 m^2 (2,152 $ft.^2$) of sales space

- Medium-sized food store—independent or chain store in which the primary items sold are foods and beverages and that has 200 m^2 or more of sales space and three or fewer cash registers
- Supermarket—independent or chain store in which the primary items sold are foods and beverages and that has four or more cash registers
- Convenience store—one of a chain of stores that sells foods/beverages and non-food items (e.g., magazines, products for automobiles) and that has three or fewer cash registers. For the purposes of this study, this includes convenience stores that also sell gasoline
- Drug store—store that sells prescription drugs
- Liquor store—store in which the primary items sold are alcoholic beverages or that has the word "liquor" in the store name

We excluded from the analysis 15 general merchandise stores in the sampled tracts that also sold some food items (e.g., Kmart, Super Walmart, "dollar" stores).

For the purposes of this paper, we use the term "availability" to describe whether food items were present or not; "accessibility" to describe how easily customers in stores seeking specific food items could obtain them, as measured by the length of shelf space displaying those items; and "prominence" to describe the degree to which customers not seeking specific food items might nonetheless notice them, as measured by the ratio of the shelf length of those items to total store floor space.

Analysis

We used Stata software to calculate means, standard deviations, and ratios and to conduct tests of statistical significance. We conducted a series of linear regressions to compare store types in shelf length of different food items and in the ratio of shelf length to store area. Since the shelf length distributions were skewed, the analyses were conducted on log-transformed data. To compare shelf space devoted to healthy to unhealthy foods in supermarkets, we used paired *t* tests.

RESULTS

In the 217 census tracts, we identified 620 eligible stores. We were able to conduct measurements of 212 (72%) of 296 stores in Louisiana and 213 (66%) of the 324 eligible stores in Los Angeles County; the other stores were not measured primarily because store staff would not allow observers to take measurements. We excluded six stores because the data collected were incomplete, leaving 419 stores for analysis.

The numbers of stores observed by store type and site are shown in Table 1. Los Angeles had many more liquor stores than Louisiana (63 vs. 6), probably because grocery stores in California are less likely than those in Louisiana to have licenses to sell high-alcohol content beverages. The sizes of the stores did not differ significantly by site.

Nearly all stores sold all of the unhealthy items, but the availability of healthy foods differed substantially by store type (Table 2). All supermarkets, only about one half to two thirds of small food stores, and 5–10% of convenience and drug stores sold any fresh fruits and vegetables. The accessibility of food items differed markedly by store type and showed greater differences between store types than within specific store types. For example, the difference between supermarkets and small food stores in mean shelf length of fresh vegetables was over 20-fold; in

TABLE 1 Comparison of observed stores by size and site

	Louisiana		Los Angeles		
	n	Mean area (m^2)	*n*	Mean area (m^2)	*p* value
Small store	75	86.5	55	91.3	0.51
Medium store	5	265.7	16	290.1	0.58
Supermarket	26	2,270.7	23	1,644.5	0.08
Convenience store	86	89.9	35	93.8	0.15
Drug store	12	855.0	17	1,033.8	0.26
Liquor store	6	101.3	63	108.8	0.76
Total	210		209		

contrast, the 25–75% interquartile range of shelf space for fresh vegetables among supermarkets was less than 2-fold (30.4 and 51.1 m) and among small food stores was from 0.0 to 2.2 m.* Of the total sample variance in shelf length of fresh vegetables, 86% was between store types and 14% within store types. Although supermarkets offered far more shelf space of fruits and vegetables than did other types of stores, they also devoted substantially more shelf space to the snack items (mean 205 m) than to fruits and vegetables (mean 117 m, $p<0.001$). After supermarkets, drug stores had the greatest accessibility of unhealthy items.

One would expect that smaller stores would devote less shelf space to all items given their space constraints, and in determining shopper's purchases within any given store the prominence may be more important than absolute shelf length. Table 3 addresses the prominence of healthy and unhealthy items by showing the ratio of shelf length (in meters) to store sales area (in square meters), under the assumption that store sales area is approximately proportional to a store's total shelf length. By this measure, the prominence of fresh fruits and fresh vegetables was greatest and comparable in medium-sized food stores and supermarkets. Supermarkets had significantly more prominence than small food stores of fresh fruit (30.9 m vs. 11.0/1,000 m^2, $p<0.001$) and borderline more prominence of fresh vegetables (28.3 vs. 21.6 m/1,000 m^2, $p=0.06$); they had approximately 30 times the prominence of fresh fruits and vegetables of convenience stores. Medium-sized food stores and supermarkets also devoted approximately the same proportion of their shelf space to snack items. The prominence of these unhealthy items was highest in convenience stores, liquor stores, and small food stores.

