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REVIEW ARTICLE

# Concepts, Characterizations, and Cautions: A Public Health Guide and Glossary for Planning Food Environment Measurement

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**Abstract:**

***Background:***

There is no singular approach to measuring the food environment suitable for all studies. Understanding terminology, methodology, and common issues can provide a foundation for cohesive and convincing findings.

***Objective:***

This review is designed to support investigators and teams newly engaged in food environment measurement who are seeking to optimize and justify measurement choices across projects.

***Methods:***

This guide defines key terms and provides annotated resources identified as a useful starting point for exploring the food environment literature. The writing team was a multi-institutional academic-practice collaboration, reflecting on measurement experience with food environments and other retail establishments across the US and in New York City.

***Results:***

Terms and annotated resources are divided into three sections: food environment constructs, classification and measures, and errors and strategies to reduce errors. Two examples of methods and challenges encountered while measuring the food environment in the context of a US health department are provided. Researchers and practice professionals are directed to the Food Environment Electronic Database Directory (https://www.foodenvironmentdirectory.com/) to compare available data sources for food environment measurement, focused on the US; this resource incorporates annual updates informed by user input and literature reviews.

***Discussion:***

Measuring the food environment is complex. This guide serves as a starting point for understanding some of the public health options and challenges for neighborhood food environment measurement.

***Conclusion:***

Food environment measures and data sources vary in suitability depending on research and practice objectives. Reducing barriers to navigating existing literature can catalyze new insights and facilitate theoretically-grounded food environment measurement.

***Classifications:***

Built Environment, Food Environment

**Keywords:** Neighborhood characteristics, Geographic information systems, Data sources, Environment and public health, Public health practice, Resource guide.

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## 1. BACKGROUND

The factors that affect an individual's decisions about obtaining and consuming food, including the availability, convenience, accessibility, and acceptability of food sources, are referred to as the foodscape [1] or food environment [2]. The neighborhood food environment in particular, has a potential role in influencing diet-related health outcomes and may be modified by food policy [3, 4].

No single approach to measuring the neighborhood food environment is suitable for all studies or uses. Awareness of terminology, concepts, measurement options, and common data quality issues can support the appropriate use of measures of the food environment. Prior glossaries [5 - 7] and reviews [8, 9] have defined food environment-related terms but are not focused on neighborhood food environment measurement and associated challenges for those investigators and teams newly engaged in food environment measurement.

## 2. METHODS

This guide and the Food Environment Electronic Database Directory (Table **1**) were developed through an academic-practice collaboration, reflecting on the experience of a multi-institutional team focused on food sources and other retail establishments across the US relevant to cardiovascular disease [10 - 15]. This guide is designed to support a shared understanding so that each research or practice team engaged in food environment measurement can justify their choices and initiate informed discussion about reasons for measurement strategies to vary across projects.

We aim to complement prior work by sharing selected definitions, annotated resources (Table **1**), and two examples of food environment measurement by a local health department within the US. Terms and resources are organized below to inform (1) constructs, (2) classification and characterization, and (3) cautions about errors and their mitigation.

## 3. GLOSSARY OF TERMS

### 3.1. Constructs: Clarifying what to Measure in the Food Environment

This section describes conceptual elements used to define food environments.

#### *3.1.1. Food Environment*

Range of food products and food sources that can be accessed in one's everyday environment (including stores and restaurants within the built environment and mobile vendors or informal food sales), providing opportunities or constraints to dietary choices. Includes availability, convenience, accessibility, and acceptability of food sources [6, 16 - 19]. Is situated within the broader food system with other factors that impact dietary outcomes [20] and which can be integrated over time [21].

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#### *3.1.2. Availability*

Quantity and diversity of food stores or other establishments that can be physically accessed by individuals, often defined within a geographic area. Can also be defined for specific types of food or beverage items in institutional settings such as offices and schools, based on offerings within on-site cafeterias or vending machines [4, 6, 16, 17].

