Nutrition Environment Measures Survey in Stores (NEMS-S)

Development and Evaluation

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Background: Eating, or nutrition, environments are believed to contribute to obesity and chronic diseases. There is a need for valid, reliable measures of nutrition environments. This article reports on the development and evaluation of measures of nutrition environments in retail food stores.

Methods: The Nutrition Environment Measures Study developed observational measures of the nutrition environment within retail food stores (NEMS-S) to assess availability of healthy options, price, and quality. After pretesting, measures were completed by independent raters to evaluate inter-rater reliability and across two occasions to assess test–retest reliability in grocery and convenience stores in four neighborhoods differing on income and community design in the Atlanta metropolitan area. Data were collected and analyzed in 2004 and 2005.

Results: Ten food categories (e.g., fruits) or indicator food items (e.g., ground beef) were evaluated in 85 stores. Inter-rater reliability and test–retest reliability of availability were high: inter-rater reliability kappas were 0.84 to 1.00, and test–retest reliabilities were .73 to 1.00. Inter-rater reliability for quality across fresh produce was moderate (kappas, 0.44 to 1.00). Healthier options were higher priced for hot dogs, lean ground beef, and baked chips. More healthful options were available in grocery than convenience stores and in stores in higher income neighborhoods.

Conclusions: The NEMS-S tool was found to have a high degree of inter-rater and test–retest reliability, and to reveal significant differences across store types and neighborhoods of high and low socioeconomic status. These observational measures of nutrition environments can be applied in multilevel studies of community nutrition, and can inform new approaches to conducting and evaluating nutrition interventions.
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Introduction

Social and built environments are believed to exert important influence on individuals' access to affordable, healthful food.[1–5] Understanding of healthy nutrition environments, while growing, is limited by the lack of reliable and valid measures of these environments. To advance science, and to inform public health policy, there is a need for well-defined concepts and valid, reliable measures of nutrition environments. Both "community" and "consumer" nutrition environments can affect food choice. The **community nutrition environment** is comprised of the number, type, location and accessibility of food outlets such as grocery stores. The **consumer nutrition environment** is what consumers encounter in and around places where they buy food, such as the availability, cost, and quality of healthful food choices.[6]

The presence of food stores, and the availability of healthful products in those stores, appear to be important contributors to healthy eating patterns among neighborhood residents.[7] Racial and ethnic disparities in access to supermarkets, that typically have good availability of healthful foods, have been documented.[8,9] Black Americans' fruit and vegetable intake was considerably higher when they had more supermarkets in their census tracts,[10] and proximity to a supermarket was favorably associated with the diet quality of pregnant women[11] and with lower prevalence of obesity and overweight.[12] Low-income women who shopped at supermarkets and specialty stores consumed more fruits

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and vegetables than those who shopped at independent grocers.[13] Thus, the community nutrition environment appears to affect individual food choice and may affect long-term health.

Studies of the **consumer** nutrition environment within stores, particularly regarding availability, quality, and price, also reveal disparities and associations with dietary intake. Horowitz et al.[14] found significantly lower availability of five foods recommended for diabetics in less-affluent and ethnic minority neighborhoods, and findings of lower availability of healthful foods in low-income and high-minority neighborhoods were replicated.[15] The higher costs of more healthful foods is a concern.[16] Jetter and Cassady[17] found that most people in their study had access to healthful foods, but the healthier market basket was 35% to 40% more expensive than a standard market basket because of the higher costs of whole grains, lean ground beef, and skinless poultry. Cheadle et al.[18] found community-level associations between grocery store environments and individual dietary practices, with the most significant relationships between low-fat milk consumption and the proportion of shelf space for skim, 1% fat, and 2% fat milk.

