EXAMINING LOCAL FOOD ENVIRONMENT FOR SNAP-ED PARTICIPANTS IN FULTON AND CLARKE COUNTIES, GEORGIA

by

WUYANG CAI

(Under the Direction of Xiaobai Yao)

ABSTRACT

In 2014, nearly 2 million Georgia residents, including about 500,000 children, lived in food deserts. And nearly 19% of Georgians suffered from food insecurity (Feeding America, 2014). The Supplemental Nutrition Assistance Program (SNAP), is a federally-funded program that provides monthly benefits to low-income households to help pay for the cost of food. SNAP is offering education program (SNAP-Ed) to help people make better dietary decisions with limited benefits. This study analyzes food environments in the study area by accessing the association between neighborhood deprivation and access to food stores for SNAP-Ed households in 2007 and 2014. The food accessibility was measured by two methods: proximity and density, both of which have experienced change over time. These data suggest that food environment changed over short periods of time. Findings show that high level of neighborhood deprivation was found to be associated with better accessibility to supermarkets and warehouses. In contrast, the change of neighborhood deprivation index was a more influential determinant in accessibility to discount store, convenience store, specialty store and meat stores.

INDEX WORDS: Food environment; Neighborhood deprivation; Food accessibility

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CHAPTER 1

INTRODUCTION

Household food insecurity is defined by Coleman-Jensen et al. (2012) as the "perception of households' access to adequate food is limited by a lack of money and other resources." In 2014, 19% Georgians were food insecure, meaning they cannot afford to buy healthy food on a regular basis (Feeding America, 2014). When it comes to making nutritional foods accessible to all Georgians, food insecurity is only part of the problem. In 2014, nearly 2 million Georgia residents live in food deserts, including 500,000 children (Feeding America, 2014). Food deserts are defined by the U.S. Department of Agriculture as low-income communities with low access to a reliable source of fresh vegetables, fruits and other healthy foods (USDA, 2016).

To counter these problems of food deserts and food insecurity, nutrition education programs like SNAP Nutrition Education (SNAP-Ed) can help households maximize use of food stamps to buy healthy foods by teaching them economic self-sufficiency (Holben, 2010) and offering recommendations for dietary modifications. An effective SNAP-Ed program intervention teaches household resource management skills, and when coupled with SNAP food assistance, can help reduce food insecurity and increase purchases of healthful foods. However, public spending in SNAP, which reached its highest levels in 2013 ($79.9 billion) was reduced by $5 billion in both 2014 and 2015 (USDA, accessed 2016). As food insecurity and food deserts are at high level of incidence rate, alternative policy options may be devised that focus on the supply-side of the issue, that is, facilitating households' ability to obtain food through improvements of the food environment they are exposed to (Bonanno et al., 2014).

Historically, much of the research on food environment has focused on the relationship between neighborhood deprivation and the geographic access to food stores. In the United States, low-income and racial/ethnic minority communities often have more poorer access to grocery stores and a higher concentration of fast food and convenience store outlets (Dubowitz, et al., 2008; Creel, et al., 2008; Young, Zenk, and Mason, 2009). Findings from studies suggest that poor food access is significantly correlated with deprivation in socioeconomic status (SES) in multiple regions (Morland et al. 2002; Glanz et al. 2007; Hemphill et al., 2008; Walker et al., 2010). Although the relationship between neighborhood deprivation and the geographic access to food stores has received some attention, previous studies have often relied on definitions of neighborhoods predefined as administrative areas (Pearce et al., 2007). For example, some studies (Zenk et al., 2005; Burns, and Inglis, 2007; Pearce et al., 2007) have examined distance to stores, but calculated distance from a geographical "centroid" rather than from residents' actual home address. Among these studies, many of them have problems related to the use of aggregate data. According to Robinson's line of argument (1950), any assumption about an individual deduced from a group to which the individual belongs may result in an assessment error known as "ecological fallacy" (Portnov et al., 2007). One purpose of this research, then, is to uncover deficiencies seen in studies on food accessibility caused by ecological fallacy and improve the methods used to characterize food accessibility by calculating accessibility from participants' home address.

An additional factor that fuels the food environment problem is the nature of changed environment over time. There is evidence that access to supermarkets in low-income urban areas has declined over time (Larsen et al., 2008). Researchers in the U.S. and other developed countries are becoming more interested in the role of socioeconomic factors in temporal declines

in healthy food environments (Burgoine et al., 2009; Pearce and Day, 2010; Filomena et al., 2013). But findings are mixed and studies examining temporal patterns in food environments are sparse (Mackenbach et al., 2014). In particular, a major gap in the literature limit our understanding of inequities in the food environment, that is, do patterns of change in the neighborhood Socioeconomic status environment also reflect changes in exposure to different types of food resources (Richardson, et al., 2014) ? Understanding the relationship between these two longitudinal neighborhood exposures may shed insight on how to modify food environments for socioeconomically disadvantaged populations.

The purpose of this study is to examine the influence of neighborhood deprivation and food accessibility on food environments by investigating two research questions: 1) Was neighborhood deprivation associated with the accessibility of food stores in Fulton and Clarke Counties, GA? 2) Was the change of these two variables associated over time in Fulton and Clarke Counties, GA?

CHAPTER 2

LITERATURE REVIEW

The term "food desert" has been widely used to describe areas where low-income residents do not have access to healthy and affordable food and fast food restaurants dominate the landscape (Mari Gallagher Research and Consulting Group 2006; Beaulac et al. 2009). In 2014, nearly 2 million Georgia residents, including about 500,000 children, lived in food deserts (Feeding America, 2014). And besides food deserts, food insecurity is another statewide issue. According to Feeding America (2014), nearly 19% of Georgians suffered from food insecurity in 2014, which means that even if they live near a grocery store they still cannot afford to buy food. Most recent food desert research has studied on food access by analyzing the distance to and density of food stores (Leal and Chaix, 2011). The results have often been combined with social deprivation to identify vulnerable populations at risk from poor food access (Zenk et al., 2005; Apparicio et al., 2007; Larsen and Gilliland, 2008; Shannon, 2014). Research has demonstrated that access to healthy foods in urban areas is limited by factors such as poverty and race (Galvez et al., 2007; USDA 2013a). Specifically, studies have indicated better access to supermarkets and the a wider variety of healthy foods in higher income areas, while a greater density of convenience stores and smaller grocery stores are found in more socially disadvantaged areas (Morland et al,. 2002; Moore and Diez Roux, 2006; Kelly et al., 2011). Furthermore, current research shows a lower prevalence of supermarkets and a higher prevalence of independently owned grocery stores in low-income and predominately black neighborhoods and a greater

proportion of households without individual vehicles in these neighborhoods (Morland et al. 2002).

Having known the current situation, one question we might ask is, "Is there any governmental support for these groups of people who are suffering from food desert and/or food insecurity?" The answer is "Yes." The Food Stamp program, formally known as the Supplemental Nutrition Assistance Program (SNAP), is a federally-funded program that provides monthly benefits to low-income households to help pay for the cost of food(Food and Nutrition Service, 2015). SNAP participants can use their Electronic Benefit Transfer (EBT) card to purchase anything in a grocery store except alcohol, prepared foods, and nonfood items (Food and Nutrition Service, 2015). To counter the problem of food insecurity and food deserts, nutrition education like SNAP Nutrition Education (SNAP-Ed) can help participants maximize use of food stamps to buy healthy foods by teaching individual and household economic self-sufficiency (Holben, 2010). While total public spending as well as average benefit per person in SNAP, which reached their highest levels in 2013 were reduced in both 2014 and 2015 (USDA, accessed 2016). Besides seeking help from these federal nutrition assistance programs like SNAP, it is important to facilitate households' ability to obtain food through improvements of the food environment they are exposed to (Bonanno et al., 2014).

The local food environment was defined as "the number, type, location, and accessibility of food outlets" (Moore et al., 2008), which have been shown to be an independent predictor of individuals' food choice and diet quality in developed countries (Moore and Diez Roux, 2006; McKinnon et al., 2009). The previous studies frequently use density, or proximity, or both to measure food environments. For example, Moore and his colleagues (2008) examined the local food environment with the density of supermarkets within one mile of participant's home. They

found that participants with better access to supermarkets tended to have a healthier diet. Frank and his colleagues (2012) evaluated food environments based on the density of fast food restaurants within 0.5 mile and the distance to supermarkets from each block group. However, people live in a continuous world and individual's exposure to spaces cannot be limited arbitrarily by distance or boundaries (Mathews 2012). And it is hard to determine a best buffer distance to use with food store catchment areas because of various modes of transportation and urban settings. Different from previous research which used pre-defined administrative areas (Cummins et al., 2009; Anchondo et al., 2011; Gustafson et al., 2012; Mercille et al., 2013), these studies using the individual-level measure may get rid of the problems caused by aggregate data, whereby the aggregation and mapping of multiple individuals' food accessibility experiences is possible (Horner and Wood, 2014).