#### *3.1.3. Convenience*

Qualities of retail and food options that minimize effort needed from consumers to purchase, prepare, and consume food. Includes establishment characteristics beyond availability, such as store hours, delivery services, and food product characteristics, such as shelf-life [6, 16].

#### *3.1.4. Accessibility*

Qualities and characteristics affecting how readily individuals can purchase and consume food items. Includes both convenience and whether the consumer has sufficient time or transportation mode options to overcome barriers to access. Importantly includes *Affordability*, which depends on both food prices and individual purchasing power [4, 6, 16, 17].

- Eligibility and use restrictions for *Nutrition Assistance Programs* such as the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) are food policy factors related to addressing food insecurity [22]. The acceptance of corresponding payment *via* Electronic Benefits Transfer (EBT) cards varies [22, 23].
- Much research has focused on *food deserts* as a limiting factor to healthy food consumption, though area-based sociodemographic factors may be more crucial [24].

#### *3.1.5. Acceptability*

Agreement between available foods and population food preferences, factoring in taste, culture, customs, and knowledge [4, 16].

#### *3.1.6. Food Quality*

Perceived and quantifiable characteristics of food products that impact alignment with consumer needs and preferences. For a health-oriented consumer, quality may include the density of desired nutrients relative to unhealthy components (*e.g.*, additives, sugar, sodium, or trans fats). Quality can also include freshness and appearance [6] or, conversely, the degree to which foods have been processed.

- The NOVA classification defines *Ultra-Processed Foods* as ingredient and meal formulations resulting from extensive industrial-scale processing, often containing artificial colors, flavors, emulsifiers, and other additives [25]. Implications of ultra-processed food intake continue to be examined with both a health and equity lens [26, 27], alongside associated nutrition characteristics and consumption patterns.

### *3.1.7. Food Retail Store*

Commercial locations with food products available, including food to be prepared or consumed off-premises. It may include retail locations that are not primarily food retailers but offer some food items for purchase (*e.g.*, pharmacies and department stores) [16, 28]. Note that the classification of food retail stores selling a wide range of items may rely on which items are most salient, as defined by typical consumer intentions, marketing, relative pricing, or shelf space [29]. The classification of a store as healthy or unhealthy has national and cultural context and requires a subjective lens rather than uniformity [30].

### *3.1.8. Urban Agriculture*

Systems and settings for cultivating, processing, and distributing fresh produce and animal products as food in urban and suburban settings. It includes community gardens, rooftop farms, and hydro-, aero-, or aquaponic facilities. Assumes a scale of production and commerce beyond personal consumption or informal community sharing [31, 32]. Though peri-urban agriculture is sometimes included within this definition, the two differ in spatial distribution and can be considered distinct parts of a food system [33].