Despite the increased interest in nutrition environments, little progress has been made in devising reliable and valid measurement tools. Nearly 2 decades ago, Cheadle et al.[19] assessed the proportion of shelf space devoted to healthful alternatives, such as reduced-fat milk, poultry and fish, and 100% whole wheat bread. They found high inter-rater reliability (0.73 to 0.78) and test–retest reliability ranging from 0.44 to 1.00. Horowitz et al.[14] measured availability of five diabetic-recommended foods in grocery stores and reported excellent inter-rater reliability ranging from 0.94 to 1.00. Other published reports have been less clear about the rigor of their methods or did not report reliability of the measures.[15,17,20]

Psychometrically sound measures are needed to obtain accurate and reliable estimates of the relationship between nutrition environments and individuals' dietary intake, as well as to evaluate change in nutrition environments secondary to intervention. The purpose of the present study was to develop observational measures of nutrition environments in retail stores, evaluate measure reliability, and examine differences in nutrition environments across different types of stores and between higher and lower income neighborhoods.

Methods

The Nutrition Environment Measures Study (NEMS) developed and evaluated nutrition environment measures for retail stores (NEMS-S, described here) and restaurants (NEMS-R, described in a separate paper).[21]

Neighborhood Selection

The NEMS study was conducted in four neighborhoods in the Atlanta metropolitan area, with neighborhood defined as one census tract. Each neighborhood had a minimum of 15 retail food outlets to ensure sufficient variability for this measurement study. The neighborhood selection process was designed to maximize the ability to contrast food outlet types in neighborhoods with differing levels of income and walkability, as determined by data from the 2000 U.S. Census and regional land-use data and street network data from the SMARTRAQ study and the Georgia Regional Transportation Authority to measure walkability.[22] These neighborhood characteristics were selected based on previous evidence of socioeconomic disparities in nutrition environments[8,9] and because of the recognized importance of neighborhood walkability as a determinant of physical activity and obesity.[22–25] The main measurement study was conducted in four neighborhoods that represented four possible combinations of neighborhood walkability (high/low) and socioeconomic status (high/low). Two other neighborhoods (one high-walkability and one low-walkability) were selected for pretesting measures.

Identification and Classification of Stores

Retail food outlets (stores) were identified, enumerated, classified, and mapped using multiple data sources. County retail food license lists were matched against street names and addresses from land-use data from the Georgia Regional Transportation Authority, and verified and supplemented using printed Yellow Pages, online business directories, and field work. Food outlets that were closed to the public (e.g., within workplaces or private residential housing facilities) were excluded. Stores were classified into two main categories: grocery stores and convenience stores (including food marts within gas stations). Specialty stores (e.g., bakeries) were excluded because of the limited range of products. Number of cash registers was used to indicate store size.

Development of Tools and Procedures

The developmental phase of the study involved reviewing available literature and tools,[9–11,14,15,19] consulting investigators doing related work, pretesting proposed measures in two neighborhoods, and developing detailed protocols and staff training materials. The pretest results identified ambiguous instructions, problems with the feasibility of some measures, and important scheduling issues. They also alerted the study team to the most common questions raised by clerks and customers during observations. These results were used to refine the protocols and training.

Nutrition-related variables were selected based on the types of food products that contribute the most fat and calories to the American diet,[26] and those that are most recommended for healthful eating.[27–29] "Healthful" was defined based on publications of federal agencies[27,29] and health professional organizations and researchers.[28,30]

Using an iterative process involving field work, research team deliberation, and expert consultation, 10 indicator food categories were developed: fruit, vegetables, milk, ground beef, hot dogs, frozen dinners, baked goods, beverages (soda/juice), whole grain bread, and baked chips. The mea-

Table 1. Food store nutrition environment measures and variables assessed by direct observation