As a type of data source, survey has been conducted in much previous research and provided individual level data. Rose and Richards (2004) conducted a secondary data analysis using the 1996-1997 National Food Stamp Program Survey. Their findings showed that environmental factors are importantly related to dietary choice in a nationally representative sample of low-income households. Cross-sectional analysis of data obtained from the National Health and Nutrition Examination Survey was utilized by Bleich and colleagues (2013) indicating that there is little or no difference in sugar-sweetened beverages (SSBs) consumption patterns between two groups of people with different SNAP enrollment status. As in our study, a survey has been conducted by SNAP-Ed to collect household level data such as home address and demographic variables, helping us access a more accurate neighborhood food environment.

Few studies have measured neighborhood deprivation and food store accessibility at two time points simultaneously. Previous studies have investigated disparities in the types of food

stores located in neighborhoods. Many of these studies investigated differences by income level (Hendrickson et al., 2006; Sharkey et al., 2008) or racial characteristics (Rose et al., 2000; Zenk et al., 2005) and have used cross-sectional study designs (Burgoine et al., 2009). However, their findings may not consider possible instability in food environments. Understanding fluctuations in local food environments can be valuable to further understand how those environments influence the health behaviors of affected residents. If food retail environments are stable, with consistency in number, accessibility and types of food stores, this lends support for the assumption that residents are chronically exposed to the features of their food environments. However, if food environments are not stable, residents may need to adopt behaviors in order to adapt to the changes of the food environments. Additionally, if there are fluctuations in food environments, they may open opportunities for food policy to make a positive impact on community health (Burgoine et al., 2009). Thinking of the situation that many stores were not available for SNAP-Ed participants to go grocery shopping at one time point while available in another time point, it is of value to study the change of neighborhood food environment over time.

This study fills the gap in the literature by addressing the following research objectives: 1) to examine whether the association between changes of neighborhood deprivation and food accessibility over time was significant; 2) to evaluate how many households resided in a more walkable neighborhood and what characteristics of these households (considering neighborhood deprivation and food accessibility) were.

CHAPTER 3

DATA AND METHODOLOGY

3.1 Data

3.1.1 UGA SNAP-Ed Survey

The Supplemental Nutrition Assistance Program- Nutrition Education (SNAP-Ed) is funded by the USDA's Food and Nutrition Service and offered nationwide. In Georgia, SNAP-Ed is offered through the University of Georgia (UGA) and HealthMPowers, offering nutrition classes designed to help individuals make better food buying decisions. The goal of SNAP-Ed is to improve the likelihood that persons eligible for SNAP will make healthy food and lifestyle choices that prevent obesity.

Recently, a self-administered survey was conducted in a convenience sample of 823 adults participating in the SNAP-Ed in Fulton and Clarke, Georgia. Survey participants were asked for their home address and the name and location of their major food shopping store for street network distance measures. "Major food shopping store" was identified by asking, *What is the name and address of the store where you most often use for grocery shopping?* To ensure their privacy, stochastic variations between -0.015 and 0.015 decimal degrees were given to residences during the geocoding procedure within ArcGIS 10.2 (ESRI, Redlands, CA).

3.1.2 Study Areas

The study is carried out in Fulton and Clarke Counties, both located in Georgia (See Figure 1). Fulton County is a county located in the Piedmont section of Georgia. As of the 2013 census, the population was 984,293 (U.S. Census Bureau, Retrieved 2014), making it the most

populous county in Georgia. Its county seat is Atlanta, the state capital since 1868. Ninety percent of the City of Atlanta is within Fulton County. Fulton County is the principal county of the Atlanta metropolitan area. As for Clarke County, the population was 121,265 in 2013 (U.S. Census Bureau, Retrieved 2014). Its county seat is Athens, with which it is a consolidated city-county. There are 474 responses from Fulton and 349 from Clarke respectively in the UGA SNAP-Ed survey. While Fulton County is identified as a composite of central city and suburban areas, Clarke County also has some high density areas. However, the scales of these two counties are quite different, and with the hypothesis that residents in Fulton have better food store accessibility, I am interested in studying the local food environment of these two counties.

The county and tract boundary shapefile were downloaded from the U.S. Census Bureau website (U.S. Census Bureau, Retrieved 2014) and all other road network data were obtained from the University of Georgia Information Technology Outreach Services.