**Table 1. Selected references to guide food environment research.**

| Author/Ref | Use |
|---|---|
| **Constructs** | |
| Downs *et al.* [18] | • Describes dimensions of sustainable diets<br>• Provides conceptual depiction of key elements (availability, affordability, convenience, promotion and quality, and sustainability) based on type of food environment<br>• Lists overview of tools used to assess these elements. |
| Nodari *et al.* [6] | • Compares commonly used definitions of the food environment<br>• Describes conceptual frameworks for the food environment<br>• Provides tools and methods that have been implemented or that are under evaluation in food environment research for dimensions of food environment<br>- Food availability and access; prices and affordability; convenience and time savings; promotion and advertising; quality and safety. |
| Turner *et al.* [24] | • Defines food environment<br>• Distinguishes between external and personal domains<br>• Identifies a conceptual framework and methodological framework that situates the food environment within the broader food system<br>• Discusses methodological considerations: unit of analysis, data, measures, strengths, challenges<br>• Recognizes research gaps. |
| **Classification and Measurement** | |
| Online resource created by this writing team | • The Food Environment Electronic Database Directory can be accessed at https://www.foodenvironmentdirectory.com/<br>• Allows users to filter and compares available data resources for food environment measurement, focused on those with national coverage in the US<br>• This dynamic resource is envisioned to incorporate user feedback and annual literature review updates. |
| Swanson [59]. | • Guides researchers in selecting the appropriate measurement tool<br>• Compares measurement methods by a variety of metrics, including:<br>- Validity and reliability<br>- Rural or urban<br>- Store environment characteristics (ex. products, quality, pricing, WIC/SNAP)<br>- Number of items in tool<br>- Type of tool (short-answer, scale, open-ended, *etc*.)<br>• Distinguishes between consumer and store-owner perspectives. |
| Lytle [40]. | • Discusses psychometric standards for tools that assess the food environment<br>- Standards of reliability and validity, lack of reporting and rigor in evaluation<br>• Provides guidance on how is the obesogeneity or diet-related disease risk of environments quantified<br>- How to reduce the amount of data that are generated when attempting to assess environments<br>• Critiques the use of different study designs to assess environmental factors<br>- Longitudinal *versus* group randomized trials *versus* neighborhood-level<br>- Selection bias when looking at how neighborhood characteristics affect the individual<br>• Discusses how the food environment is assessed in the broader context of an ecologic model<br>- Interactions between physical and social environments and individual food choice<br>- Challenge of defining "neighborhood"<br>• Need better understanding of what influences the choices people make within their environments. |
| Ohri-Vachaspati and Leviton [19]. | • Evaluates food environment measurement instruments<br>• Highlights importance of evaluating instruments based on purpose, user, and resources available<br>• Describes characteristics and criteria for rating instruments:<br>- Levels of food environment, type of instrument, what is captured, features of the environment measured, appropriateness for purpose, technical assistance available, psychometric tests, type of validity, reliability testing, type of population assessed, instrument users, required resources to use data, required expertise<br>• Contrasts food environment instruments based on type (community, organizational, informational, consumer). |

*(Table 1) contd.....*

| Author/Ref | Use |
|---|---|
| Wilkins *et al.*. [29] | • Outlines 5 dimensions of methodological diversity:<br>- The choice of food outlet data (validity of measure)<br>- Methods used to extract food outlets of interest (scope included, business classifications)<br>- Ways that the food outlet constructs are defined (interpretation)<br>- The geocoding methods used (validity of measure, spatial accuracy)<br>- Ways that the food outlet access is operationalized (validity and interpretation) *i.e*., type of metric (intensity or proximity, buffer size, count per area/capita)<br>• Proposes reporting framework to assess food environment studies (Geo-FERN: geographic information system food environment reporting). |
| **Types of Errors and How to Mitigate** | |
| Han *et al.*. [59] | • Investigates the extent of classification error for food stores in Dun and Bradstreet and InfoUSA (InfoUSA, Business Analyst, ESRI)<br>- Identifies patterns of misclassification by food store outlet attributes<br>- Assesses systematic biases in the accuracy by neighborhood characteristics<br>• Recognizes no associations in correct classification by tract characteristics, but association of correctly classifying convenience and specialty stores by racial demographics<br>• Critiques overall validity<br>- Larger grocery stores and supermarkets tended to be more accurately classified<br>- Misclassified stores tended to be atypical (attached to gas stations, produce markets, meat markets, *etc*.). |
| Jones *et al.*. [45] | • Outlines step-by-step approach for improving data quality of commercial businesses lists to measure the food environment<br>• Describes importance of assessing count, classification, location accuracy, and bias by neighborhood characteristics in choosing a business list to use<br>• Provides guidance on improving data quality:<br>- Supplement data with outlet name<br>- Automated reclassification technique (SIC code, then chain names were applied to reclassify incorrect records, different spellings)<br>- Only retain records that are geocoded to the exact address or ZIP+4, back cast records that had a PO box listed.<br>- De-duplicate records using company name matching, address matching, and geographic methods general merchandise stores deduplicate geographically. |
| Sacks, Robinson, & Cameron [39]. | • Identifies previous literature reviews regarding the assessment of the healthiness of food environments and diet/obesity-related outcomes<br>• Examines patterns of exposure to food environments (*e.g*., how people move through their environments and where they access food)<br>• Identifies lack of composite measures of food environments<br>- Proportions may better capture food environment rather than absolute measures<br>- Create index measures<br>• Describes importance of standardized methods, tools, analyses, terms, and classifications<br>• Demonstrates the need for diverse study designs<br>- Longitudinal designs provide better understanding of exposure and outcomes<br>- Ecological and natural experiment study designs could be better utilized. |
| Hirsch *et al.*. [14] | • Provides steps to leverage business data for longitudinal research using NETS longitudinal database on local business establishments from Walls & Associates (Walls & Associates, Denver, CO)<br>• Describes the method for re-geolocating addresses<br>• Discusses classification using standard codes<br>- Food and restaurants, alcohol, social, physical activity, walkable, and healthcare<br>- 8-digit SIC codes<br>- Randomly checked using NETS data and Google StreetView (Google, CA)<br>- Integrating complementary data sources (chain name lists from Technomic/Restaurants and Institutions (R&I) and TDLinx®)<br>• Explains hierarchical classification system and naming conventions to avoid double counting establishments<br>• Describes the final step of linking to neighborhoods and participant residences (buffer zones). |

