



Capturing individuals' food environments using flexible space-time accessibility measures



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A B S T R A C T

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Within the geography, transportation, and public health communities there has been intense interest in better understanding the linkages between health outcomes such as obesity rates and people's access to healthy foods. In this nexus, personal access to healthy food is shaped by a number of individual and geographical factors including people's time available for shopping, the quality of proximal food vendors (e.g. supermarkets vs. convenience stores), and the nature of the transportation systems available to facilitate mobility. Building on recent research in disaggregate accessibility modeling, including that of time geography, this paper describes an individual-level modeling approach for quantifying peoples' food environments. The approach works by measuring the accessibility people have to local food shopping opportunities given their activity patterns and available time budgets. Individuals' food accessibility may be compared to one another and the underlying mobility afforded by the transportation system is accounted for. Moreover, the individual-level measure is such that it may be resolved to places, whereby the aggregation and mapping of multiple individuals' food accessibility experiences is possible. Hence, possible 'deserts' or areas of inaccessibility may be identified through a bottom-up analysis of the travel and mobility experience of a representative sample of individuals. These ideas are demonstrated with spatial data from a smaller urban area in Florida. Results show that individual and place-based differences in food accessibility may be delineated with the metrics.

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Introduction

Within the geography, transportation, and public health communities there has been intense interest in better understanding the linkages between inequitable health outcomes and people's access to healthy foods (Paez, Gertes Mercado, Farber, Morency, & Roorda, 2010; White, 2007; Wrigley, Warm, Margetts, & Whelan, 2002). In this nexus, personal access to healthy food is shaped by many factors including people's socioeconomic characteristics and time available for shopping, the quality of proximal food vendors (e.g. supermarkets vs. convenience stores), and the nature of the transportation systems available to facilitate mobility (Preston & Rajé, 2007; Smoyer-Tomic, Spence, & Amrhein, 2006; Widener, Farber, Neutens, & Horner, 2013). Cumulatively, these conditions converge to determine a 'food environment' for each individual, which has implications for their overall health and well being (Burgoine, Alvanides, & Lake, 2013; Walker, Keane, & Burke, 2010).

Food environments have received substantial attention in the literature, with many researchers seeking to define geographic areas without access to healthy food (McKinnon, Reedy, Morrisette, Lytle, & Yaroch, 2009; Walker et al., 2010; Wrigley et al., 2002). Collectively known as 'food deserts,' these are places which may lack adequate access to healthy food sources. Food deserts are essentially a geographical construct, where spatial data and mapping technologies are used to identify possible policy interventions that may be utilized to improve food accessibility (Burgoine et al., 2013; Gatrell, Reid, & Ross, 2011; Rigby et al., 2012). Among the best known attempts to delineate food deserts has been by the U.S. Department of Agriculture (USDA) who use Census data to map tracts identified as having inadequate access to food opportunities (USDA, 2013a). Their metrics depend on factors including the relative income of the tract, proximity to food shopping locations, and the availability of personal vehicles. This methodology and others like it are 'aggregate' assessments that reveal information about areas but do not necessarily reflect the experiences of individuals. For instance, the amount of free time available an individual has for shopping would also influence their accessibility and hence shape their food environment (Neutens, Schwanen, & Witlox, 2011; Widener et al., 2013).

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Many of these issues have been explored in work measuring individual-level accessibility, where researchers have designed approaches that account for individual contexts and constraints (Horner & Downs, 2012; Kwan & Weber, 2003; Miller, 1991; Neutens, Schwanen, Witlox, & De Maeyer, 2008; Páez, Scott, & Morency, 2012). Coupled with highly precise spatially disaggregate data on the movement of individuals; these metrics can reveal several important dimensions about a given person's accessibility to any set of goods or services. Although these metrics offer a level of specificity at the individual level, they are limited by the fact that they are difficult to generalize across multiple individuals (Horner & Downs, 2012; Neutens et al., 2011). In the delineation of food environments, mapping areas with limited access to food opportunities may not be possible because combining the experiences of individuals remains a challenge.

Building on recent research in disaggregate accessibility modeling including that of time geography (Downs & Horner, 2012; Horner & Downs, 2012), this paper describes an individual-level modeling approach for quantifying peoples' food environments. The approach works by measuring the accessibility people have to food shopping opportunities given their activity patterns and available time budgets. Individuals' food accessibility may be compared to one another, while the potential movement facilitated by the transportation system via its network structure is accounted for. Additionally the individual-level measure may be resolved to places, whereby aggregation and mapping of multiple individuals' food opportunities is possible. Hence, areas of inaccessibility may be identified through a bottom-up analysis of the travel experiences of a representative sample of individuals (Horner and Downs, 2014, *in press*). These ideas are demonstrated with spatial data from a smaller urban area in Florida.

