Measures of the Food Environment
A Compilation of the Literature, 1990–2007

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Background: Valid and reliable measures are required to assess any effect of the food environment on individual dietary behavior, and form the foundation of research that may inform obesity-related policy. Although many methods of measuring the food environment exist, this area of research is still relatively new and there has been no systematic attempt to gather these measures, to compare and contrast them, or to report on their psychometric properties.

Evidence acquisition: A structured literature search was conducted to identify peer-reviewed articles published between January 1990 and August 2007 that measured the community-level food environment. These articles were categorized into the following environments: food stores, restaurants, schools, and worksites. The measurement strategies in these studies were categorized as instruments (checklists, market baskets, inventories, or interviews/questionnaires) or methodologies (geographic, sales, menu, or nutrient analyses).

Evidence synthesis: A total of 137 articles were identified that included measures of the food environment. Researchers focused on assessing the accessibility, availability, affordability, and quality of the food environment. The most frequently used measure overall was some form of geographic analysis. Eighteen of the 137 articles (13.1%) tested for any psychometric properties, including inter-rater reliability, test–retest reliability, and/or validity.

Conclusions: A greater focus on testing for reliability and validity of measures of the food environment may increase rigor in research in this area. Robust measures of the food environment may strengthen research on the effects of the community-level food environment on individual dietary behavior, assist in the development and evaluation of interventions, and inform policymaking targeted at reducing the prevalence of obesity and improving diet.
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Introduction

The rise in obesity prevalence in recent decades has increased interest in the food environment as a possible causal factor, given its potential impact on behavior related to diet, weight, and health outcomes. Valid and reliable measures of the food environment are required in order to assess any effect of the food environment on individual dietary behavior. These measures form the foundation of research that may inform obesity-related policy.

Measurement of the food environment and its effect on dietary behavior is a relatively new field of inquiry, and pioneering researchers have been innovative in their development and use of tools to assess these environmental effects. A working group of researchers expert in measuring the food environment was formed by the National Cancer Institute in 2006. This group, consisting of internal NCI and extramural scientists, identified the need to create a consolidated list of the measures of the food environment. The working group noted that no systematic compilation of measures of the food environment has been completed and that such a compilation would benefit researchers and community groups interested in reviewing or using existing measures. This paper is an initial attempt to identify measures of the food environment used in research and serves as the basis of the discussion of food environment measures by Lytle[1] in this supplement to the *American Journal of Preventive Medicine*.

The "food environment" can be interpreted in many different ways. For Glanz and colleagues,[2] the food environment is broadly defined to include home, community, and media/information environments. In this study, however, the food environment is limited to community-level organizations and food

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resources. At least one review article on measures of the home environment already exists,[3] and including articles that measure the media/information environment was beyond the scope of this review. For the purposes of this paper, therefore, the food environment is defined to include food stores, restaurants, schools, and worksites. These four environments differ qualitatively from each other. Food stores and restaurants are often places to which one travels to purchase food and there may or may not be a great deal of choice regarding one's options. Worksites and schools, on the other hand, are places where individuals spend time for other purposes, and that usually also happen to provide food (e.g., vending machines, cafeteria); employees and students may or may not be able to travel off-site for food or beverages.

Evidence Acquisition

Inclusion and Exclusion Criteria

Articles included in this study were those that measure the food environment published in English-language, peer-reviewed journals from January 1990 to August 2007. Initial literature searches using multiple search engines were conducted, including Web of Knowledge, PubMed, PsycINFO, Scopus, and Google Scholar. Keywords included: food, nutrition, diet, environment, community, neighborhood, neighbourhood, school, worksite, basket, assess*, measure*, and instrument (where * denotes wildcard search). The following specific journals from January 2004 to August 2007 also were searched for relevant measures and articles: *Journal of Nutrition Education and Behavior, American Journal of Preventive Medicine, Health Education and Behavior, Journal of the American Dietetic Association*, and *Preventive Medicine*. The initial list of articles generated by these searches was shared with researchers who have expertise in measuring food environments, and their suggestions on any missing articles were solicited. Additionally a "snowball method" was used, whereby articles referenced in previously located studies that fit the inclusion criteria were examined. In an attempt to be as inclusive as possible, articles containing instruments in which relatively few of the items related to the food environment were included.

