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Using urban commuting data to calculate a spatiotemporal accessibility measure for food environment studies

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ABSTRACT

Improving spatial access to healthy foods in urban regions is recognized as an important component of reducing the prevalence of chronic illness and achieving better health outcomes. Previously, researchers exploring this domain have calculated accessibility measures derived from the travel cost from home locations to nearby food stores. This approach disregards additional opportunities that present themselves as residents move throughout the city. A time-geographic accessibility measure is utilized to explore how single-occupancy automobile commuting affords access to supermarkets. Results show residents in some TAZs have more access when accounting for their commuting behavior than when measuring access from their home. This finding suggests more nuanced calculations of accessibility are necessary to fully understand which urban populations have greater access to healthy food.

1. Introduction

Spatial accessibility to healthy foods is an important aspect of encouraging nutritious diets as a means to reduce the prevalence of chronic illnesses, such as diabetes and cardiovascular disease (Cummins and Macintyre, 2002; Hung et al., 2004; Joshipura et al., 2001). Neighborhoods lacking access to vendors that provide healthy food options, like fresh fruits and vegetables, have been labeled "food deserts" (Shaw, 2006; Walker et al., 2010). Food deserts are often associated with socioeconomically disadvantaged populations, which exhibit a range of poor health outcomes, such as increased risk of diabetes (Everson et al., 2002) and stroke (Cox et al., 2006). It is assumed that the poor nutritional quality of locally available foods negatively influences the diets of residents, resulting in these undesirable health outcomes (Hendrickson et al., 2006; Lopez, 2007; Schafft et al., 2009).

However, previous food desert studies have not consistently identified a link between access to healthy foods and better health outcomes (An and Sturm, 2012; Wrigley, 2002). One potential reason for these inconsistent findings could be the failure of previous research to consider the impact of the temporal dimension on accessibility (Widener et al., 2011). Generally, the bases of most food accessibility metrics involve measuring the distances between residents' households to the available food stores in a city (Larsen and Gilliland, 2008; Lee and Lim, 2009; Raja et al., 2008). Such measures provide basic information about which urban regions lack spatial access at a point in time, but neglect to account for how a population's movements constrain the level of access over the course of a day. Omitting these dynamics is problematic because it can distort the true level of spatial access different subpopulations experience, and subsequently misinform policy makers' decisions regarding appropriate interventions (Neutens et al., 2012; Widener et al., 2011).

This paper introduces a time-geographic approach to further understand how the urban spatial structure of daily commuting behavior alters the spatiotemporally static image of food deserts. We present a study of Cincinnati, Ohio, a city recognized as having a number of "food deserts" (ERS USDA, 2012). The study utilizes a spatiotemporal measure to produce a novel representation of residents' level of access to healthy foods using data on regional commuting patterns, as opposed to previously derived metrics that only consider access from home locations (with exception to Salze et al. (2011)). Given the daily movements of an urban population, this novel measure can provide new

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information to public health and transportation policy makers seeking to understand the role spatial access to healthy food plays in population health.

2. Background

Physical accessibility to goods and services that aid in improving and maintaining health is recognized as an integral component of the overall level of access a person experiences. While other components, like social and economic factors, are also critical to overall accessibility, physical access is arguably the most rudimentary (US Department of Health and Human Services, 2010). If a person cannot physically travel to a location providing something they need, the other two components become less relevant.

In this paper, a healthy food vendor is defined as a supermarket or a large grocery store with a wide variety of foods, including fresh produce, which are generally not available in smaller grocery and convenience stores in the USA (Powell et al., 2007). The process for selecting supermarkets in this analysis is discussed in more depth in Section 3.1. For many studies on access to healthy food vendors, distance and transportation costs are used to understand the level of access experienced by people across various study areas (Alwitt and Donley, 1997; Bertrand et al., 2008; Lee and Lim, 2009; Metcalf and Widener, 2012; Widener et al., 2012). For example, Páez et al. utilize travel survey data to infer activity spaces around low-income residents' households, calculated by modeling the average distance of all daily trips, to gauge access to retail and fast food vendors throughout Montreal (Páez et al., 2010).