In summation, the scope and aims of this paper are to outline a flexible individual-based measure of food environments. Next, we discuss key conceptual areas underpinning this work, including those of health policy research and accessibility. We then turn to present our modeling approach, which is based on a number of recent new developments in the area of time geography and accessibility analysis. This is followed by details of our application and computational results. We conclude with a discussion of our approach in the broader context of transportation and food policy research issues, and make suggestions for future research.

Background and concepts

Food opportunities and environments

Researchers have long known that lower socioeconomic groups are disproportionately affected by adverse health outcomes (Walker et al., 2010). These health disparities include higher rates of obesity, diabetes, and hypertension (Walker et al., 2010). It has also been noted that socio-economically disadvantaged groups are more likely than others to experience food shortages, are less likely to purchase foods recommended for good health, and consume fewer fruits and vegetables (Coveney & O'Dwyer, 2009; Rose & Richards, 2004). Increasingly, researchers have turned their attention to environmental factors that may contribute to inequitable health outcomes. Previous research has examined access to health care centers, pharmacies, and food stores as contributing to adverse health outcomes experienced by lower socioeconomic groups (Rose et al., 2009; Walker et al., 2010).

Since the 1990's studies have attempted to explore health disparities by investigating neighborhood food environment (Cummins & Macintyre, 2002; Wrigley, Warm, & Margetts, 2003). The food environment of any given geographic area is primarily defined by factors relating to store or restaurant proximity, food

prices, and food and nutrition assistance programs (USDA, 2013b). Studies show that healthy foods are predominantly more expensive and more difficult to access in neighborhoods of lower socioeconomic status (Gatrell et al., 2011; Walker et al., 2010; White, 2007). These findings have led to the term "food desert", which describes a neighborhood or other geographical unit with a shortage of supermarkets offering an affordable variety of nutritious foods.

While the term "food desert" has become linked to the food environment movement, there is still considerable debate among researchers as to its exact nature and definition. The USDA has defined a food desert as an "area in the United States with limited access to affordable and nutritious food, particularly such an area composed of predominantly lower income neighborhoods and communities." According to the 2008 Farm Bill, for an area to be defined as a "food desert", 33% of a census tract's population must travel more than one mile to the nearest store that offers fresh fruits and vegetables (Rigby et al., 2012). Since 2010, the USDA has adopted a more nuanced approach in determining whether a census tract has access or not by using ½ mile and 1 mile demarcations to the closest food store in urban census tracts and 10 and 20 mile demarcations for rural census tracts (USDA, 2013a). However, the USDA does not use individual-level data to augment or validate their measure.

Despite this standard definition, there remains a robust debate and plurality of opinions regarding the appropriate methodologies, specifications, and assumptions involved in determining whether people have sufficient access to food (Short, Guthman, & Raskin, 2007; Walker et al., 2010). Some earlier methodologies appearing in food access research were based on a limited conceptualization of accessibility, such as the number of local food opportunities in a given neighborhood, the number of food opportunities within a given distance of a place, or the minimum distance to the nearest food opportunities (Coveney & O'Dwyer, 2009). These analyses were often based on Euclidean or straight-line distance and did not take into account the underlying transportation system (Larsen & Gilliland, 2008). Incorporating transportation networks, where roads, transit, and footpaths define the means of travel, has been noted as the preferred means of capturing separation between people and food stores (Apparicio, Cloutier, & Shearmur, 2007; Larsen & Gilliland, 2008). Still, other research has enhanced the ways in which food accessibility is tracked by combining multiple measures (Coveney & O'Dwyer, 2009; Walker et al., 2010). In the past, some food access studies have utilized aggregate modeling approaches, which may assume that individuals at a given place have equal accessibility to food opportunities. Unsurprisingly, some researchers have criticized these methods as an oversimplification of the individual dynamics of reaching food stores (Coveney & O'Dwyer, 2009; Rose et al., 2009). Other studies have recognized the importance of analysis at the individual scale and its potentials for identifying differences in local environments, including the food accessibility context (Chaix et al., 2012; Choi & Suzuki, 2013; Kestens, Lebel, Daniel, Theriault, & Pampalon, 2010; Paez et al., 2010; Zenk et al., 2011).

In short, how 'accessibility' is operationalized has clear implications for describing food environments. Individual context matters immensely since research has shown that although lower socioeconomic groups tend to reside in neighborhoods defined as food deserts, individuals will not always choose to shop within their local neighborhoods, sometimes driving relatively longer distances to reach a particular food store (Cummins & Macintyre, 2002; Walker et al., 2010). In addition, existing approaches can ignore individuals' ability to make multiple stops on one trip, and commonly, neglect travel behavior and individual context. As such, we now turn our attention to describing some of the basic approaches for measuring accessibility and their implications for understanding food issues.

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