If the same measure was used in more than one study, only one of the articles in the compilation was included, based on whether it was the article that described the measure in most detail, the most recent article (if considerable modifications were made by the same investigator), or the first publication to use the measure. This meant that some articles[4–20] that used instruments reported in multiple articles were excluded. Also excluded were articles that focused solely on measuring the home environment, individual-level psychosocial factors related to the food environment, individual-level dietary assessment (e.g., food frequency questionnaires, 24-hour recalls, or food records), or web-, television-, and other media-based marketing. All of these topics were outside the scope of this review.

Categorizing the Food Environment

The food environments were categorized as the food store environment (e.g., grocery stores, supermarkets, specialty food stores, farmers' markets, and food pantries); restaurant food environment (e.g., fast food and full-service restaurants); school food environment (e.g., cafeterias, vending machines, and snack shops in daycare settings, schools, and/or colleges); and/or worksite food environment (e.g., cafeterias, vending, snack shops).

Defining Measures of the Food Environment: Instruments and Methodologies

Based on the information available in the articles, all of the measures of the food environment were categorized as instruments or methodologies. Instruments are standardized assessment tools used to assess the observed or the perceived food environment. Typically, for the time period of this review, they are paper-based forms completed by trained observers, interviewers, or by subjects themselves. An instrument may take the form of a checklist (based primarily on a pre-defined list of indicator foods); market basket (based on a pre-defined list of foods representing the total diet); inventory (the reporting of all foods); or interview/questionnaire (pre-determined list of questions regarding the environment). Although any given instrument may include different elements of a checklist, market basket, inventory, and/or interview/questionnaire, the categorizations were based on the predominant elements within the instrument. Note that there may be wide variation in the comprehensiveness of the instruments. The instruments can be tested for relevant psychometric properties (e.g., reliability and validity), applied to different types of food environments, and modified as needed for specific populations. The data for checklists, market baskets, and inventories are collected by observation, while interviews/questionnaires are self-reported or recorded by a trained interviewer.

The checklist and market basket have similar characteristics in that they both may collect information on food availability, price, and quality. However, they also have clear differences. In the context of the food environment, a checklist includes a list of indicator foods that are selected based on predetermined criteria, such as those foods that are identified by the researchers as meeting or not meeting current dietary recommendations. In contrast, a market basket is a list of foods that represent an adequate total diet, which may include both the healthy and unhealthy foods

frequently consumed by the population, or may reflect a standardized diet plan such as the U.S. Department of Agriculture's Thrifty Food Plan (see for example Andrews and colleagues[21]). Market baskets have been commonly used in economics to compare costs of a particular subset of goods over time and/or by location. In food environments, a market basket is limited to food stores, whereas a checklist can be used in food stores, restaurants, schools, and worksites. For analysis purposes, prices may be imputed for foods listed in the market basket that are not available at a given store. However, because the checklist represents predetermined indicator foods, the lack of availability in itself is relevant to the analysis and may provide for a comparison between different locations or the assessment of "healthy" foods in a given environment.

Methodologies include sales analysis, menu analysis, nutrient analysis, and geographic analysis. A sales analysis uses data from sales, cashier receipts, and food service reporting forms as the basis for data collection and evaluation, whereas a menu analysis uses information on a menu, such as the specific foods and beverages listed. A nutrient analysis compiles data on calories and nutrients such as saturated fat and sodium. Sales analysis, menu analysis, and nutrient analysis may be combined to determine availability of certain foods (e.g., fruits and vegetables) and/or the nutrient content of lunches, à la carte foods, and vending.