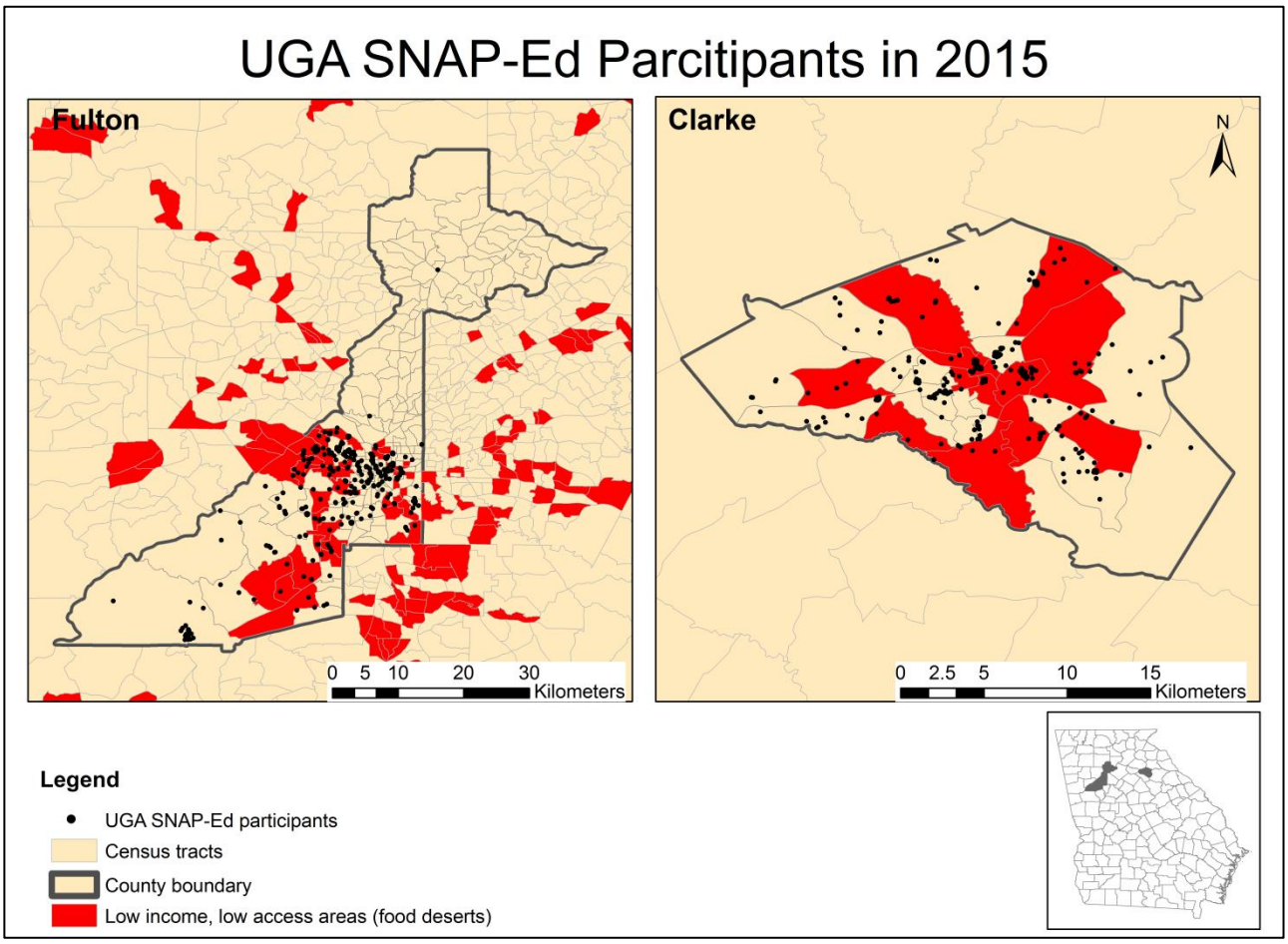


Figure 1. Study area and SNAP-Ed survey participants' residences

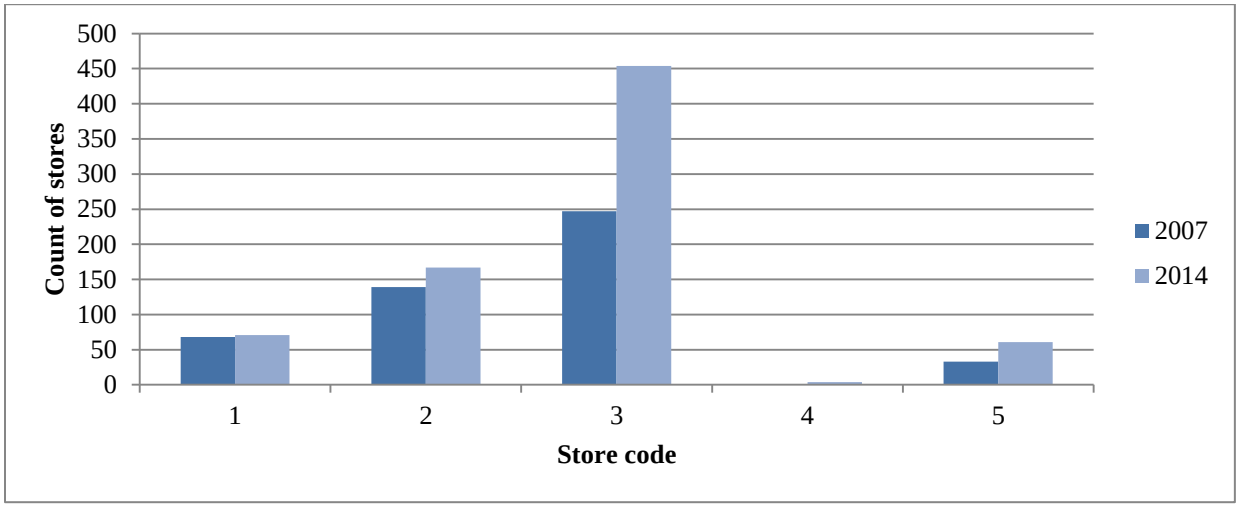
3.1.3 Food Retailers

The food retailers include retailers that have actively processed SNAP benefits. A list of 1,058 food retailers was developed from two national directories of retail food stores. One directory is from the commercial data provider InfoUSA (available at http://www.infousa.com). The other directory is from a list of authorized stores that accept SNAP benefits (available at http://www.snapretailerlocator.com). These two independent data sources were used to reduce inaccuracies in store operational status and store misclassification (Grimm et al., 2013). They were joined based on store name and location. Food retailers were categorized using the North American Industry Classification System (NAICS) provided by InfoUSA, which also contains information on store size. Once the InfoUSA and SNAP store listings were combined, stores

were classified into five categories based on NAICS code and store size: 1) big box retailers and major supermarkets; 2) groceries; 3) dollar/ discount stores, pharmacies/other retailers, and convenience/small food stores; 4) warehouses; 5) specialty markets and meat stores. Store code was assigned to each of the stores by the classification, and several of the stores were classified based on name when no matching InfoUSA record was located. Each food retailer was then tagged with its SNAP enrollment status in 2007 and 2014 and the year it was first recorded in InfoUSA database.

Figure 2 shows the number of five categories of stores in Fulton (Figure 2a) and Clarke Counties (Figure 2b). Stores of code 3 (dollar/discount stores, pharmacies/other retailers and convenience/small food stores) made up over 50% of total food stores in both counties in 2007 and 2014, while there were almost no warehouses in the list. Overall count of stores for the two counties shows an increasing trend from 2007 to 2014 except that of store code 5 (specialty markets and meat stores) in Clarke County. In this study, particular attention is paid to the spatial distribution of different categories of food stores, in order to gain a clearer picture of how residents' surrounding food environments are influenced by the proximity and density of food stores.

(a) Fulton County



(b) Clarke County

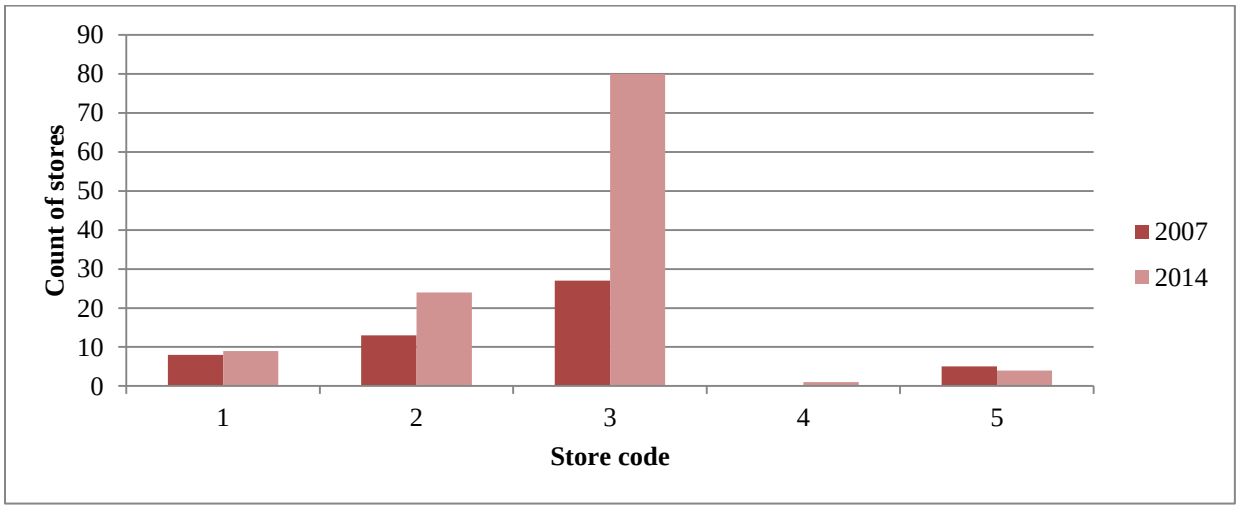


Figure 2. Count of food stores by store code in 2007 and 2014

In Figure 3 and Figure 4, the spatial distribution of SNAP-Ed participants' residences showed a clustering pattern in the central area in both two counties, food stores of code 4 are not presented because of the small volume (count of 0 in 2007 and less than 5 in 2014). General differences in the count of each type of food stores can be observed in Figure 3 and Figure 4,

with dollar stores and convenience stores exhibiting a very high proportion of the total amount, as opposed to warehouse's nonexistence in 2007. Since participants also go to buy food outside of the counties, all the food stores in the list are shown which I used in the procedure of calculating food store accessibility. It is notable that participants living in Fulton are surrounded by big box retailers and major supermarkets 10 times as much as those living in Clarke in 2007.