Type of Food	Variables measured: Availability	Quality	Price[a]: Absolute	Comparative
Fruit (fresh): 10 types	X	X	X	
Vegetables (fresh): 10 types	X	X	X	
Milk: skim/low-fat versus whole	X			X
Ground beef: lean versus regular	X			X
Hot dogs: low-fat versus regular	X			X
Frozen dinners: Reduced-calorie versus regular	X			X
Beverages				X
Soda: diet/low-calorie versus regular	X			
Fruit juice: 100% juice versus juice drinks	X			X
Baked goods: lower fat versus regular	X			X
Bread: 100% whole grain versus refined	X			X
Snack chips: baked/low-fat versus regular	X			X

[a]Comparative price applies when there is price information for a healthier food option and the equivalent "regular" comparison (e.g., skim milk vs whole milk), while absolute price applies when the item is compared across store type and neighborhood characteristics.

sures focus on availability of more healthful or recommended choices, quality of produce, and prices (see Table 1).

The specifications for measures of fruits and vegetables were based on national food sales and/or food-consumption data (e.g., federal and industry data to identify the top ten most consumed fruits and vegetables in the United States).[31] Potatoes were excluded from the vegetable list, consistent with dietary assessment approaches often used in nutrition epidemiology research.[32] The quality indicator for produce was an acceptable/unacceptable rating based on the majority of a given type of fruits or vegetables being clearly bruised, old looking, overripe, or spotted. Measures of shelf space for skim/low-fat and whole milk were adapted from procedures developed by Cheadle et al.[19] Other measurement criteria were based on federal government and industry standards/definitions related to food sales (e.g., definitions of lean beef as 90% lean/10% fat, low-fat products, standard package sizes, units of fruit/vegetables). Cost was assessed based on the posted nonsale prices per pound for fruits and vegetables (or per item if sold only by the piece); and for "healthier" versus "regular" options for comparable products, such as low-fat dairy products, lean meats, and prepackaged main dishes. Product comparison and other procedures were standardized. Ratings were completed between the hours of 9 AM and 4 PM to maintain consistency relative to stock on the shelves.

The study was approved by the Emory University institutional review board (IRB). Upon entering the premises, the raters introduced themselves to store managers or clerks and presented a letter describing the study, the voluntary nature of participation, and including the Principal Investigator's and IRB contact information for further inquiries.

To test the feasibility and applicability of the measures in other geographic locations, research staff and investigators completed the measures in five cities in Ohio, Maryland, Virginia, Nevada, and South Carolina.

Rater Training and Quality Control

Raters were research assistants with college educations but without prior specialized nutrition training. Training for raters included both classroom and field work over a 2-day period in the two pretest neighborhoods. During the training, all assessments were done by two raters, monitored for high reliability (>90% agreement), and raters received feedback to improve performance.

Design of Measurement Study

To assess inter-rater reliability, two trained raters independently visited food outlets to complete the same set of assessments on the same day. To assess test–retest reliability, outlets were reassessed within 1 month after the initial observations by one of the same raters. The range of time for retest visits was 7 to 28 days with a mean of 9.1 (±4.8 days).

Data Analysis Methods

All data analysis was completed using SAS version 8 (SAS Institute Inc., Cary NC, 1999). Descriptive statistics and store and neighborhood comparisons were computed with chi-square and *t*-tests using one randomly selected record per store. The main analyses of reliability were completed using data for stores for which all three measures had been completed (two on one occasion, one at a later date). Percent agreement and kappa statistics were used, with Cramer's V used when kappa could not be computed because of asymmetric rater response dimensions.[33,34]

Prices of fresh produce were converted to standard units (piece or pound) using data from the Economic Research Service of the U.S. Department of Agriculture. Price comparisons were computed as a percentage, based on the average price for a healthy item compared to its regular alternate, and as comparisons between neighborhoods and type of store using *t*-tests.

Composite "food environment quality" scores were calculated for each store, using three dimensions (availability, quality, and price). Availability scores assigned two points per indicator for the availability of healthier options, and an extra point for more varieties (e.g., two extra points for three or more varieties of lean meat). Price scores assigned two points for a lower priced healthier option and −1 point for a higher priced healthier option, and up to three points were assigned for having more produce of acceptable quality. The total score that could range from −8 to 50. (Details are available in the appendix (available online at www.ajpm-online.net) or on request from the first author.)