As an attempt to develop a single index of the healthfulness of stores' mix of items, we calculated the ratio of the sum of the shelf lengths of healthy items to the sum of the shelf lengths of the unhealthy items (Table 4). For all stores, this ratio was below 1.0, indicating that stores devote more of their shelf space to a limited number of unhealthy snack items than to all fruits and vegetables. This ratio was the lowest by far (0.10 or below) and very similar in convenience stores, drug stores, and liquor stores; was in a middle range (0.18 to 0.30) in small food stores; and was highest in medium food stores (0.40 to 0.61) and supermarkets (0.55 to 0.72). Across all store types, this index was higher in Los Angeles than Louisiana, with the differences being statistically significant for small food stores (0.30 vs. 0.18, $p<0.001$), convenience stores (0.05 vs. 0.02, $p<0.001$), and supermarkets (0.72 vs. 0.55, $p<0.05$).

*A table with the quartiles of shelf length for all of the different food items by store types is available by request from the authors.

TABLE 2 Availability and accessibility (measured by shelf length) of different types of food items in different stores[a]

	Shelf length (m)			Shelf length (m)			Shelf length (m)		
	% Any	Mean (SD)	Median	% Any	Mean (SD)	Median	% Any	Mean (SD)	Median
A. Primary food stores									
	Small food stores			Medium food stores			Supermarkets		
Fresh fruit	46%	1.0 (2.5)	0.0	86%	7.6 (8.7)	4.4	100%	42.0 (20.6)	39.3
Fresh vegetables	65%	1.9 (3.0)	0.9	95%	7.5 (7.0)	4.1	100%	42.0 (17.2)	40.2
Canned fruit	89%	1.2 (1.1)	0.9	95%	2.3 (1.3)	2.0	100%	6.9 (4.3)	5.6
Canned vegetables	95%	2.5 (1.9)	2.1	91%	4.8 (3.3)	4.3	100%	13.5 (8.2)	12.2
Frozen fruit	4%	0.02 (0.1)	0.0	27%	0.3 (0.6)	0.0	84%	1.7 (2.2)	1.5
Frozen vegetables	25%	0.3 (0.7)	0.0	64%	1.4 (1.5)	1.3	98%	10.3 (7.9)	7.8
Salty snacks	100%	7.2 (3.3)	6.7	95%	10.9 (4.6)	10.5	100%	54.4 (23.0)	52.4
Cookies and pastries	100%	6.2 (3.3)	5.8	95%	8.5 (4.0)	8.3	100%	62.4 (40.2)	51.0
Candy	100%	4.9 (2.9)	4.1	95%	6.8 (3.1)	6.4	100%	37.7 (25.0)	33.5
Carbonated beverages	100%	11.8 (6.5)	10.9	95%	18.6 (10.8)	19.5	100%	50.2 (20.1)	50.7
B. Non-food stores									
	Convenience stores			Drug stores			Liquor stores		
Fresh fruit	11%	0.2 (0.7)	0.0	3%	0.2 (0.9)	0.0	17%	0.2 (0.7)	0.0
Fresh vegetables	5%	0.05 (0.2)	0.0	3%	0.03 (0.2)	0.0	17%	0.4 (1.2)	0.0
Canned fruit	44%	0.3 (0.6)	0.0	93%	1.4 (1.2)	1.2	68%	0.8 (0.8)	0.6
Canned vegetables	56%	0.5 (0.8)	0.2	90%	1.2 (1.1)	0.7	86%	2.0 (2.1)	1.2
Frozen fruit	0%	0.0	0.0	0%	0.0	0.0	4%	0.03 (0.1)	0.0
Frozen vegetables	1%	0.002 (0.02)	0.0	3%	0.03 (0.7)	0.0	6%	0.2 (1.1)	0.0
Salty snacks	100%	11.3 (5.5)	10.6	100%	21.3 (9.0)	21.0	99%	9.8 (4.1)	10.1
Cookies and pastries	100%	7.2 (3.4)	6.6	100%	12.7 (7.4)	11	99%	5.6 (3.0)	4.9
Candy	100%	8.2 (3.4)	8.1	100%	41.1 (13.4)	39.6	99%	6.2 (3.1)	6.1
Carbonated beverages	100%	10.3 (4.9)	9.3	100%	25.5 (11.9)	22.6	100%	15.0 (8.9)	13.7