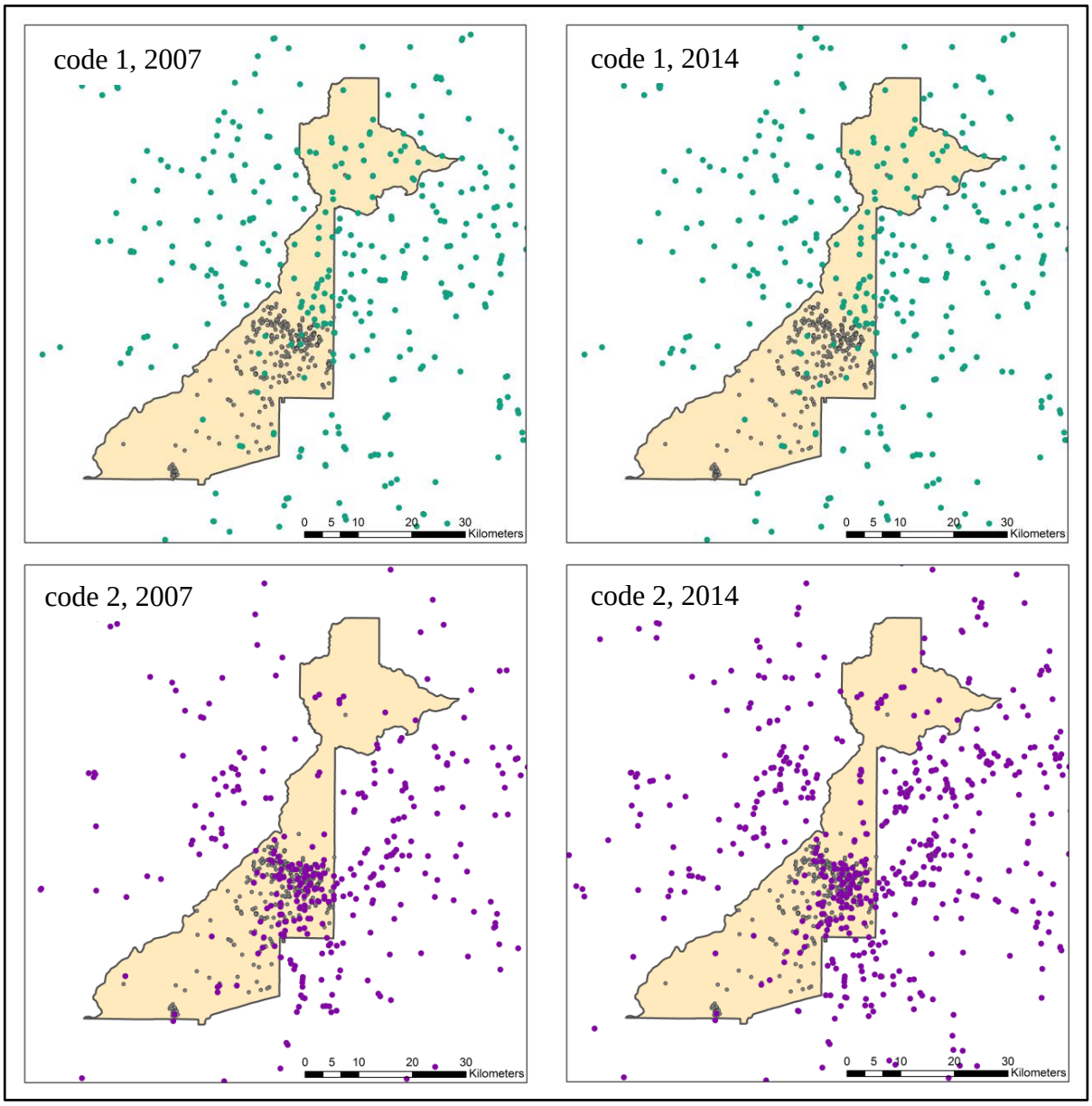


Figure 3. Food store locations in Fulton County

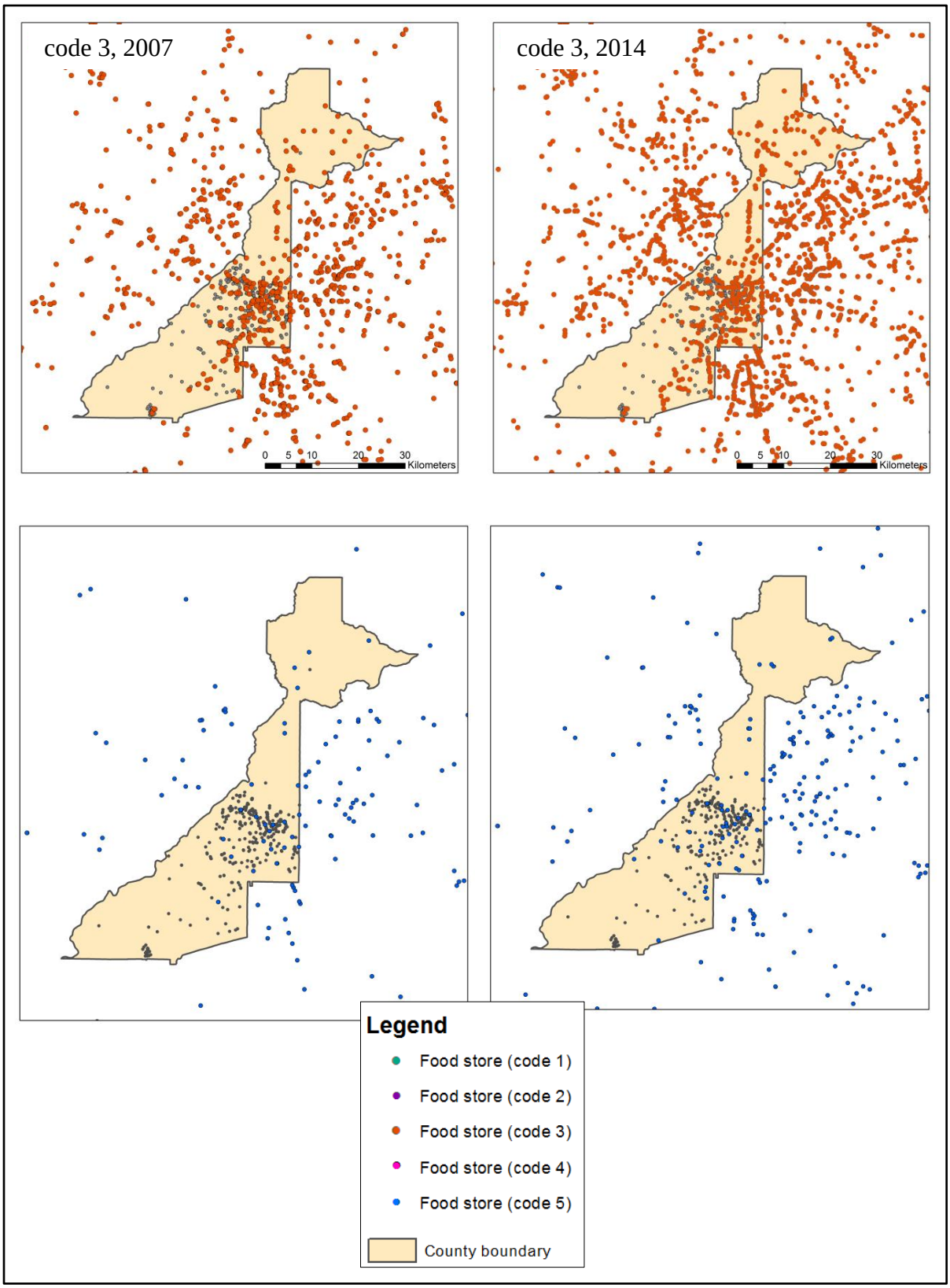


Figure 3. Food store locations in Fulton County (Cont.)

It is obvious that participants in Clarke County were surrounded by less count of food stores, which were located in the central part of the county where participants gathered.