Comparisons between grocery stores and convenience stores and high- and low-income neighborhoods provide a test of whether the NEMS measures would yield results similar to what has been reported in other research regarding socioeconomic and racial/ethnic disparities in nutrition environments.[8,9,14] Exploratory analyses were also conducted to compare the healthfulness of the food environments in high- versus low-walkability neighborhoods. The study was not powered to be able to detect store type by neighborhood type interactions. Data were collected and analyzed in 2004 and 2005.

Results

Description of Sample and Response Rates

A total of 88 stores (24 grocery, 64 convenience) were identified in the four study neighborhoods, ranging from 16 to 27 per neighborhood. A 100% completion rate for all three sets of measures was achieved in the grocery stores; however, three convenience stores declined to participate (for a 95.3% completion rate) and two other convenience stores refused second visits, yielding a net 90.6% rate for completing all measures at stores. This resulted in 24 grocery stores and 61 convenience stores for most analyses, but 58 convenience stores for test–retest reliability analyses. Two thirds of the grocery stores had three or more cash registers, and small grocery stores (defined as having only one or two cash registers) were more common in lower income neighborhoods. The mean time to complete the measures was 41.8 (SD 14.4) minutes for grocery stores and 14.4 (SD 5.3) minutes for convenience stores.

Reliability

Table 2 shows findings for inter-rater reliability and test–retest reliability for all categories of foods, and for each type of fruit and vegetable assessed. Rates of agreement and kappa statistics for inter-rater reliability were consistently very high, ranging from 92% to 100% and 0.83 to 1.00. Test–retest reliability was likewise very

Table 2. Reliability of nutrition environment measures of availability

	Inter-rater reliability		Test–retest reliability	
Type of food	**% Agreement**	**Kappa**	**% Agreement**	**Kappa**
Any fruit	96.47	0.93	92.68	0.85
Bananas	96.47	0.93	86.59	0.73
Apples	98.82	0.98	92.68	0.85
Oranges	98.82	0.97	92.68	0.84
Grapes	100.00	1.00	98.78	0.97
Cantaloupe	100.00	1.00	100.00	1.00
Peaches	96.47	0.90	95.12	0.86
Strawberries	98.82	0.96	98.78	0.96
Honeydew melon	100.00	1.00	100.00	1.00
Watermelon	97.65	0.93	98.78	0.96
Pears	98.82	0.97	95.12	0.88
Any vegetables	100.00	1.00	96.34	0.91
Carrots	100.00	1.00	100.00	1.00
Tomatoes	98.82	0.97	95.12	0.87
Sweet peppers	100.00	1.00	98.78	0.97
Broccoli	100.00	1.00	100.00	1.00
Lettuce	100.00	1.00	96.34	0.90
Corn	98.82	0.97	97.56	0.93
Celery	100.00	1.00	100.00	1.00
Cucumbers	100.00	1.00	97.56	0.93
Cabbage	100.00	1.00	100.00	1.00
Cauliflower	98.82	0.96	98.78	0.96
Skim/low-fat milk	100.00	1.00	97.56	0.95
Lean ground beef	98.82	0.96	98.78	0.96
Low-fat hot dogs	100.00	1.00	98.78	0.95
Reduced calorie frozen dinners	100.00	1.00	98.78	0.96
Beverages—grocery stores				
Diet soda	98.82	0.97	100.00	1.00
100% fruit juice	100.00	1.00	100.00	1.00
Beverages—convenience stores				
Diet soda	98.82	0.97	98.78	0.97
100% fruit juice	100.00	1.00	100.00	1.00
Low-fat baked goods	95.29	0.88	93.90	0.84
100% whole grain bread	92.94	0.83	90.24	0.75
Baked/low-fat chips	96.47	0.92	95.12	0.89

