Rethinking Food Deserts Using Mixed-Methods GIS

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Abstract

Food deserts—low-income neighborhoods with poor access to affordable, healthy food—have increasingly been seen as a driver of obesity and related health conditions in urban neighborhoods. Most current research uses an approach based on a Geographic Information System, or GIS, to identify food deserts using store locations, but data that link food environments to health outcomes have been inconsistent. This article outlines an alternative methodology that shifts from the proximity *of healthy food stores to the food-provisioning* practices *of neighborhood residents. Using a mixed-methods approach, this research relies on several data sources: (1) geographic tracking on daily mobility created using Global Positioning System, or GPS, software on a smartphone, (2) georeferenced photographs also created using smartphones, (3) food-shopping diaries and store receipts, and (4) semistructured qualitative interviews. The resulting analysis identified how factors ranging from perceived neighborhood disorder to available transit options shape decisions about how and where to get food. By more explicitly focusing on the food-provisioning strategies of low-income households and the factors that shape them, this research suggests potential pathways toward healthier, more livable cities.*

Introduction

British researchers first popularized the term *food desert* in the mid-1990s (Cummins and Macintyre, 1999; Wrigley, 2002). Since that time, it has become an increasingly common way to refer to neighborhoods where nutritious foods—most often defined as fresh produce and meats—are unavailable, of poor quality, or overly expensive. In the United States, several policy initiatives have been based on this research. Pennsylvania's Fresh Food Financing Initiative, which began in 2004, was one major response to this research, providing grants and loans to improve food-related infrastructure in areas with low food access (Pennsylvania Fresh Food Financing Initiative, 2014). Many of these funds were used to expand or create new supermarkets. President Barack Obama expanded this model at the federal level by creating the Healthy Food Financing Initiative (HHS,

2010). Along with the creation of these federal and state programs, several U.S. cities have created initiatives to improve food access in low-income neighborhoods, including the creation of a food policy task force by the U.S. Conference of Mayors (Boston Mayor's Office, 2012).

Current research on food deserts primarily makes use of an approach based on Geographic Information Systems (GIS)-based analysis that relies on the proximity of supermarkets to residential areas (Black, Moon, and Baird, 2014; Caspi et al., 2012). This methodology is conceptually clear and relatively easy to implement. It requires census data and a listing of major food retailers, both widely available, in addition to data on health outcomes such as body mass index, or BMI, or reported food consumption. Recent research shows little or no association between food deserts and these health outcomes, however, which puts into question the efficacy of this spatial analytical approach (Cummins, Flint, and Matthews, 2014; Lee, 2012).

This article describes an alternative methodology, one that moves from measures of food *proximity* to the food-provisioning *practices* of urban residents. This mixed-methods study combines Global Positioning System (GPS) data on daily mobility, food-shopping diaries, georeferenced photos, and semistructured qualitative interviews. It identifies the role of other major factors affecting food access, including perceived neighborhood disorder and store quality, the role of social networks, and the effect of available transit options. In contrast to approaches that privilege only objective analysis of geospatial data, this method is also more explicitly participatory, including the voices and perspectives of urban residents. It thus provides a useful lens on the daily food provisioning of urban households and the factors that shape them.

Measuring Food Access

Early research on food deserts mostly used market-basket studies, comparing the availability and price of goods across store types and neighborhoods (Block and Kouba, 2007; Cummins and Macintyre, 2002; Hendrickson, Smith, and Eikenberry, 2006). This research often documented discrepancies in food price and quality between lower and middle-to-upper-class neighborhoods. This labor- and time-intensive research limits analysis, however, because it usually assesses only a small number of neighborhoods. As a result, spatial analysis of food-store distribution across urban areas has become increasingly common (Apparicio, Cloutier, and Shearmur, 2007; Zenk, et al., 2005). In this approach, proximity to healthy food sources—most often supermarkets—is combined with measures of social deprivation, such as poverty level, racial composition, and/or vehicle access. The U.S. Department of Agriculture's (USDA's) own Food Access Research Atlas is arguably the most widely used example of this approach (USDA Economic Research Service, 2014). This online tool[1] provides an interactive national map showing the locations of all low-access, low-income census tracts, which are defined using only two variables: poverty level and distance to the nearest supermarket.