### 3.2. Classification and Measurement: Operationalizing Food Environment Constructs

This section covers operationalization of *Food Environment* measures and sources of data (including those listed in the Food Environment Electronic Database Directory, an online resource to be updated based on ongoing user input and annual literature review, see Table **1**).

#### *3.2.1. Food Establishment Classification*

Systematic use of criteria to define *Food Retail Stores* of interest (*e.g*., supermarkets, convenience stores, fast food outlets). Commonly incorporates standard coding systems and may consider establishment characteristics such as floor space, number of employees, or annual sales [29]. Granular classification requires attention to potential overlap among large (warehouses *vs*. supermarkets) or small (convenience stores *vs*. bodegas) food stores and among restaurants (national chain fast-food *vs*. other casual, quick service). Adopting or adapting previously published classifications is recommended to increase comparability between studies [29], unless there is scientific justification for creating a new measure. However, when existing classification definitions prove insufficient, prior models can guide tool development and testing [34].

#### *3.2.2. Standard Coding Systems*

Numeric codes with corresponding labels for retail and other establishments to categorize establishment type, which may be included in establishment-level datasets used to measure the food environment. Comparison to ground-truthed data may aid in understanding how comprehensively such systems reflect food items available. Two common systems are:

- Standard Industrial Classification (SIC): Codes of 4 to 8 digits that group together similar establishment types: the first two numbers represent the major industry, the third digit represents subgroups within that industry, and subsequent digits give further specificity [35]. The U.S. government stopped updating codes in 1987, though original codes have since been expanded. Mainly used by the private sector for economics and marketing.

- North American Industry Classification System (NAICS): A standard created by U.S. government agencies to replace the SIC system, providing more granular classification and used for governmental operations and classifications. NAICS uses a six-digit system; the first two digits represent the major sector, the third represents the subsector, the fourth represents the industry group, the fifth represents the industry type, and the sixth represents the national industry [35, 36].

#### *3.2.3. Store Catchment Area*

The geographic area primarily served by a given *Food Retail Store*. It can be defined in a variety of ways, including distance, travel time, or transit accessibility, and will likely be larger in rural and low population density settings [37]. Defining catchment areas is useful for identifying customers' demographics and preferences that inform context-specific measurement of *Food Quality*, *Accessibility*, and *Acceptability*.

#### *3.2.4. Neighborhood*

A geographically and socially delineated context for individuals' behavior and environment. These may be defined through distance-based or political boundaries around homes, workplaces, schools, or commuting routes [38, 39]. People spend time in multiple settings; no single geographic unit perfectly characterizes the physical, social, cultural, and policy environments experienced [40].