Table 3. Reliability of nutrition environment measures of quality of fresh produce

Type of food	Inter-rater reliability		Test–retest reliability	
	% Agreement	Kappa	% Agreement	Kappa
Fruit				
Bananas	91.43	0.68	80.00	0.29
Apples	85.29	0.55	90.00	0.75
Oranges	85.71	0.58	76.00	0.11
Grapes	100.00	[a]	100.00	[a]
Cantaloupe	94.12	[a]	100.00	[a]
Peaches	94.44	0.64	95.12	[a]
Strawberries	92.86	[a]	98.78	[a]
Honeydew melon	100.00	[a]	100.00	[a]
Watermelon	100.00	[a]	100.00	[a]
Pears	91.30	0.67	95.12	0.46
Vegetables				
Carrots	94.74	0.64	88.89	[a]
Tomatoes	95.00	0.64	94.44	[a]
Sweet peppers	94.74	0.64	100.00	1.00
Broccoli	100.00	[a]	100.00	[a]
Lettuce	100.00	[a]	100.00	[a]
Corn	86.67	0.44	93.33	[a]
Celery	100.00	[a]	94.44	[a]
Cucumbers	100.00	1.00	100.00	[a]
Cabbage	100.00	[a]	100.00	[a]
Cauliflower	100.00	[a]	100.00	[a]

[a]Statistics could not be computed because of two or fewer levels per crosstabulation.

high, with the lowest repeatability for 100% whole grain bread at 90.2% and 0.75.

Table 3 shows the reliability results for measures of the quality of fresh fruits and vegetables. Agreement among raters was very high, but kappa statistics were either low or could not be calculated for several items. This was because of the high proportion of "acceptable quality" (68% to 100% where available), combined with the limited availability of most types of fruits or vegetables (all available in less than 35% of stores except oranges, apples, and bananas).

Price Comparisons and Shelf Space

The prices for most healthy (lower fat, lower calorie, and whole grain) options were not significantly different from the comparable regular items. Similarly priced healthier and standard options for milk, baked goods, diet soda, and 100% fruit juice were found at the stores. Whole grain bread cost, on average, 108% of refined bread ($p<0.04$), and the most marked differences were found in the higher cost of lean ground beef (147% of regular), low-fat hot dogs (124% of regular), baked chips (131% of regular), and 100% fruit juice at grocery stores (153% of juice drinks) (all $p<0.01$). Across all stores, 40.0% of the shelf space for milk was devoted to skim and low-fat milk, with most of the difference between milk varieties accounted for by convenience stores ($p<0.02$ for proportion of skim vs whole milk; skim/low-fat=30.4% of shelf space).

Store Type and Neighborhood Differences

Table 4 shows the availability comparisons by store type and neighborhood socioeconomic status (SES). Grocery stores had significantly higher availability for all items except 100% fruit juice, diet soda (which convenience stores were more likely to carry), and baked chips (although grocery stores had significantly more varieties of baked chips, 2.6 vs 1.1, $p<0.01$). Higher income neighborhoods were significantly more likely to have healthful options for all foods except diet soda, 100% fruit juice, and low-fat hot dogs. There was only one difference between stores in high- and low-walkability neighborhoods, with 100% whole grain bread being available more often in stores in high-walkability areas (41.9% vs 14.2%, $p<0.01$).