Spatial analytical approaches enjoy wide usage and reflect increasingly common use of geospatial data in "smart city" approaches to urban governance (Townsend, 2013). The relationship between neighborhood store environment and health and dietary outcomes is a tenuous one, however (Caspi et al., 2012). Some studies have shown that distance from place of residence to food stores

[1] http://www.ers.usda.gov/data-products/food-access-research-atlas.aspx.

is associated with food consumption habits (Gustafson et al., 2013; Hutchinson et al., 2012). Several studies have found little or no link between the two characteristics (Boone-Heinonen et al., 2011; Lee, 2012). One recent well-publicized study examined changes in residents' eating habits in a neighborhood targeted by the Pennsylvania Fresh Food Financing Initiative. Although residents were aware of their new neighborhood supermarket, their shopping and eating habits did not change significantly as a result (Cummins, Flint, and Matthews, 2014).

The inconsistency of these results questions the reliability of distance-based measures that rely on place of residence as a sole predictor of food-provisioning and consumption habits. Indeed, other studies have shown how distance is only one factor shaping food provisioning. In the late 1990s, USDA-sponsored research found that the supermarkets that food stamp clients used were more than twice as far from home as the closest supermarket (USDA Economic Research Service, 2009). Subsequent research has also demonstrated that low-income households often purchase food from stores outside their home neighborhoods (Clifton, 2004; Ledoux and Vojnovic, 2012; Shannon, 2014). Aside from distance, numerous other factors shape decisions about how and where to get food, including cultural preferences, perceptions of neighborhood safety, and store quality (Latham, 2003; Sampson, 2012; Zenk et al., 2011). By developing data sources that illustrate how individuals make use of urban food systems, rather than simply mapping the locations where food is available, research on food access can better identify neighborhood- and metropolitan-level factors that shape the ways residents procure food. The research outlined in this article provides a model of one such approach.

Critical GIS and Mixed-Methods Research

Several studies provide models for how to incorporate daily practices into geospatial analysis, many of them falling under the broad heading of critical GIS (O'Sullivan, 2006; Sheppard, 2005). Kwan (2008), for example, used travel logs and interviews with Muslim women soon after the terrorist attacks on September 11, 2001, to map how formerly routine daily trips to school and work became significantly shortened and filled with anxiety. Both Rogalsky (2010) and Matthews, Detwiler, and Burton (2005) used tracking and interview data to map the daily trips of welfare clients, showing how family commitments, shopping needs, and institutional demands meant regular long-distance trips, often using public transit, at a significant cost in both time and money. Knigge and Cope (2006) used grounded visualization, combining analysis of demographic data and participant observation within neighborhoods, to analyze the political battles over vacant lot space in Buffalo, New York. Critical GIS research is often more participatory in nature, prioritizing situated accounts over a supposedly objective and expansive analytical view (Pavlovskaya and St. Martin, 2007).

One primary contribution of critical GIS has been its mixed-methods approach. While some of these projects repurposed geospatial technologies for qualitative research (Cope and Elwood, 2009), others combined both quantitative and qualitative components in ways that preserve their respective strengths—breadth of view and analytical clarity in the case of quantitative work and the interpretative richness and nuance of qualitative approaches. Here, the use of mixed-methods provides a complex view of a world that is always just beyond our epistemological grasp (Elwood, 2009; Nightingale, 2003). Drawing on this work and combining quantitative and qualitative data on food-provisioning practices in complementary ways, the methodology described in the remainder of this article provides a richer understanding of the factors shaping food access at the household and neighborhood levels.