[a]Supermarkets have significantly more shelf length for all items than all other store types ($p<0.001$) with the exception of candy in drug stores

TABLE 3 Prominence of food items (measured as ratio of shelf length to store area) in different types of stores (in meters/square meter × 1,000)

	Small food stores	Medium food stores	Supermarkets	Convenience stores	Drug stores	Liquor stores
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Fresh fruit	11.0*** (23.3)	26.3 (25.6)	30.9 (26.8)	1.3*** (4.9)	0.1*** (0.7)	1.9*** (7.4)
Fresh vegetables	21.6 (34.1)	28.0 (23.6)	28.3 (19.2)	0.7*** (3.9)	0.7*** (0.4)	3.9*** (12.1)
Canned fruit	13.4** (10.4)	8.5 (4.3)	5.4 (6.0)	4.0 (9.1)	1.7 (2.0)	11.4* (33.1)
Canned vegetables	31.4*** (24.7)	17.7 (10.5)	9.3 (7.5)	7.9 (15.9)	1.6 (2.2)	23.8** (50.7)
Frozen fruit	0.2*** (1.2)	0.9 (1.8)	1.2 (1.9)	0*** (–)	0.0*** (–)	0.2*** (1.1)
Frozen vegetables	2.4** (5.5)	5.0 (5.4)	5.6 (3.0)	0.02*** (0.3)	0.02*** (0.1)	1.7*** (11.2)
Salty snacks	91.5*** (44.3)	41.7 (13.9)	35.9 (22.8)	146.6*** (77.9)	25.7 (14.1)	111.4*** (84.5)
Cookies and pastries	77.5*** (39.9)	33.0 (13.4)	36.8 (15.2)	97.6*** (68.3)	17.2 (18.2)	62.7** (52.1)
Candy	64.9*** (51.4)	22.3 (7.6)	22.5 (15.1)	117.0*** (94.6)	32.7 (32.7)	67.7*** (37.8)
Carbonated beverages	143.9*** (77.1)	35.2 (10.5)	33.3 (22.8)	139.2*** (105.0)	13.5*** (13.5)	186.2 (296.0)

*$p<0.05$ compared to supermarkets, **$p<0.01$ compared to supermarkets, *** $p<0.001$ compared to supermarkets

TABLE 4 Ratio of shelf length of healthy to unhealthy foods[a], by store type and site

	Louisiana	Los Angeles	
	Mean (SD)	Mean (SD)	*p* value
Small food stores	0.18 (0.14)	0.30 (0.28)	<0.001
Medium food stores	0.4 (0.35)	0.61 (0.29)	0.25
Supermarkets	0.55 (0.29)	0.72 (0.27)	0.036
Convenience stores	0.02 (0.04)	0.05 (0.04)	<0.001
Drug stores	0.02 (0.03)	0.03 (0.02)	0.26
Liquor stores	0.04 (0.02)	0.10 (0.07)	0.18

[a]Shelf space for fruits and vegetables (fresh, frozen, or canned) divided by shelf space for carbonated beverages, salty snacks, candy, and baked snacks

DISCUSSION

The data from this study describe three important patterns of in-store food availability in the USA. First, there were large variations among different store types and much smaller variations within individual store types in the absolute and relative shelf length of healthy and unhealthy food items. Second, while convenience stores, liquor stores, and small food stores offer the least healthy mix of items, stores of all types devote more shelf space to unhealthy than to healthy items. And third, it appears that the "food environment" may be different in different regions in the USA, with stores in Louisiana offering a less healthy mix of foods than stores in Los Angeles. The measurements and ratios obtained in this study can be used for further research into the impact of the food environment on consumption and to develop simple criteria for the "healthfulness" of stores.