A geographic analysis draws data from specific geographic measures. It may include the use of GIS or other means of assessing geospatial location. The articles that were included in this compilation assessed the food environment based on three previously defined accessibility measures: diversity, proximity, and/or variety.[22] Diversity—as it pertains to geographic measures—refers to the density and type of food stores or restaurants within a specific area (the specific area may be defined within a given spatial region, shopping catchment, buffer area, or population). To assess the number of food stores or restaurants, different coverage methods may be used; for example, the count may be within a given radius, count per population, or count per square linear area, such as square mile. Proximity is based on the nearest distance to food stores or restaurants. The minimum distance method between residence and food store or restaurant may be assessed by shortest path, Euclidean distance ("as the crow flies"), or Manhattan distance (by city block or street). Variety includes assessing the overall availability of different types of foods stores or restaurants as well as their prices and quality.

Table 1. Number of journal articles measuring the food environment published by year (n=137)

Year	Journal articles
1990	1
1991	2
1992	3
1993	5
1994	2
1995	3
1996	1
1997	7
1998	2
1999	5
2000	4
2001	5
2002	13
2003	6
2004	16
2005	17
2006	26
2007*	19
Total	137

*2007 total through August

Evidence Synthesis

A total of 137 articles were identified that included measures of the food environment.[22–158] Table 1 shows the number of articles published from January 1990 to August 2007, demonstrating the increased interest in measurement of the food environment, particularly in recent years. Ninety-seven of the 137 articles (70.8%) were published from January 2002 to August 2007.

Table 2 presents summaries of the overall number of articles that used the different types of measures, both instruments and methodologies. Many articles used multiple measures, hence the total number of instruments and methodologies do not sum to 137. The most frequently used measure overall came from some type of geographic analysis (68). Among instru-

Table 2. Summary of food environment articles by type of measure

Instruments (number of articles)	Article reference number
Interviews/questionnaires (34)	23, 31, 32, 35, 37, 42, 45, 52, 54, 60–63, 67, 68, 71, 73, 77, 88, 90, 91, 103, 105, 110, 111, 113, 125, 127, 131, 136, 138, 144, 147, 155
Market baskets (29)	28, 30, 33, 40, 43, 47, 53, 63, 64, 68, 74, 75, 77, 85, 94, 95, 99, 104, 106, 114, 117, 125, 137, 139, 140, 145, 148–150
Checklists (19)	38, 55, 65, 66, 70, 79, 80, 94, 96, 115, 121, 122, 129–132, 135, 150, 157
Inventories (12)	39, 56, 61, 62, 87, 89, 98, 113, 131, 143, 152, 157
Methodologies (number of articles)	
Geographic analysis (68)	22, 24–27, 30, 33, 34, 36, 40, 41, 47–50, 53, 55, 56, 65, 66, 69, 70, 74–76, 79–82, 84–87, 92, 94–97, 99–102, 104, 107–109, 119–121, 123, 124, 126, 128, 129, 132, 133, 137, 139–143, 145, 150, 151, 153, 156, 157
Sales analysis (24)	23, 29, 37, 44–46, 51, 57–59, 62, 72, 73, 78, 83, 89, 98, 112, 114, 116, 118, 146, 147, 158
Nutrient analysis (17)	29, 44, 46, 61, 62, 78, 89, 93, 98, 116, 117, 131, 136, 146–148, 158
Menu analysis (11)	29, 38, 55, 93, 96, 116, 129, 134, 136, 154, 158

Table 3. Summary of instruments measuring the food environment reporting psychometric properties