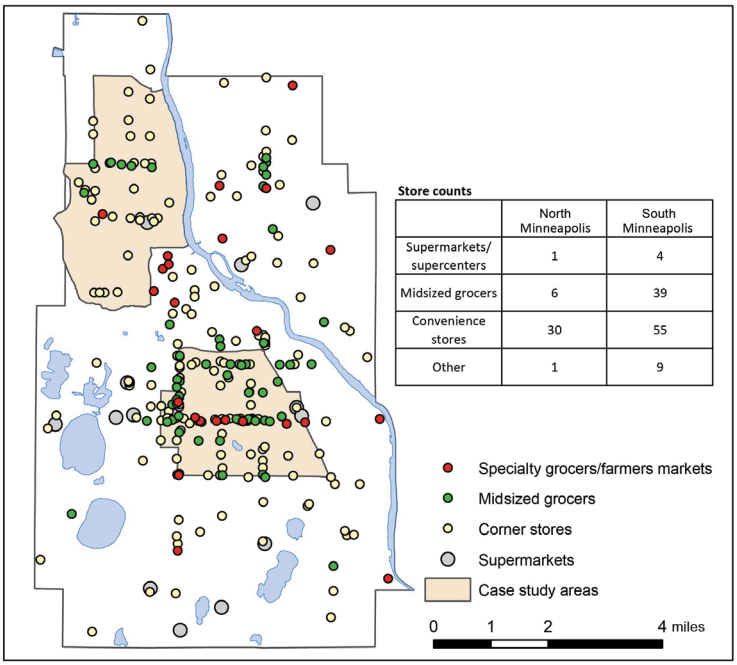
Study Context and Sampling

This research project, conducted in the Twin Cities (Minneapolis/St. Paul), Minnesota, was composed of two main sections. The first section used dasymetric mapping to analyze ZIP Code-level data on the Supplemental Nutrition Assistance Program (SNAP, formerly known as food stamps). I drew on these data to create disaggregated estimates of both client locations and benefit redemptions at SNAP-accepting retailers in neighborhoods with the highest concentration of SNAP clients. Two main findings emerged from this analysis. First, even in neighborhoods with a supermarket, a net "outflow" of SNAP dollars was evident, meaning that clients often traveled out of these areas to use program benefits. Second, midsized grocers (for example, discounters, ethnic retailers) accounted for a much larger proportion of benefit redemptions (31 percent of the total) within these neighborhoods than they did outside them (4 percent). More information on this section of this research is available in a related publication (Shannon, 2014).

The second section, which this article details, used case studies in two low-income neighborhoods in Minneapolis, using data on daily mobility, photographs of foods and stores used by study participants, and semistructured interviews. These two neighborhoods, north and south Minneapolis (exhibit 1), shared a high density of SNAP clients but differed demographically in significant ways (exhibit 2). North Minneapolis residents are largely White or African-American, with a smaller population of immigrant Hmong families from Southeast Asia. South Minneapolis also has

Exhibit 1

Case Study Neighborhoods and SNAP Food Retailer Locations, Minneapolis, Minnesota



SNAP = Supplemental Nutrition Assistance Program.

Exhibit 2

Study Area and Participant Demographics

	North Minneapolis	South Minneapolis	Twin Cities
Twin Cities demographics			
Population	44,535	59,874	3,318,486
Median age	28	29	36
Median household income ($)	32,730	32,524	79,922
Percent White	24	41	81
Percent African-American	50	26	7
Percent Asian American	14	3	6
Percent Hispanic	8	31	5
Percent with diploma	76	74	93
Percent with college degree	17	28	39
Percent SNAP households	34	24	8
Percent households with a car	76	71	92
Case study participants (N = 38)			
Total participants	18	20	
Median age	46	43	
Median household income ($)	15,684	11,400	
White	6 (33%)	8 (40%)	
African-American	8 (45%)	5 (25%)	
Hmong	4 (22%)	NA	
Hispanic	NA	7 (35%)	
High school diploma	15 (83%)	18 (90%)	
College degree	7 (39%)	6 (30%)	
SNAP recipients	12 (67%)	12 (60%)	
Access to a vehicle	9 (50%)	12 (60%)	
Male	5 (28%)	10 (50%)	
Female	13 (72%)	10 (50%)	

NA = data not available. SNAP = Supplemental Nutrition Assistance Program.
Sources: 2010 census; 2007–2011 American Community Survey

large White and African-American populations, along with immigrant households from South and Central America and East Africa. At the time of the study, south Minneapolis also had six times as many midsized to large food retailers (43 versus 7) as north Minneapolis. Although these two neighborhoods provided contrasting cultural and commercial landscapes, they shared high levels of economic hardship.

I used a quota sampling method in each neighborhood, recruiting roughly equal numbers of White, African-American, and immigrant populations (Hispanic populations in south Minneapolis and Hmong populations in north Minneapolis). A summary of study participants (N = 38) is provided in exhibit 2. These participants were recruited primarily through posting flyers in public spaces (for example, libraries, sign posts, neighborhood centers) along with advertisements on the online classified system Craigslist. In a few cases, participants heard of the study through word of mouth. Participants received a gift card in return for their completion in the study.

Study Methods

My study methods collected three broad forms of data from participants: (1) GPS tracks of daily mobility, (2) written and photographic diaries of food procurement, and (3) semistructured interviews about their activities during the 5-day study period. This length of time (2 weekend days and 3 weekdays) provided enough food-related trips for productive interview conversations without making the interviews overly burdensome. Many participants described their food shopping as a monthly pattern oriented around receipt of SNAP benefits, so while I considered study periods of up to 2 weeks, even these might not have been a fully representative sample. To investigate other possible food sources, I asked participants to describe any other food sources they used regularly and their reasons for doing so.