- Both *Geographic Extent* (entire area throughout which neighborhoods will be measured) and *Scale of Measurement* (geographic units used for characterization and comparison have implications for errors encountered and the feasibility of ground-truthing or other efforts to improve validity. Smaller-scale measurements and projects with a smaller geographic extent may allow more stakeholder involvement and tailoring of existing neighborhood definitions and measures; a larger geographic extent makes such methods less feasible, though still worth considering for a subsample of geographic units.

#### *3.2.5. Density-based Measures*

Measures characterizing the intensity of food establishment presence within a boundary, potentially relevant to both *Availability* and *Accessibility*. Estimates of density commonly use the count of establishments within a given category as the numerator and a defined land area as a denominator. However, retail density measures may present a challenge for interpretation, especially across settings of different urbanicity or within high-density settings [7, 39-41].

#### *3.2.6. Ratio-based Measures*

Measures characterizing relative intensity across food establishment categories within a boundary, which may point to their relative *Convenience*. Commonly relies on binary (*e.g.*, healthy/unhealthy) categorization [42]; estimates commonly include healthy retail establishment (variously defined) counts in the numerator and unhealthy or total food retail in the denominator, leading to challenges in low-density settings where counts in the denominator may equal 0.

#### *3.2.7. Longitudinal Measures*

Measures that incorporate multiple moments or periods of time, providing a way to examine trends across years or decades. Longitudinal measures of both food environment and dietary or health outcomes allow for the examination of temporal sequencing in studies of the food environment on health, an identified gap in the food environment literature [43]. Observed trends over time are more interpretable if based on consistent classification methods and temporally appropriate linked health data [14].

#### *3.2.8. Supermarket Transition or Greenlining*

A longitudinal process bringing in *Food Retail Stores* to an area that emphasize gourmet, healthy, or natural ingredients over *Affordability*, which may be concurrent with gentrification, urbanization, or related sociodemographic transitions. Such changes may align with *Food Quality* preferences of only a segment of the population in the store catchment area, with rising food costs exacerbating inequities in food insecurity particularly if concurrent with a shrinking supply of affordable housing and amenities [44].

#### *3.2.9. Sociodemographic Indicators*

Characteristics of individuals and geographic units that may confound or mediate *Food Environment* effects. These are likely to impact where a person lives and how food is acquired, as well as impacting overall health for reasons unrelated to the *Food Environment;* they commonly include personal and area-based education, income, and wealth and may also incorporate household composition and area-level patterns by identity groups such as gender, race, and ethnicity, or may combine several area-based measures into a single index variable [39].

### 3.3. Errors: What Goes Wrong and How to Mitigate

Terms in this final section describe sources of error that commonly arise when operationalizing food environment measures and strategies to limit or quantify such errors.

#### *3.3.1. Duplication*

A single food retail location appearing multiple times in a dataset or contributing to the count across multiple food retail categories. It can be addressed through systematic criteria to identify and remove duplicates. Criteria to define duplicates may differ across food retail categories; large establishments such as supermarkets at the same address in the same year are likely to represent duplication error, yet smaller establishments such as fast-food restaurants are commonly co-located, requiring other information, such as business name to identify duplicates [45].

#### *3.3.2. Misclassification*

Misalignment between an establishment's food offerings and assigned retail category. Misclassification may be reduced through systematic spot-checking or field validation [19], followed by refinement of classification definitions and documenting decision rules [34, 45, 46].

##### *3.3.2.1. Low Sensitivity*

Not all relevant food establishments are correctly included, resulting in an undercount for a given food retail category.

##### *3.3.2.2. Low Specificity*

Food establishments are incorrectly included, exaggerating the count for a given food retail category.

#### *3.3.3. Spatial Error*

Inaccurate location information, which can result from errors in the address or geocoding reference files. Consequences typically include inaccurate area-based counts, attenuated estimates of association, and reduced statistical power. Bias can also arise from systematic differences in spatial error over time or along a gradient of urbanicity (spatial errors are typically larger in rural areas than urban and suburban areas) [29]. Spatial error can be reduced through improving address completeness or the geocoding process. Documentation of geocoding methods and results can inform discussion of limitations or planning of quantitative bias analyses to evaluate the likely impact on results [45, 46].