Study/instrument name (if applicable)	Environment	Instrument type	Reliability	Validity
Dibsdall (2003)[52]	Food stores	Interview/questionnaire	Cronbach's alpha	
Echeverria (2004)[54]	Food stores	Interview/questionnaire	Cronbach's alpha, test–retest	
Giskes (2007)[65]	Food stores	Checklist	Inter-rater	
Glanz (2007)[66] NEMS-S	Food stores	Checklist	Inter-rater, test–retest	Face, construct
Horowitz (2004)[79]	Food stores	Checklist	Inter-rater	
Mujahid (2007)[110]	Food stores	Interview/questionnaire	Cronbach's alpha, test–retest	
Wechsler (1995)[143]	Food stores	Inventory	Inter-rater, test–retest	
Benjamin (2007)[31] NAP-SACC	Schools (daycare)	Interview/questionnaire	Inter-rater, test–retest	Criterion, construct
Kubik (2002)[88]	Schools	Interview/questionnaire	Cronbach's alpha	Face
Kubik (2005)[91]	Schools	Interview/questionnaire	Cronbach's alpha	
Murnan (2006)[111]	Schools	Interview/questionnaire	Test–retest	Construct
Thompson (2007)[138]	Schools	Interview/questionnaire	Cronbach's alpha, test–retest	Face
Cassady (2004)[38]	Restaurants	Checklist	Inter-rater	
Edmonds (2001)[55]	Restaurants	Checklist	Inter-rater	
Mujahid (2007)[110]	Restaurants	Interview/questionnaire	Cronbach's alpha, test–retest	
Saelens (2007)[129] NEMS-R	Restaurants	Checklist	Inter-rater, test–retest	Face, construct
Golaszewski (2002)[67]	Worksites	Interview/questionnaire	Inter-rater, internal consistency	Content, criterion, face, construct
Oldenburg (2002)[115] CHEW	Worksites	Checklist	Inter-rater; intraclass; correlation coefficients	
Ribisi (1993)[127]	Worksites	Interview/questionnaire	Internal consistency reliability coefficients	Construct

ments, the most commonly used measures were interviews/questionnaires (34), followed by market baskets (29), checklists (19), and inventories (12). Among methodologies, after geographic analyses, the measures most reported included sales analyses (24), nutrient analyses (17), and menu analyses (11).

Eighteen of the 137 articles (13.1%) tested for any psychometric properties, including inter-rater reliability, test–retest, and/or validity. Table 3 provides a summary of these articles by environment, and the details of any reliability or validity tests reported. Only eight included any validity testing, such as face validity, content validity, construct validity, or criterion validity. (The Mujahid and colleagues[110] article is noted in Table 3 twice because the instrument used in the study referred both to food stores and restaurants.)

Table 4 provides summaries of the number of articles and a listing of the citations in each food environment that was assessed, including food stores (80), schools (37), restaurants (26), and worksites (11). These categories are not mutually exclusive, as some articles included multiple environments. Each specified food environment was further stratified based on the specific type of measure used: checklist, market basket, interview/questionnaire, inventory, geographic analysis, nutrient analysis, sales analysis, and/or menu analysis. Articles often used more than one type of measure. Therefore the sum of the number of measures is greater than 137.

Articles measuring food stores most frequently used instrument(s) and/or some type of geographic analysis. Instruments were used to evaluate different aspects of the food environment, including availability, price, and quality. Geographic measures, which identified the diversity, proximity, and variety of food stores, were used to compare different geospatial areas and define the presence or absence of "food deserts." First used as a term in 1996 by the United Kingdom Nutrition Task Force's Low Income Project Team, food deserts are "areas of relative exclusion where people experience physical and economic barriers to accessing healthy food."[159]

In restaurants, as with food stores, the measures used were most often some type of geographic analysis. Checklists, menu analyses, inventories, and interviews/questionnaires also were used. Geographic analyses often were used to compare the proximity, diversity, and variety of restaurants between different geographically-defined areas. Menu analyses also were used to assess and compare quality, cost, and labeling.

For schools, the food environment was most frequently assessed to evaluate the effect of an intervention. Thus, sales analysis, menu analysis, and nutrient analysis were used separately, and in combination, to evaluate the availability and quality of food offered, labeling/signage, cues for healthy eating, barriers to healthy eating, pricing, and/or the nutrient content (e.g., amount of fat, saturated fat, sodium, and calories) for lunches, à la carte foods, and vending.