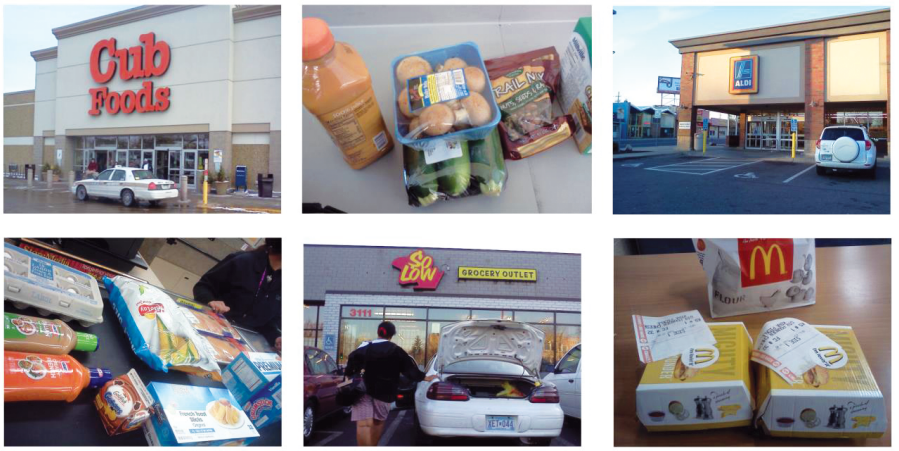
Study participants used Android smartphones to collect data on daily mobility and to take photographs of their food and food sources. The phone I chose, the LG Optimus T, had already been on the market for more than a year, reducing its price, but it had the needed hardware specifications. I registered these phones on a daily use plan with a major U.S. provider, meaning that a small fee was charged only on days the phones were in operation and that the phones would have unlimited service on those days.

The main function of these phones was collecting GPS data on daily mobility. It was difficult to find a suitable GPS-tracking application for Android. I used three applications during the course of the study, because my first choice was discontinued 1 month into the trial and the second option was unstable on the project phones. The final solution was FollowMee (https://www.followmee.com), a third party application that proved to be the most reliable and that provided data in a spreadsheet format easily transferred into GIS software. I set the application to record locations every 5 minutes, which allowed the phones to last a day on a single charge. This approach provided sufficient data to identify the general neighborhoods where individuals spent their time. Although GPS trackers provide greater temporal and spatial accuracy than phones, they add expense and require study participants to carry an additional device. The additional accuracy was also not necessary in this case. To protect privacy, I added noise to these GPS data, random numbers for both latitude and longitude that fell within a range of +/-167 meters (0.0015 decimal degrees). Visual tests showed that this approach made determining the location of home or workplaces significantly more difficult. I shared maps that demonstrate this additional uncertainty with participants in discussions of study risk before enrollment. For my final interviews for participants, I created and discussed a map of each participant's daily trips, using these data (see discussion in the following section).

Participants also used these smartphones to take pictures of food sources they used and the foods they procured during the study period. These images provided a ground-level view of these sites and created a visual link between food sources and the varieties of foods people purchased and gathered. Participants' food sources included workplace kitchens and friends' homes, along with supermarkets and restaurants (exhibit 3). Each phone automatically synced photos to an online storage service, enabling me to check the quality of images during the study period. Because smartphones automatically georeference photos, these photos could be placed on a map using software such as Google Earth. Although most participants had no trouble using the phone's camera, images did sometimes suffer from poor quality, primarily blurriness or low light for outside shots.

Exhibit 3

Participants' Photos of Food Sources and Purchased Foods



In addition to taking photographs, participants kept a written record of any food source used during the study period. This record included a shopping diary that listed store names and locations; information about when, how, and with whom they visited the stores; and how much money they spent. Although participants also had the option of using their smartphone to complete these diary records via an online form, all but one participant preferred the paper version. Participants also saved receipts from any food purchase made during the study period. The receipts verified store locations. Except in the case of sit-down and fast-food restaurants, the receipts were coded based on type of food purchased (for example, dairy, meats, dry goods, and produce). This approach provided detailed data for analyzing food-shopping patterns; I could summarize trip characteristics based on which products were purchased to determine food-shopping patterns.

Two interviews framed participation in the study. An initial interview, which lasted 20 to 30 minutes, included collecting participants' background information and providing them instructions for their role in the study. A second semistructured interview after the study period lasted 40 to 75 minutes. This interview had three sections. First, we examined the map of GPS data, and participants identified the main locations where they had spent time, talking about their daily routines. Second, participants described each food source they used, talking about their reasons for using the place and their impressions of it. Third, we spoke more generally about other food sources they did or did not use on an ongoing basis and the ways they thought their food options could be improved.[2] These interviews provided essential insights into factors shaping how and where these participants got food. For example, one woman traveled far across town to go grocery shopping rather than use the supermarket in her neighborhood, largely because of her limited walking ability and the direct bus route to this preferred store. Another woman gathered a group of friends for an early morning trip to a suburban Wal-Mart store to take advantage of their once-a-week meat specials. The details of these trips would have been difficult to discern using only GPS data.