Table 5 presents the composite scores for healthy nutrition environments by store type and neighborhood SES. In general, the scores for Availability and Quality cut across the possible ranges (0 to 27 for availability; 0 to 6 for quality); but scores for the Price dimension used only a small part of the range from −8 to 17 points. The store type and neighborhood differences for Availability, Quality, and Total scores were significant and in the predicted directions with higher availability and quality in grocery stores versus convenience stores and high-income versus low-income neighborhoods. However, the Price scores, while low in general (mean of 1.1, SD=2.1), differed significantly in the opposite direction, with convenience stores and low-income areas having higher scores (i.e., lower

Table 4. Availability of healthier options by store type and neighborhood SES

Type of food	Availability (%) Grocery stores (n=24)	Availability (%) Convenience stores (n=61)	Significance	Availability (%) High-income areas (n=44)	Availability (%) Low-income areas (n=41)	Significance
Any fruit	87.50	36.07	$p<0.01$	61.36	39.02	$p<0.05$
Any vegetables	91.67	3.28	$p<0.01$	36.36	19.51	$p<0.08$
Skim/low-fat milk	75.00	22.95	$p<0.01$	61.36	12.20	$p<0.01$
Lean ground beef	62.50	0.00	$p<0.01$	27.27	7.32	$p<0.05$
Low-fat hot dogs	70.83	3.28	$p<0.01$	27.27	17.07	NS
Reduced calorie frozen dinners	62.50	3.28	$p<0.01$	29.55	9.76	$p<0.05$
Beverages						
Diet soda	79.17	98.36	$p<0.01$	92.00	89.00	NS
100% fruit juice	91.67	98.36	NS	97.67	94.88	NS
Low-fat baked goods	66.67	8.20	$p<0.01$	38.64	9.76	$p<0.01$
100% Whole grain bread	79.17	8.20	$p<0.01$	38.64	17.07	$p<0.05$
Baked/low-fat chips	70.83	60.66	NS	77.28	48.78	$p<0.01$

NS, not significant; SES, socioeconomic status.

prices). Because the scoring system assigned two points per indicator for a lower priced healthy option, the magnitude of difference found could be accounted for by stores having a single healthful food item priced lower than its regular counterpart, for example, skim milk, baked chips, or lean ground beef.

Discussion

The NEMS-S food store environment measures developed and evaluated in this study had high inter-rater and test–retest reliabilities and provide support for the construct validity of the measures. Because the indicator foods were carefully selected based on authoritative guidelines and recommendations, face validity of the measures is also affirmed. These measures provide an evaluation of food stores available in specific locations, so they assess aspects of the community nutrition environment. The unique contribution of these measures is the assessment of the availability, price, and quality of foods available within stores, reflecting the environment confronted by consumers making food choices.

The high inter-rater reliability indicates the definitions and instructions in the measurement protocol and the training methods are sufficient to prepare observers to collect high-quality data. The high test–retest reliability suggests limited change in availability, quality, and price of the measured indicator food categories and foods over a period of several weeks. Thus, multiple measures are not needed to obtain a stable estimate of nutrition environments in food stores. However, the availability, price, and quality of fresh produce usually change across seasons, so investigators are encouraged to repeat observations to assess or control for seasonal effects.

Previous studies have shown healthful foods are less available in low-income or minority neighborhoods,[14,15,17] and replication of those findings in the present study support the ability of the new measures to discriminate between high- and low-income neighborhoods. Because it is hypothesized that healthful foods will be more available, lower in price, and higher in quality in grocery stores than in convenience stores,[17] present findings indicate the new measures are sensitive enough to detect those expected differences. The NEMS-S composite scores in Table 5 show that the differences in healthful food availability and quality between grocery stores and convenience stores are very large. These findings, like those of previous studies,[17] suggest differences in food store environments may be large enough to have substantial effects on food purchasing and health-related outcomes. Differences in availability of healthy foods also was

Table 5. Composite scores for healthy nutrition environments by store type and neighborhood SES[a]

	Mean score (±SD) Grocery stores (n=24)	Mean score (±SD) Convenience stores (n=61)	Mean score (±SD) High income (n=44)	Mean score (±SD) Low income (n=41)
Availability	17.33 (9.43)	3.54 (2.36)	10.23 (9.20)	4.44 (5.71)
Price	0.13 (2.95)	1.54 (1.41)	0.30 (2.35)	2.05 (1.14)
Quality	5.13 (1.75	0.77 (1.37)	2.61 (2.54)	1.34 (2.22)
Total	22.58 (9.39)	5.85 (3.21)	13.14 (10.25)	7.83 (7.66)