#### *3.3.4. Modifiable Aerial Unit Problem*

A fallacy that arises in interpretation, especially when results from a geographic unit selected because of ease of use or data availability are assumed to hold for an area definition that is more personalized or optimally-scaled. Associations across differing geographic scales may not be replicable when units differ in size (*e.g.*, census tract *versus* county) or where boundaries are drawn (*e.g.*, circular buffers centered on home addresses *versus* centered on postal code centroids) [47, 48]. If such associations are not robust to a differently defined geographic unit, that uncertainty produces a challenge known as the *Uncertain Geographic Context Problem,* whereby the selection of the most relevant spatial context is unclear. Newly developed statistical methods are beginning to address the impact of food environment features on health outcomes at different geographic scales [49].

##### *3.3.4.1. Temporal Misalignment*

Inaccuracies in food environment measures due to using data from a time period dictated by data availability or convenience, rather than the time period anticipated to influence dietary and health outcomes [50]. Identification of frequently updated longitudinal food environment data makes it possible to optimize temporal alignment, especially if combined with residential histories or activity spaces to capture where individuals are located across time [39, 51].

##### *3.3.4.2. Model Misspecification*

Biased or oversimplified patterns of association resulting from inaccurate assumptions embedded in statistical modeling. Assumptions are commonly violated due to non-linearity, non-random missing data, or spatial non-independence [51, 52]. Regarding non-linear associations between food environment measures and health outcomes, some types of food retail may have the largest influence when rare (as a *Limiting Factor*), as absence most strongly constrains choice; once the same retail category or food type becomes common (reaching *Saturation*), the dietary behavior and health effects of each additional establishment may be diminished [53].

## 4. PRACTICE IMPLICATIONS: EXAMPLES FROM PRACTICE AT A LOCAL HEALTH DEPARTMENT

These terms may feature into the clear articulation of research aims regarding measurement, operationalization of the food environment, and any tradeoffs or potential shortcomings. The following examples illustrate use of food environment measures by the New York City (NYC) Department of Health and Mental Hygiene, and how purpose and geographic extent differ in ways that inform food environment measurement.

### 4.1. Example 1. Incorporating food environment into NYC Community Health Profiles

#### *4.1.1. Purpose and Geographic Extent*

The Health Department periodically publishes Community Health Profiles [54] to summarize health statistics across the city's 59 community districts, publicly offering an historical archive. Each Community Health Profile visualizes place-based health determinants and includes geographic and social health disparities. While food environment is represented as a single ratio-based indicator in 2018, it appears alongside many other community indicators and presented within the context of myriad social and environmental (or geographic) determinants of health. The final selection of the ratio-based indicator required: a review of measures available throughout the geographic extent, a balance of simplicity and interpretability, and audience appropriateness (non-specialists, community members) [55].

#### *4.1.2. Construct Identified fo Inclusion*

The ratio of supermarkets to bodegas (corner stores) is a measure rooted in the food environment and health literature [42, 56]. This is relevant to inequities in availability and convenience. Food items sold in supermarkets and bodegas typically differ in nutritional quality and these venues also differ in relative affordability of fresh items. The selected ratio-based measure has advantages of interpretability and ease of comparison across geographic areas within an urban setting.

Operationalization of the selected ratio-based measure: Counts of supermarkets and bodegas come from an open-source list of retail stores from the New York State Department of Agriculture and Markets. Summary health statistics are presented alongside the supermarket to bodega ratio in each Community Health Profile report.