Much of this research relies on the assumption that the distance to a healthy food vendor is measured from the home location. One exception to this is found in research conducted by Salze et al., who introduce a study that reframes how accessibility to food stores can be calculated (Salze et al., 2011). In their paper, the authors propose a measure that considers the potential for spatial interaction given commuting behaviors in the Bas-Rhin administrative region of France. While this work does provide insights into how travel behavior affects access to food vendors, it does not take into account the importance of the available time a resident has to actually utilize a food store that can be more easily accessed thanks to commuting behavior.

This paper explores how automobile commuting patterns affect spatial accessibility to healthy food stores in Cincinnati, Ohio and expands on Salze et al.'s work by quantifying the amount of time a commuter will have to shop at a food store given the amount of free time available to them after accounting for their commuting costs. In addition to providing a spatiotemporal accessibility measure, this research also offers insights into the single occupant car-commuting population, which made up over three quarters of commuters in the U.S. in 2009 (McKenzie and Rapino, 2011). Concentrating on the automobile commuting population is an important step in understanding how movement in an urban region can influence which residents have access (Horner, 2004), as the regularity of the commuting trip may provide routine opportunities to shop at healthy food stores that are not captured by home-based accessibility metrics. To add context to this study, the American Community Survey finds that approximately 71% of workers 16 years and over in Cincinnati commute to work by driving alone, while approximately 9% commute using public transportation (US Census, 2012). While the focus of this research is on automobile commuters, the study can be replicated for commuters utilizing other modes on their journey-to-work, like public transit.

3. Methods

A first step in understanding the dynamics of access to healthy foods in urban environments involves the use of tools capable of quantifying the level of availability given an approximation of the typical time–space constraints on the population. The following section describes an interaction metric that can be used to understand how much access to healthy foods a resident has, given her/his daily commute.

3.1. Market interaction potential

We apply an interaction potential metric that uses interzonal commuting patterns to generate a healthy food accessibility score based on time–space prims (Farber et al., 2012). This accessibility measure incorporates aggregate travel patterns such as commuter flows and activity constraints. For example, a resident could live in neighborhood *i*, where there is a low level of spatial access to healthy food vendors. However, the same resident could have a daily commute to neighborhood *j*, where there are many healthy food vendors, thus providing an opportunity for healthy grocery shopping. This idea is illustrated in Fig. 1. The figure shows two potential space–time prims of an individual: one with co-located anchors at the home location and one with dislocated anchors at work and home. The individual can access both a convenience store and a supermarket along the way from work to home, whereas she/he would only be able to access convenience stores from the home location within the same time budget.

Previous healthy food environment measures are confined to investigating locations of residence alone, thus discounting this second opportunity. However there is evidence that some households chain trips when shopping for groceries (Cervero, 1996; Horner and O'Kelly, 2007; Popkowski Leszczyc et al., 2004). With this in mind, it is important to note this approach is meant to explore access to healthy food stores for commuters who are also the primary grocery shoppers, and who do not necessarily shop during weekends. Despite this, determining to what extent accessibility exists from these non-residence anchor points allows researchers to reconceptualize the impact of the food environment.

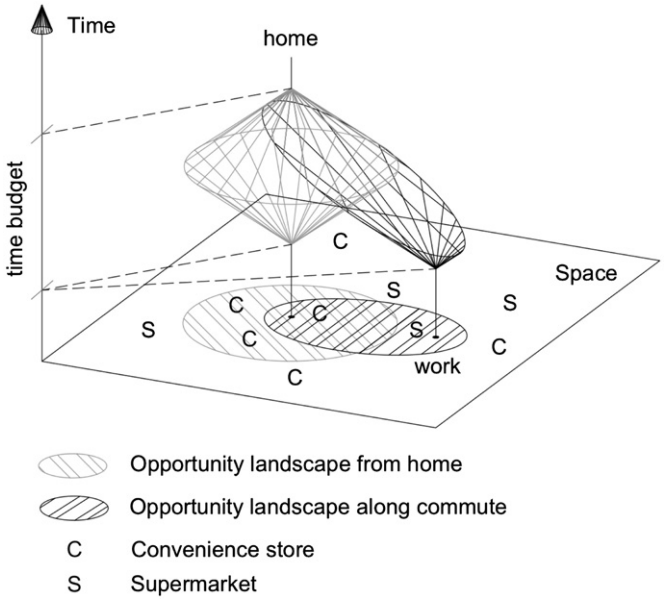

Fig. 1. Example of how routine movements may expand a household's access to healthy food.