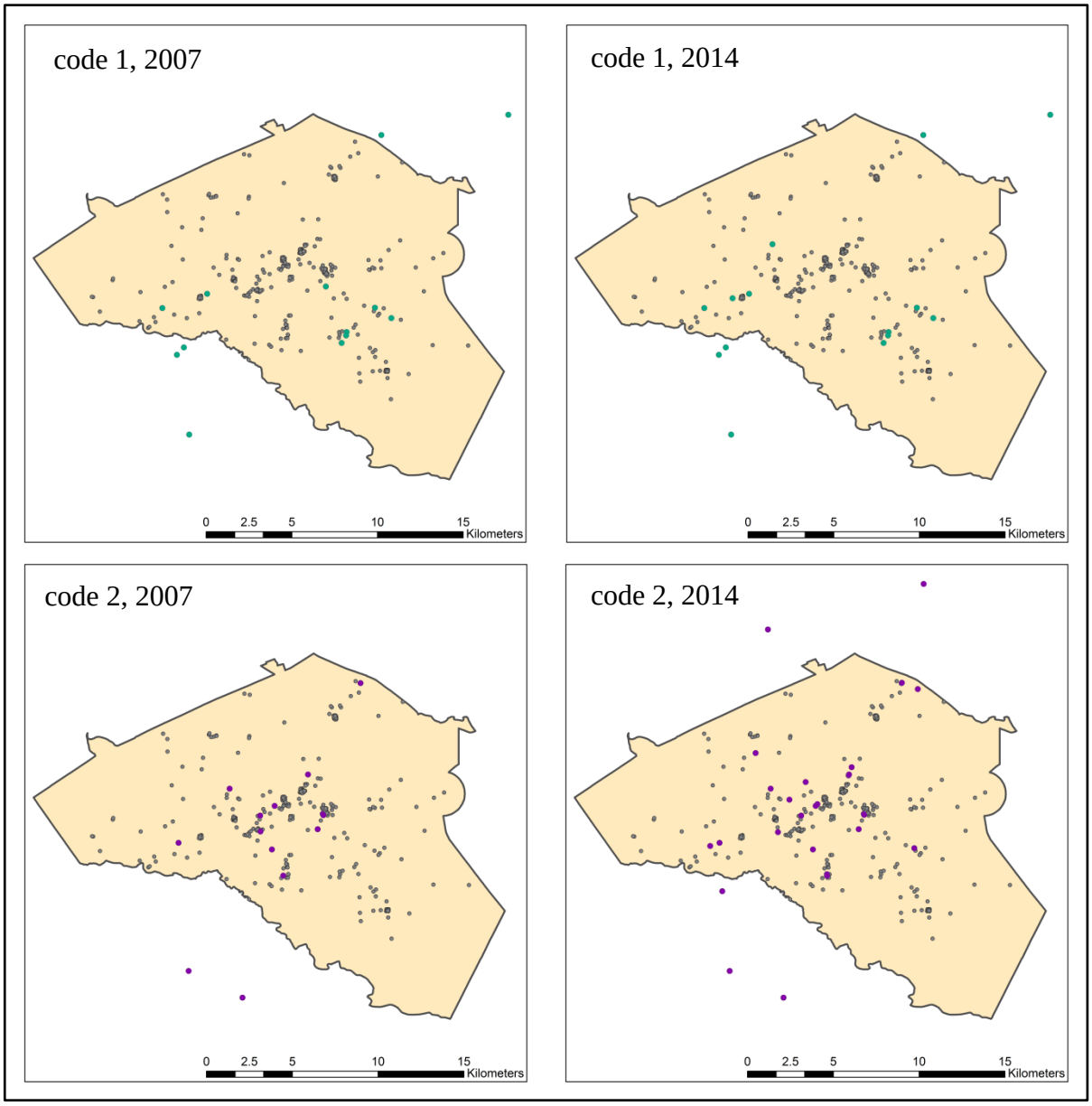


Figure 3. Food store locations in Clarke County

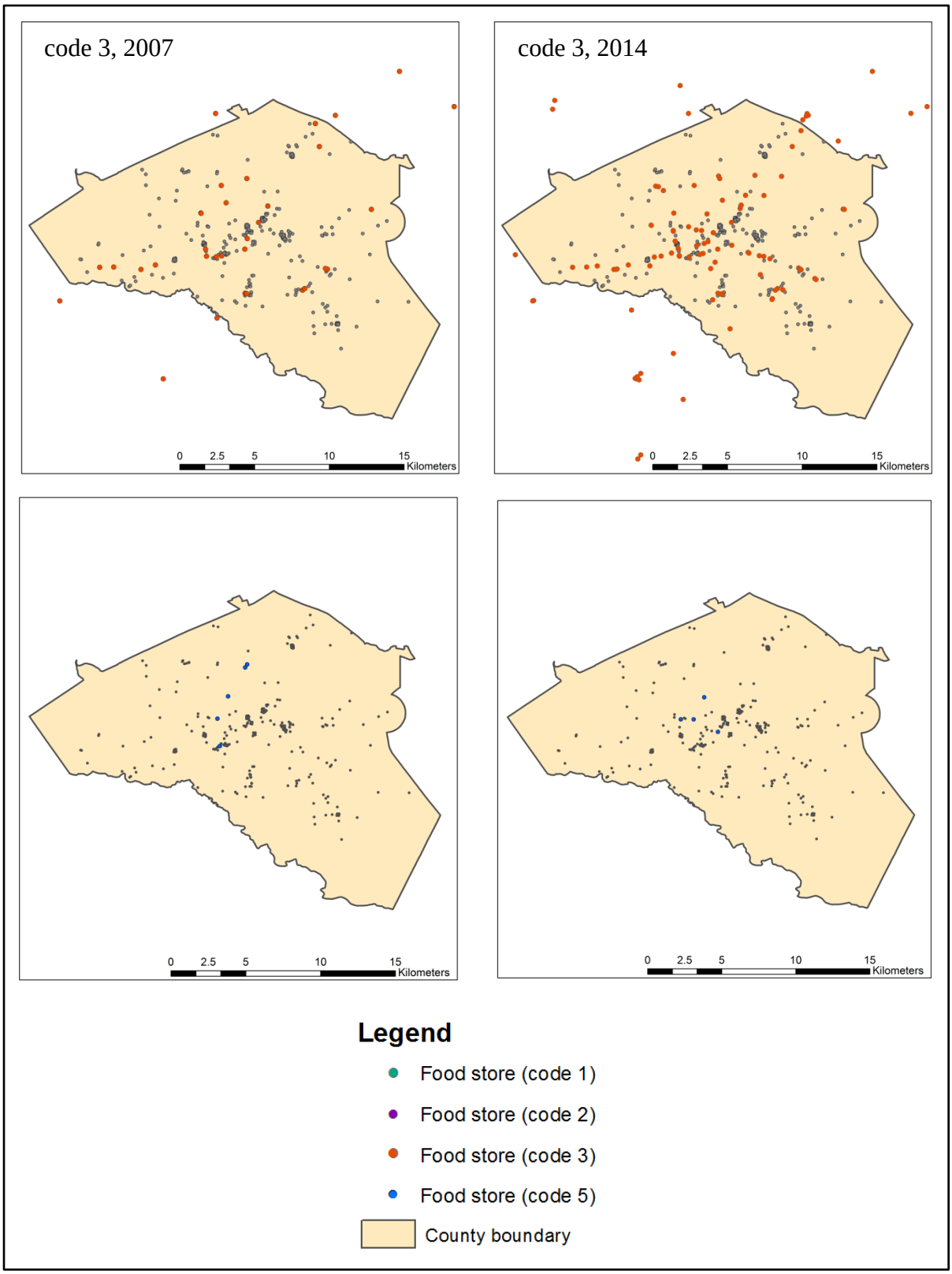


Figure 3. Food store locations in Clarke County (Cont.)

3.1.4 Census Data

"Neighborhoods" in our analysis are represented at the census tract (CT) level. There are 204 census tracts comprising Fulton County and 30 for Clarke County. As the food store data was derived from 2007 and 2014, to match with the food environments in both time points, American Community Survey (ACS) 2006- 2010 and 2010-2014 5-year estimate data were obtained through the United States Census Bureau (State and County Quickfacts, accessed 2016), both tabulated using 2010 census data. Variables of interest were total population, % Black, % households with no access to a vehicle, medium tract income, % unemployed, % population below 185 percent of poverty level and % families on food stamps. The reason why I chose these variables is explained in detail in Chapter 3.2.1. A database was then created with the census tract Federal Information Processing Standards (FIPS) codes as our ID indicator. Variable names and definitions are provided in Table 1, with summary statistics for all variables provided in Table 2.

Table 1. Census variable names and definitions

Variable Name	Variable Description
B	Percentage of Black
NV	Percentage of households with no access to a vehicle
P	Percentage of population below 185 percent of poverty level
F	Percentage of families on food stamps
UE	Percentage of unemployed
MI	medium tract income

3.2 Methodology

In consideration of the limitations of previous measurement methods, a first-difference estimator is utilized to generate changes over time. In order to calculate neighborhood deprivation index, I propose a Principal component analysis (PCA) method to personalize the computing of it to different census tracts. Then, food store accessibility is measured based on proximity and diversity provided by the surroundings. Practically, food stores are categorized into five types by their NAICS code and store size. Finally, statistical analyses are conducted to study the change over time between neighborhood deprivation index and food store accessibility. The method is implemented in three steps (shown in Figure 5):