Several other research groups have assessed the availability of various foods in different types of food stores.[22–27] In these studies, nearly all supermarkets contain some fresh fruits and vegetables, [24,26,27] but only approximately one fourth to one third of small stores or convenience stores contained any fresh fruits or vegetables.[25,27] Block et al. in suburban Chicago and Connell et al. in the lower Mississippi delta enumerated the items that were available from a standard "market basket" and found that supermarkets contained nearly 100% of the fresh fruits and vegetables, but small independent groceries contained 29–45% and convenience stores contained only 8–28% of these items.[24,28] In contrast, both Block and Connell found that supermarkets contained nearly 100%, independent smaller groceries contained 60–71%, and convenience stores contained 48–68% of the fats, oils, sugars, and sweets in their market baskets—indicating that customers have more extensive choices in calorie-dense items than fruits and vegetables in smaller stores.[24,28] To our knowledge, this is the first study that has measured the length of shelf space allotted to these items in the USA. In addition, very few studies have considered liquor stores and drug stores as sources of food, even though these stores may be important sources of food for families that do not own cars or live in neighborhoods that are distant from supermarkets. We found that these stores are very similar to convenience stores in the small amount of shelf space used for healthy foods and overabundance of unhealthy foods.

Studies of food availability are hampered by variation between studies on how food stores are defined. In this study, we categorized stores not based on Standard Industry Classification (SIC) or North American Industry Classification System

(NAICS) codes but rather based on their size, number of cash registers, primary products, and whether they were independent or part of a chain. SIC and NAICS codes are widely available but do not differentiate between supermarkets, medium-sized food stores, and small food stores, which differ markedly in their mix of foods sold. Our classification is more consistent with the functions these stores serve to their customers, but cannot be readily determined from widely available datasets. To advance this research, it would be helpful to develop a better classification system for food stores and include this in large datasets.

Limitations of this study include the fact that the only stores observed were those that sold alcohol. Based on subsequent store observations in Louisiana, we estimate that approximately 85% of food stores, 75% of convenience stores, and 40% of drug stores sell some type of alcoholic beverages. Differences in food availability in those stores that do and do not sell alcohol in these subsequent observations did not seem large, but more data are needed on this. Thus there is a potential bias in an unknown direction introduced into our study by limiting the store observations to those that sell alcohol. In addition, our store measurements did not collect information about other in-store factors that might influence sales, such as the height of shelves, number of shelves, or whether the items were displayed on the sides or ends of aisles. While this simplification approximates a measure of likelihood that a random shopper would "bump into" an item type, it is an incomplete measure of the prominence of the item type. Food stores are extremely complex environments to measure, and even if every item could be measured, experts would have difficulty agreeing on which items should be classified as "healthy" or "unhealthy". To avoid being overwhelmed with this complexity, we chose to restrict our measurements to a very limited number of items for which there would be a general consensus regarding their value to health. Our study also was conducted only in two geographic areas, and we do not know the degree to which the stores in these areas are representative of those in the rest of the country. In spite of these limitations, this study provides new and useful information about the environment that customers encounter inside stores.

Our findings have implications for both researchers and policymakers. Researchers conducting studies on the relationship between the food environment and diet or health can often obtain databases that characterize food stores by type, but they rarely have information about the foods available in those stores. Our measurements indicate that store type is a reasonable proxy measure for store contents. At the same time, they also indicate that a full measurement of the food environment must take into account all of these store types, including liquor stores and drug stores, rather than only stores that present themselves as primarily selling food. If these other sources are missed, the studies will underestimate the abundance of unhealthy food available in many communities.

Policymakers seeking to improve health through dietary change or to reverse the obesity epidemic have an interest in increasing access to fruits and vegetables. While this may be translated into a desire to increase the number of food stores in low-income neighborhoods, a policy to accomplish this could have unintended adverse effects if it further increases the overabundance of unhealthy snack foods. Focusing only on increasing the number of supermarkets could have this effect because supermarkets offer more shelf space for unhealthy than healthy items. A better policy approach may be to increase the number of food stores of any size that meet criteria for the healthfulness of their mix of items. Our measurements suggest that a simple ratio of the shelf length of healthy items to the shelf length of unhealthy items

easily summarizes store contents and distinguishes store types. The ratio used in this study should be refined to take into account other important items (particularly non-carbonated sweetened beverages), but a very similar ratio could easily be developed and used in policymaking.

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