#### *4.1.3. Limiting but not Eliminating Error*

Data curation techniques, such as *deduplication*, *classification* and *spatial error* mitigation manage *errors*, improve classification of stores (as supermarkets, bodegas, or neither), and allow comparability across community districts. For a given year, a cross-sectional list of food stores in New York City contains tens of thousands of entries; inclusion of food establishments throughout all 5 boroughs of New York City makes ground-truthing (refinement of food retail store categories) cost prohibitive. Reliance on secondary data sources may cause the calculated ratio to be affected by errors including duplication, misclassification, and spatial error, even after reducing the extent of such error *via* data curation steps, as described in previous studies [14, 45, 57].

### 4.2. Example 2. Identifying Eligible Corner Stores for Shop Healthy NYC Intervention Planning

#### *4.2.1. Purpose and Geographic Extent*

Shop Healthy NYC is a precision public health initiative implemented by the Health Department that targets neighborhoods with a high relative prevalence of diet-related chronic disease (*e.g.*, overweight and obesity) to receive increased access to healthy food. On a rolling, yearly basis, eligible supermarkets and bodegas are recruited from a limited geography of 3-4 ZIP codes. In this year-long, two-part intervention, Shop Healthy staff work with food retailers to increase stock and promotion of healthier products.

#### *4.2.2. Construct Identified for Pre-intervention Planning*

Prior to retail store recruitment, food environment measures were used for assessment of availability and eligibility of supermarkets and bodegas.

#### *4.2.3. Operationalization Using Secondary Data and Ground-truthing*

Establishments are initially identified from both the commercially licensed Reference USA and publicly licensed New York State Department of Agriculture and Markets. Food Establishment classifications are derived from a retail audit, using zip code geographic extent. After applying exclusion criteria (*e.g.*, chain stores), further measures of the food environment (*i.e.*, availability, convenience and accessibility, affordability, acceptability, and food quality) are evaluated to identify candidate ZIP codes for this intervention. Finally, in-person interactions with retail food store owners are conducted. Comprehensive mapping of all potentially eligible locations is important for a fair process of planning and resource allocation, and for building trust with stakeholders.

#### *4.2.4. Multi-stage Checks to Minimize Error*

Secondary data sources offer preliminary categorization of food stores based on square footage and standard coding systems, though errors remain even following deduplication and other curating processes. In-person confirmation by study staff allows refinement of mapped establishments by deleting, adding, or re-classifying on a block-by-block basis to minimize errors in identification of eligible stores.

## 5. DISCUSSION

Conceptualizing, operationalizing, and limiting error in measures of the food environment is not a simple or straightforward task. Decisions about how to measure the food environment are dependent on the overall purpose, resource constraints, and environmental and social context. The heterogeneity of food stores and dynamic nature of food environments means that efficient measurement risks oversimplification. The terms and examples presented above are selected to help orient investigators and teams newly engaged in food environment measurement to the complexities of measuring a local food environment. However, these terms and examples represent only a starting point and do not fully capture every nuance of measuring food environment [58, 59].

## CONCLUSION

The terms, errors (and strategies for managing errors), annotated resources (including our Food Environment Electronic Database Directory, see Table **1**), and examples above offer a starting point for further exploration and advancement of neighborhood food environment measurement and research to inform action to benefit population health. This guide is designed to provide a shared starting point for selecting an approach to food environment measurement and identifying and managing potential errors and biases.

## AUTHORS' CONTRIBUTIONS

All authors contributed to the design and content of the paper and development of terms and definitions. SB led the literature review and annotated bibliography development with oversight from GSL; AJE, AC, and EMM supported revisions. AC led the initiation and drafting of example descriptions, with editing contributions from AJE, SB, EMM, and GSL. All authors critically revised and approved the final manuscript submission.

## LIST OF ABBREVIATIONS

**EBT** = Electronic Benefits Transfer

**NAICS** = North American Industry Classification System

**NYC** = New York City

**SIC** = Standard Industrial Classification

**SNAP** = Supplemental Nutrition Assistance Program

**WIC** = Special Supplemental Nutrition Program for Women Infants, and Children

## CONSENT FOR PUBLICATION

Not applicable.

## AVAILABILITY OF DATA AND MATERIALS

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## CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

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