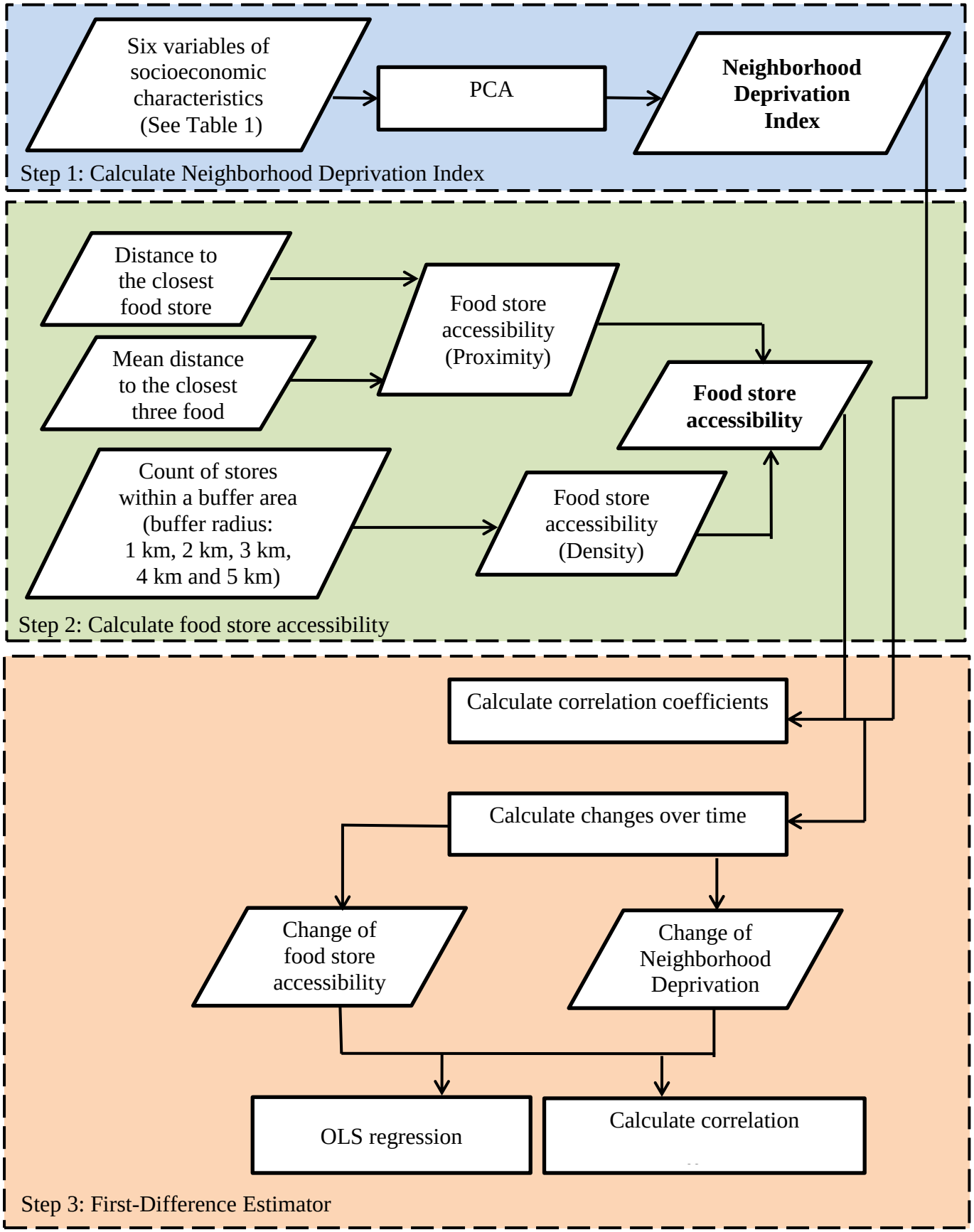


Figure 5. Flow diagram of methodology

3.2.1 Neighborhood Deprivation Index

Deprivation indices are common in public health research as they bring together a number of variables capturing a complex socioeconomic portrait (Grimm et al., 2013). Previous research has indicated that neighborhood deprivation is conceptualized as a composite of education, employment, housing, occupation, racial composition and poverty (Pickett et al., 2002; Ahem et al., 2003; Messer et al., 2006).

Socioeconomic data from the 2006-10 and 2010-14 ACS files are extracted to calculate neighborhood deprivation index following methods described by Messer and colleagues(Messer et al., 2006). They developed a neighborhood deprivation index that capitalized on U.S. census data. Using data from four socio-demographically diverse regions, he identified 20 variables that have been used consistently to approximate neighborhood-level environments for possible inclusion in the deprivation index, including variables reflecting education, employment, housing, occupation, poverty, racial composition and residential stability. The index they created has been proved to be fit diversely across geographic and socio-demographic features (Sharkey et al., 2008; Anchondo & Ford, 2011; Gustafson et al., 2012).

Considering the eligibility of SNAP-Ed participants and their potential socioeconomic characteristics, six variables were chosen to calculate the neighborhood deprivation index: (1) % Black; (2) % households with no access to a vehicle; (3) medium tract income; (4) % unemployed; (5) % population below 185 percent of poverty level; and (6) % families on food stamps. Similar indices have been used in previous work examining geographic access to food stores (Guy et al., 2004; Apparicio et al., 2007; Gustafson et al., 2012), which validated the relationship between these variables and neighborhood deprivation.

Principal component analysis (PCA) is a data reduction technique frequently used in neighborhood-level research to create socio-demographic scales or indices for inclusion in statistical models (Stafford et al., 2005; Wang and Luo, 2005; Messer et al., 2006). Since only 6 variables were chosen to create the neighborhood deprivation index, PCA was performed here to weight each variable's contribution to the final neighborhood deprivation index (Anchondo & Ford, 2011). Within RStudio, I applied a log transformation to the six continuous variables to standardize the variables prior to the application of PCA making the distributions more normally distributed. Using the loadings, which are the coefficients of the linear combinations of the six variables, I then calculated the neighborhood index for each census tract. Data from 2010 and 2014 were pooled together when doing this process so that I could compare the neighborhood deprivation index in these two time points.

3.2.2 Store Accessibility

The majority of food store locations were provided by USDA and the rest of them were geocoded in R using the Google API. Two different measures of accessibility are retained here: 1) distance to the closest food store and mean distance to the three closest food stores from residence, in order to evaluate immediate proximity; and 2) number of food stores within a walkable distance of less than 1km (approximately a 20-minute walk for an adult in an urban setting) from home address, in order to evaluate the diversity provided by the immediate surroundings (Apparicio et al., 2007). For both two of the measures, they were presented by 5 different categories of stores (coded by NAICS code and store size). A 1-km "radius" was measured as people actually travel, i.e. along a network of streets, rather than a straight-line, and was referred to as a network distance (Moore and Diez Roux, 2006). Additionally, a 2km area was identified to represent a reasonable walking distance and a wide range of food retail outlets

(store corner stores, supermarkets) (Donkin et al., 1999). However, for those who owe a vehicle or have access to public transportation, shopping trips may extend over longer distances. Individuals in the Multiethnic Study of Atherosclerosis (MESA) sample reported traveling a median distance of 5.6 km to shop for food (Auchincloss et al., 2008). As there is no clear guideline about the most appropriate radius for assessing the spatial availability of stores in exploratory analyses, I also investigated 2-, 3-, 4- and 5-km densities to see if the food environment changes a lot when people travel further.

3.2.3 Statistical and spatial analysis

Before doing statistical and spatial analysis, neighborhood deprivation index was imputed to each household for both 2007 and 2014. After identifying deprived areas and households with high and low levels of accessibility to food stores in the study area, I used an empirical approach to study the link between neighborhood's deprivation and food store accessibility at the household level. To explore this link with the 823 households in 2007 and 2014 respectively, I performed a Pearson correlation analysis to explore the statistical significance of the link between neighborhood deprivation and food store accessibility. Since there are two different measures for accessing food accessibility (proximity and density), the statistical and spatial analysis will be performed for both kinds of measures.

Having studied the correlation between neighborhood deprivation and food store accessibility in 2007 and 2014 respectively, we are also interested in describing the interaction between their changes over time. First-difference (FD) estimator was used here to estimate this. The first difference of a time series is the series of changes from one period to the next and the estimator is obtained by running a pooled OLS estimation for a regression (Jeffrey and Woodridge, 2001). It is an approach used to control for the unobserved or omitted variables

which might have affected neighborhood deprivation and food store accessibility from 2007 to 2014 which are unique to the study areas.

Equation (1) shows changes in food store accessibility (FA) are regressed on changes in the neighborhood deprivation index ($ND\ Index$) (Jeffrey and Woodridge, 2001):

$$\Delta FA = \beta_0 + \beta_1 \Delta ND\ Index + e \quad (2)$$

where β_1 is the effect of $ND\ Index$ on FA, "Δ" represents simple change of variable between 2007 and 2014.

After controlling for total population, I first calculated the year-to-year change in neighborhood deprivation index as well as food store accessibility for each household. Then I evaluated whether the changes are significant correlated by looking at the R-squares and p-values of the FD estimator.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Descriptive statistics for the six variables of the study area are displayed in Table 2. In Fulton County, at the census tract level, it is notable that the average median household income of Fulton was as twice as high of Clarke in both of the years ($60,300), both with a big standard deviation. Overall, mean of % population below 185% of poverty level is higher in Clarke. The percentage of unemployed residents does not count much. And we can find that in both counties, a small amount of households lacked an access to individual vehicle and the mean of % SNAP enrollment was about 10%.

Table 2. Census tract socioeconomic indicators

	Fulton				**Clarke**			
	Mean		St.dev.		Mean		St.dev.	
Year	2010	2014	2010	2014	2010	2014	2010	2014
% Black	48.3	47.9	38.2	37.1	25.8	25.6	20.3	19.8
% population below 185% of poverty level	34.7	35.7	24.3	24.5	52.1	55.8	21.1	20.4
% Unemployed	10.3	13.6	8.0	9.4	6.4	9.4	4.1	5.6
Median household income (dollars)	60,322	60,839	39,465	39,682	34,039	33,096	16,329	16,185
% households without a vehicle	9.9	15.4	12.1	9.9	4.2	4.6	3.6	5.3
% SNAP enrollment	12.3	16.0	13.9	16.5	9.5	14.8	7.8	10.4

4.2 Neighborhood Deprivation Index

After importing the data set of six variables into R Studio with data for 2010 and 2014 pooling together, I applied PCA to the six variables. Figure 6 is the scree plot displaying the eigenvalues associated with a component in descending order versus the number of the component or factor. The first four components explained 90% of the variance of the data.