The measures used in worksites were similar to those found with schools. These environments are defined

Table 4. Summary of food environment articles by environment, stratified by type of measure

Environment (number of articles)	Article reference numbers
Food stores (80)	22–25, 27, 28, 30, 33, 35, 39–41, 43, 47, 49–56, 63–66, 68–70, 74–77, 79–82, 85–87, 92, 94, 95, 97, 99, 104, 106–109, 110, 112, 114, 117, 119–121, 123–125, 128, 132, 133, 135, 137, 139–143, 145, 148–153, 155–157
Interviews/questionnaires	23, 35, 52, 54, 63, 68, 77, 110, 125, 155
Market baskets	28, 30, 33, 40, 43, 47, 53, 63, 64, 68, 74, 75, 77, 85, 94, 95, 99, 104, 106, 114, 117, 125, 137, 139, 140, 145, 148–150
Checklists	55, 65, 66, 70, 79, 80, 94, 121, 132, 135, 150, 157
Inventories	39, 56, 87, 143, 152, 157
Geographic analysis	22, 24, 25, 27, 30, 33, 40, 41, 47, 49, 50, 53, 55, 56, 65, 66, 69, 70, 74–76, 79–82, 85–87, 92, 94, 95, 97, 99, 104, 107–109, 119–121, 123, 124, 128, 132, 133, 137, 139–143, 145, 150, 151, 153, 156, 157
Sales analysis	23, 51, 112, 114
Nutrient analysis	117, 148
Menu analysis	—
Schools (37)	26, 29, 31, 37, 44–46, 57–62, 71–73, 78, 87–91, 98, 105, 111, 113, 116, 118, 122, 130, 134, 136, 138, 144, 146, 147, 158
Interviews/questionnaires	31, 37, 45, 60–62, 71, 73, 88, 90, 91, 105, 111, 113, 136, 138, 144, 147
Market baskets	—
Checklists	122, 130
Inventories	61, 62, 89, 98, 113
Geographic analysis	26, 87
Sales analysis	29, 37, 44–46, 57–59, 62, 72, 73, 78, 89, 98, 116, 118, 146, 147, 158
Nutrient analysis	29, 44, 46, 61, 62, 78, 89, 98, 116, 136, 146, 147, 158
Menu analysis	29, 116, 134, 136, 158
Restaurants (26)	25, 26, 34–36, 38, 48, 55, 76, 82, 84, 87, 96, 97, 100–102, 110, 120, 124, 126, 129, 137, 142, 153, 154
Interviews/questionnaires	35, 110
Market baskets	137
Checklists	38, 55, 96, 129
Inventories	—
Geographic analysis	25, 26, 34, 36, 48, 55, 76, 82, 84, 87, 96, 97, 100–102, 120, 124, 126, 129, 137, 142, 153
Sales analysis	—
Nutrient analysis	—
Menu analysis	38, 55, 96, 129, 154
Worksites (11)	32, 42, 57, 59, 67, 83, 93, 103, 115, 127, 131
Interviews/questionnaires	32, 42, 67, 103, 127, 131
Market baskets	—
Geographic analysis	—
Checklists	115, 131
Inventories	131
Geographic analysis	—
Sales analysis	57, 59, 83
Nutrient analysis	93, 131
Menu analysis	93

areas with restricted, or limited, food options—and thus, they also are often the target for nutrition interventions. Some tailored measures have been developed for use in worksites. The overall emphasis in worksites was on interviews/questionnaires, with additional work done with sales analyses, nutrient analyses, checklists, inventories, and menu analyses.

Discussion

The goal of this study was to compile all relevant peer-reviewed articles that included measures of the food environment at the community level. In a companion article, Lytle[1] discusses the state of the science of these measures in greater detail. Overall, the interest in the effects of environmental factors on dietary behavior has led to research focused on the accessibility, availability, affordability, and quality of the community-level food environment. The compiled articles measured aspects related to food stores most commonly, followed by schools, restaurants, and worksites. In assessing the food environment, researchers typically used measures that fit broadly into the categories of instruments—such as checklists, market baskets, surveys, or inventories—or methodologies, which include geographic, sales, menu, and/or nutrient analyses. Researchers tailored their measurement approaches based on several factors, including whether they were focusing on "macro" or "micro" elements of the environment (i.e., spatial location of the outlet(s), or qualities related to the food and beverages

within an outlet), or examining potential disparities in the food environment.