Significance for all comparisons by store type and neighborhood SES is $p<0.01$.
[a]Higher scores indicate greater availability and better quality, and lower prices for healthful options compared to "regular" choices.
SD, standard deviation; SES, socioeconomic status.

large, suggesting disparities in access to healthy foods could contribute to well-documented disparities in eating patterns, obesity, and chronic diseases.[35]

An important limitation of the food store environment measures is the cost of personnel time. These measures require use of multiple data sources to identify food stores; there are large numbers of stores to assess, and trained observers need to spend substantial amounts of time traveling to and observing each store. The complexity of the research area is clear, but given the public health imperative to improve eating behaviors in the population,[4,36] greater priority needs to be given to understanding the role of food environments in individuals' eating patterns. High-quality measurement is required for better research in this area, and better understanding of food environments can stimulate policy changes that could have population-wide benefits in reducing nutrition-related diseases.

Another limitation of the present evaluation was that it was conducted within a single large metropolitan area. This metropolitan area, and the neighborhoods selected, provided variation in socioeconomic status and race. The four neighborhoods ranged from 7.9% to 96.6% nonwhite population, and two of the neighborhoods are more than 90% black.[37] To address the issue of broader applicability, two of the investigators and three research staff collected data using the NEMS-S tools at 11 stores in five other cities outside Atlanta during the study period. The favorable results of this feasibility assessment—that the same measurement procedures could be used in a variety of geographic areas—provided confirmation of the feasibility and applicability of the NEMS-S measures beyond the study area.

The current study evaluated the availability of healthful food choices at stores located in different types of neighborhoods and found few differences in the quality of food choices available in more or less walkable areas, but this study included only four neighborhoods. It is logical that dietary behavior may be influenced by different levels of accessibility to food outlets. However, having sources of healthful foods very close to homes may be more important in walkable neighborhoods where residents do many errands by walking. Although easy access to supermarkets has been found to be an objective[38] and perceived[39] correlate of healthy nutrition, other research did not support this association.[40] A more detailed understanding of where people shop for food, in relationship to their residential locations, and how food outlets are chosen may demonstrate some relationship to neighborhood design.

Given the need for careful measures development and reliability testing, the current study was limited by sample size to evaluate differences within store type (e.g., grocery) across neighborhoods that differ socioeconomically and in walkability. For example, it is not clear whether grocery stores in different socioeconomic areas would consistently differ on our within-store measures of consumer nutrition environment. Future studies can help elucidate whether such neighborhood differences exist. It is also likely other investigators will prioritize other food environment variables, so these measures may be modified and additional components or modules will need to be developed. For example, the measures for fruits and vegetables could be broadened to include canned and frozen varieties. The measures reported here incorporate a basic format that could be followed for other versions tailored to the needs of specific studies. However, the modifications need to be evaluated for their reliability.

The NEMS-S observational measures of nutrition environments in retail stores are feasible, highly reliable, have good face validity and support for construct validity, and are applicable in a variety of geographic locations. The measures of availability, price, and quality for individual indicator foods and the composite scores discriminated grocery versus convenience stores and high- versus low-income neighborhoods. Thus, the measures reported here can be used to test associations between food store environments and eating behavior and in multilevel studies of the determinants of obesity and chronic diseases. These measures can also be used in intervention studies and evaluations of changing food environments, to test whether an intervention results in meaningful changes in the availability, quality, and price of healthful food options. The NEMS-S measurement forms, protocol, rationale, and scoring system information can be found in the appendix (available online at www.ajpm-online.net).

Information about training in the use of NEMS-S is available at www.sph.emory.edu/NEMS.

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Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.amepre.2006.12.019.