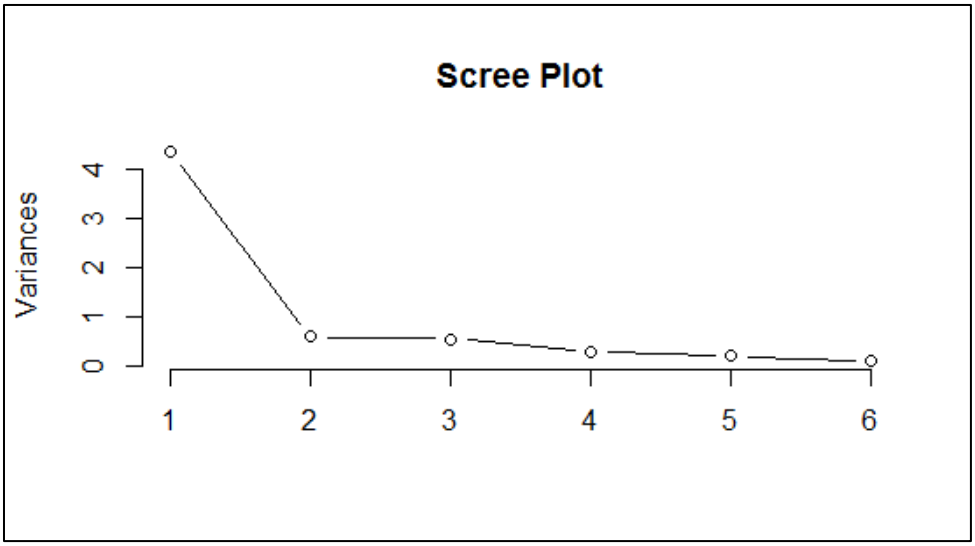


Figure 6. Scree plot of neighborhood deprivation index

We retained only the first principal component: the unique linear combination that accounted for the largest possible proportion of the total variability in the component measures, as what Messer and his colleagues applied in their research (Messer et al., 2006). Additionally, we found that the component scores of the six variables in Principal Component 1(PC1) explained the reality best, that is, the loading for medium tract income has a negative relation with the loadings for the other variables and captures the proportion of low-income participants. Thus, the neighborhood deprivation (ND) Index is constructed by each census tract, by using the following formula:

$$ND\ Index = \left(0.42 * standardized(B)\right) + \left(0.36\ * standardized(NV)\right)$$
$$+ \left(0.43 * standardized(P)\right) + \left(0.44 * standardized(F)\right)$$
$$+(0.40 * standardized(UE)) - (0.40 * standardized(MI)) \quad (2)$$

Across Clarke County, neighborhood deprivation index ranged from -1.14 to 2.43, with a mean of 0.37 for 2010; while the variation within individuals are smaller in 2014, as the mean is slightly larger than that of 2010 (see Figure 7).

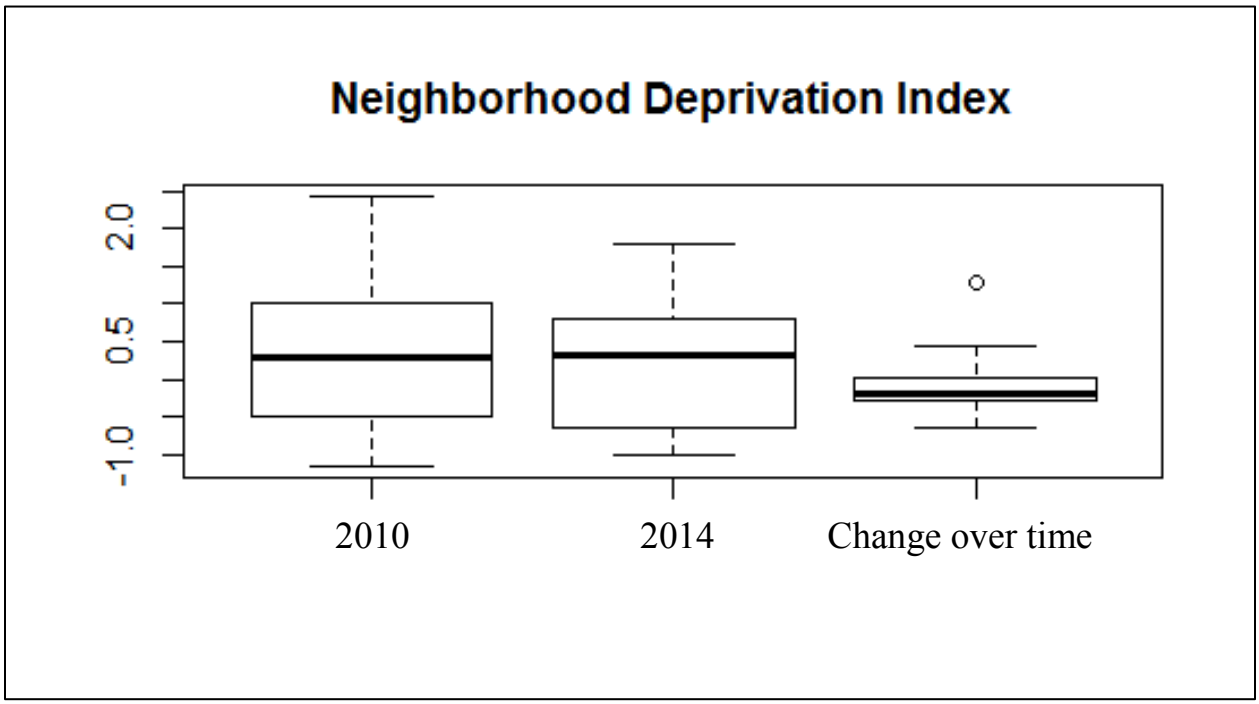


Figure 7. Box plot of neighborhood deprivation index by time, Clarke County

In Fulton County, it shows a similar pattern, neighborhood deprivation index ranged from -1.27 to 2.16, with a mean of 0.71 for 2010. The overall neighborhood deprivation index over time is larger than that of Clarke County, but with a lower standard deviation score, indicating that Fulton County is more deprived but less within area difference (see Figure 8).

Looking at the change of neighborhood deprivation index over time, change of deprivation index over time for Clarke ranged from -0.65 to 1.29, with a mean of -0.11; for

Fulton, is ranged from -0.79 to 0.65, with a mean of 0.03. Thus, these two counties demonstrated considerable neighborhood deprivation variability caused by socio-demographic variability.

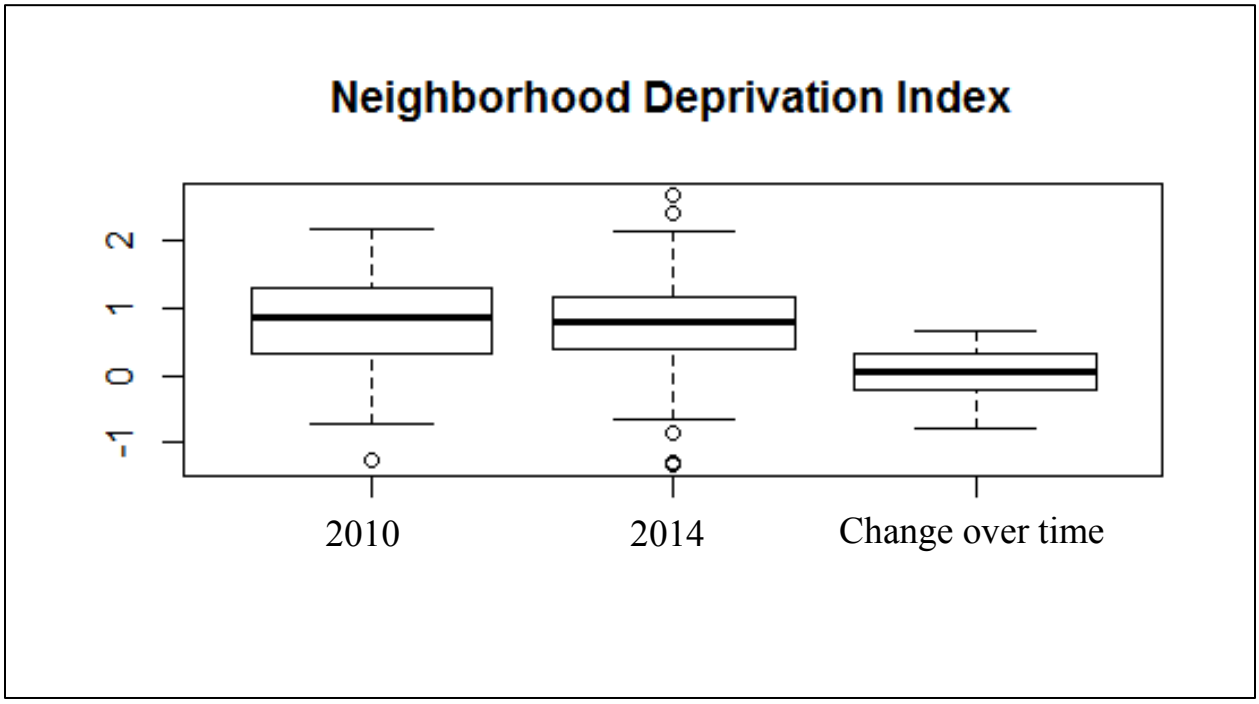


Figure 8. Box plot of neighborhood deprivation index by time, Fulton County

Figure 9 and Figure 10 show the spatial pattern of neighborhood deprivation index in 2010 and 2014 for both Fulton and Clarke Counties. From Figure 9, we can see for both of the time points, there is a clustering pattern of high neighborhood deprivation in the central area of Fulton, and when resident moves out from the center, the deprivation score decreases. Additionally, there is notable deprivation change happened in the eastern part of the county, where a small amount of participants located.