[2] A full version of this interview protocol is available at https://www.scribd.com/doc/257040526/Closing-Interview-Schedule.

In keeping with previous research using active-interviewing strategies, the goal of both interviews was to develop a shared understanding of the factors shaping participants' food-provisioning strategies (Holstein and Gubrium, 1995). Indeed, when I asked participants for their thoughts about the study, the most common response by far was how much they had learned about their own food-provisioning habits through their participation. These interviews were coded inductively using the qualitative software NVivo. Codes were based on my research questions, including themes such as perceptions of distance, store quality, and quality of foods within different store types.

After an initial analysis of these data, I invited participants to a followup focus group in which they could respond to my initial conclusions. One focus group was held for each study area, and participants were offered a free meal for their participation. My initial results largely focused on the notable variety of stores participants used and the high number of trips they made to stores outside their neighborhoods. To me, these results demonstrated a significant degree of individual mobility, a finding that ran counter to existing research that focused only on the neighborhood environment. Participants pushed back against this interpretation, however, particularly in the north Minneapolis group. To them, their shopping patterns were direct effects of the high prices and low quality of foods in their local stores. Comparing their neighborhood stores to suburban locations, where prices and quality both were more favorable, several wanted to know how my research would improve what they saw as a clear injustice. These focus groups shaped my subsequent reporting on this research, which ultimately focused on the need to situate research and policy on food access within a broader framework of neighborhood disorder and segregation and on the need to strengthen transit systems.

Lessons Learned and Recommendations

GIS-based approaches to studying food accessibility document significant disparities in the food sources available to urban residents. Relying on measures of spatial proximity, however, fails to incorporate other important factors that shape food provisioning, including perceptions of the neighborhood environment and local stores and the resident's daily mobility. The alternative approach used in this study addresses this issue by using GIS as part of a mixed-methods approach. GIS and qualitative techniques were complementary in this case. GPS data on daily mobility and shopping diaries provided a full picture of participants' activities during the study period, providing ways to assess their daily activity space and visualize their food provisioning. Interviews and photographs contextualized this mobility, providing an "on the ground" perspective of the food sources participants used and their reasons for doing so.

Smartphones were a key technology in the study. They combined GPS tracking with the ability to take georeferenced photographs, both of which could be monitored in real time by syncing data through the phone's data plan to ensure I was aware of any ongoing technical problems. The phones could also be used to collect food-shopping diary entries from study participants, although only one participant did so in this case. Phones had sporadic technical problems. Finding reliable software to collect GPS data was one obstacle. Future research using this approach should confirm the availability of suitable software or consider budgeting for the development of a custom application. The inclusion of photographs in this study was useful, but many photographs were unfortunately of low quality (were blurry or had poor lighting). Phones with better cameras may have

improved image quality through technologies like image stabilization. This project did not explicitly use the photo-voice method (Belon et al., 2014; Mahmood et al., 2012), but providing more instruction on how to use the cameras and encouraging participants to capture defining features of each food source would have borrowed elements of this approach that may have improved photo quality and usefulness.

The analysis of food environments is only one aspect of increasing reliance on spatial analytics in "smart city" initiatives (Townsend, 2013). This data-based approach to urban governance provides valuable insight on how policy initiatives can alter patterns of everyday life. As even this small-scale study suggests, however, the idea that a reliance on robust quantitative indicators produces a theory-free form of governance is fundamentally problematic (Anderson, 2008). The qualitative data developed in this project were essential to interpretation of both shopping diaries and GPS data. Through study interviews and focus groups, participants and I developed a shared understanding of the factors that shaped their food-provisioning behavior. The situated perspectives of neighborhood residents, not just their data, were needed (Haraway, 1988; Pavlovskaya and St. Martin, 2007). This mixed-methods approach thus provides one model for a participatory geospatial analysis of food access.

The growth of mobile GIS applications provides new opportunities for representing and understanding the everyday practices that form the rhythm of urban life. Future research can leverage this technology by exploring not just where food is, but where, how, and why urban residents draw on available food sources. This approach might use a smartphone application that city governments or nonprofit groups would custom design for their research. Targeted case studies in selected neighborhoods, similar to this project, might also prove useful. This small-scale study also generates broader research possibilities, such as analysis of existing transit data or citywide surveys of perceived store quality and neighborhood safety. Using this mix of methodologies to understand the everyday experiences of urban residents can thus suggest pathways to healthier, more livable cities.

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