Measures associated with micro-level aspects of the food environment included instruments as well as sales analyses, menu analyses, and nutrient analyses. Examples of these assessments include the quality of fresh produce in food stores; the types of food offered through lunches, vending, and à la carte options at schools; the menu options in restaurants; and food sales in worksites. Geographic analyses, which were the most common methodology of assessing the food environment, differ from most other measures as they operate at the macro-level. Geographic analyses assess spatial distribution of food outlets, most commonly food stores and restaurants. However, it should be noted that schools, worksites, and the home—individually or in combination—may all be relevant centroids, or points from which to conduct the spatial analysis of food stores and restaurants.

Researchers also assessed potential disparities related to the food environment. Geographic analysis was often used to test hypotheses related to disparities in food access and was frequently used in combination with other measures such as market baskets, checklists, or inventories to assess cost, availability, and quality of foods and beverages.

Specific populations, including low-income groups, rural populations, and racial/ethnic minority populations, may be at greater risk of obesity and more sensitive to environmental effects than other populations, yet relatively few instruments have been developed that specifically target the environments in which these populations live and work. Children represent another target population that may benefit from tailored instruments and methodologies to assess their environments, especially given the increased efforts and allocation for childhood obesity prevention research (children were included in 27 articles here[11,26,31,36,44,46,60–62,71,73,80,87,89,91,97,111,113,116,122,130,134,136,138,147,158,160]).

This review determined that relatively little work has been done that evaluates psychometric properties within these instruments to measure the food environment. Although many measures have been developed over the past several years, the validity and reliability of these measures often have not been critically examined, suggesting that caution may be warranted in interpreting results. The testing that has occurred has focused primarily on reliability (inter-rater, test–retest, and internal consistency), and not on validity. This issue is also noted by Oakes and colleagues[161] in this supplement. The validity testing conducted has focused on those measures developed for use in worksites and schools. However, interventions in the school environment have largely preceded work on establishing the validity and reliability of environmental measures used to characterize and evaluate change in the environment.[160] Conducting an intervention before testing a measure for psychometric properties may reflect the obvious potential for improving availability of nutritious foods in schools or, perhaps, the lack of recognition that environmental measures need to be evaluated for reliability and validity. Both valid and reliable measures of the food environment are required to assess any relationship between the food environment and dietary behavior effectively, and the findings here suggest the need for greater emphasis on psychometric testing of measures in the near term.

The strengths and limitations of this analysis also should be noted. The search criteria and methods may not have captured all relevant articles and therefore may be limited. This may be particularly true for market basket analyses, as these are often published in government reports, which were not included in the search criteria. Nevertheless, the study of the food environment and its relationship with dietary behavior and health outcomes is a nascent field, and a strength of this compilation is that it may provide a useful first step in an iterative process to categorize the research tools and methods used by researchers. The articles identified here were published in journals representing the interests of a number of disciplines and fields, including public health, nutrition, geography, economics, public policy and urban studies. This reflects the breadth of interest in the topic area, as well as the diversity of expertise brought by researchers from multiple fields.

This review illustrates that research related to measures of the food environment has increased considerably since 1990, particularly in recent years. This relatively new interest reflects an acknowledgement of the challenges with individual-level interventions; an increasing interest in the influence of environmental factors on diet quality, energy intake, and weight; and a recognition of the potential for systems-level interventions to facilitate dietary change. By compiling this list of measures, the goal was to enable access to existing work in this area, and stimulate the development of the next generation of measures of the food environment. This initial compilation of articles, instruments, methodologies, and ongoing updates is available and searchable at www.riskfactor.cancer.gov/mfe. Robust measures of the food environment may strengthen research on the effects of the community-level food environment on individual dietary behavior, assist in the development and evaluation of interventions, and inform policymaking targeted at improving diet and reducing the prevalence of obesity.

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