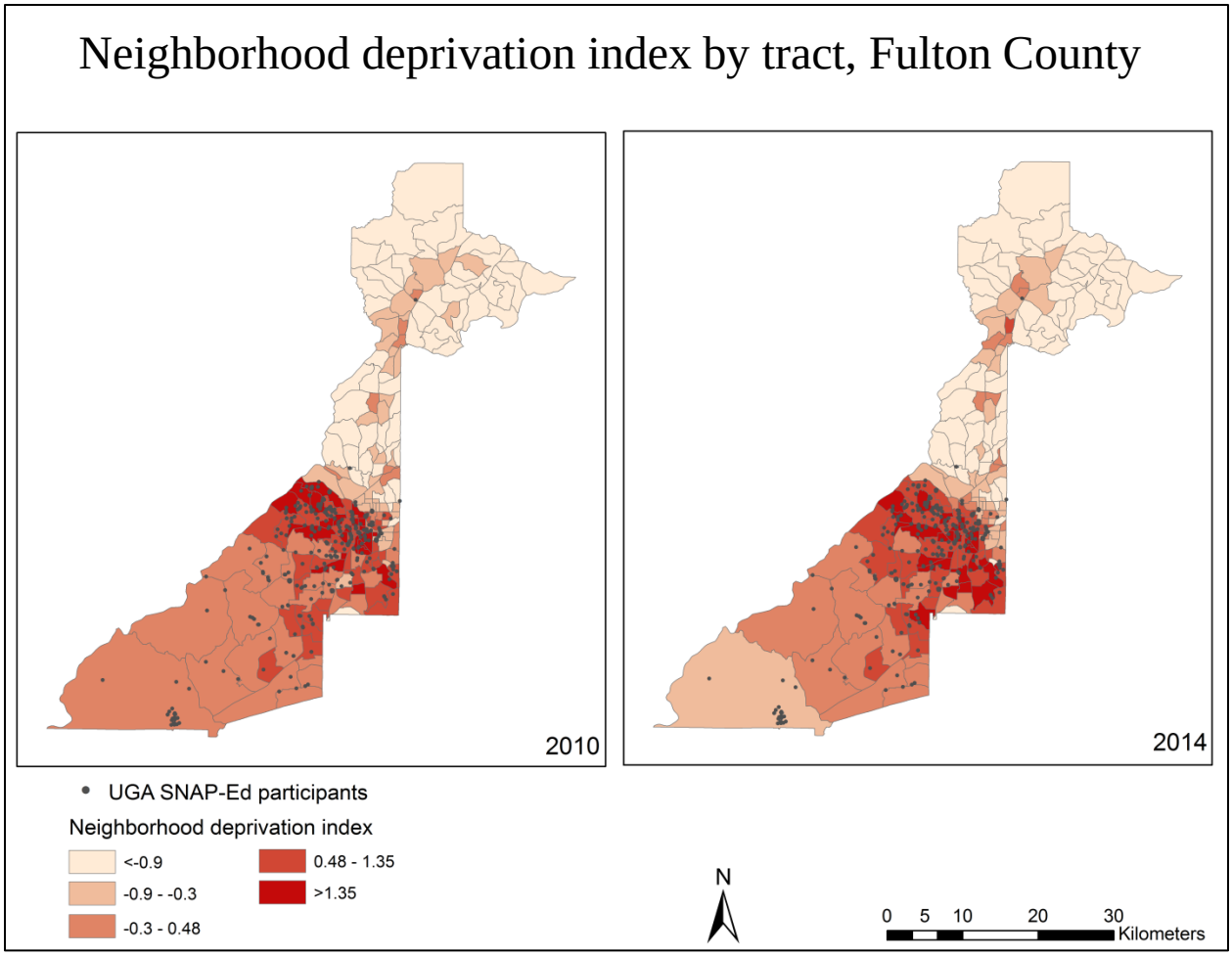


Figure 9. Spatial pattern of neighborhood deprivation index by time, Clarke County

In Clarke County, high deprivation appears in the center, while participants are more evenly distributed compared to those in Fulton County, a variety of different level of neighborhood deprivation is found with individuals (see Figure 10).

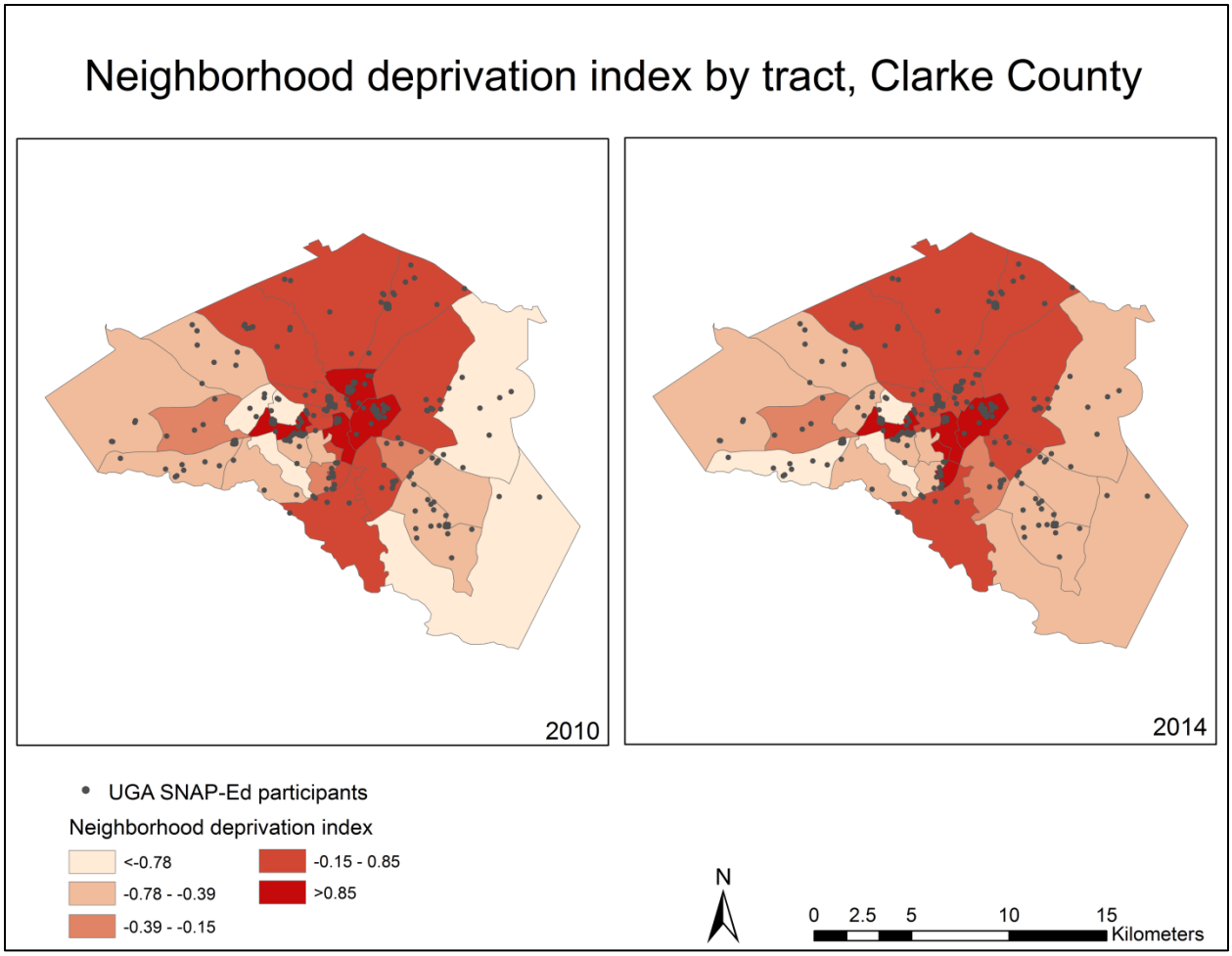


Figure 10. Spatial pattern of neighborhood deprivation index by time, Clarke County

Significant changes of neighborhood deprivation can be observed in Figure 11, where a clustering pattern of positive change in deprivation in the central area of Fulton is visually apparent. Most of the participants located in tracts with an increased deprivation. However, a similar pattern is not apparent for Clarke County, as most of the participants located in the central part experienced a negative change, while those lived in the outskirt became more deprived in socio-demographic status.

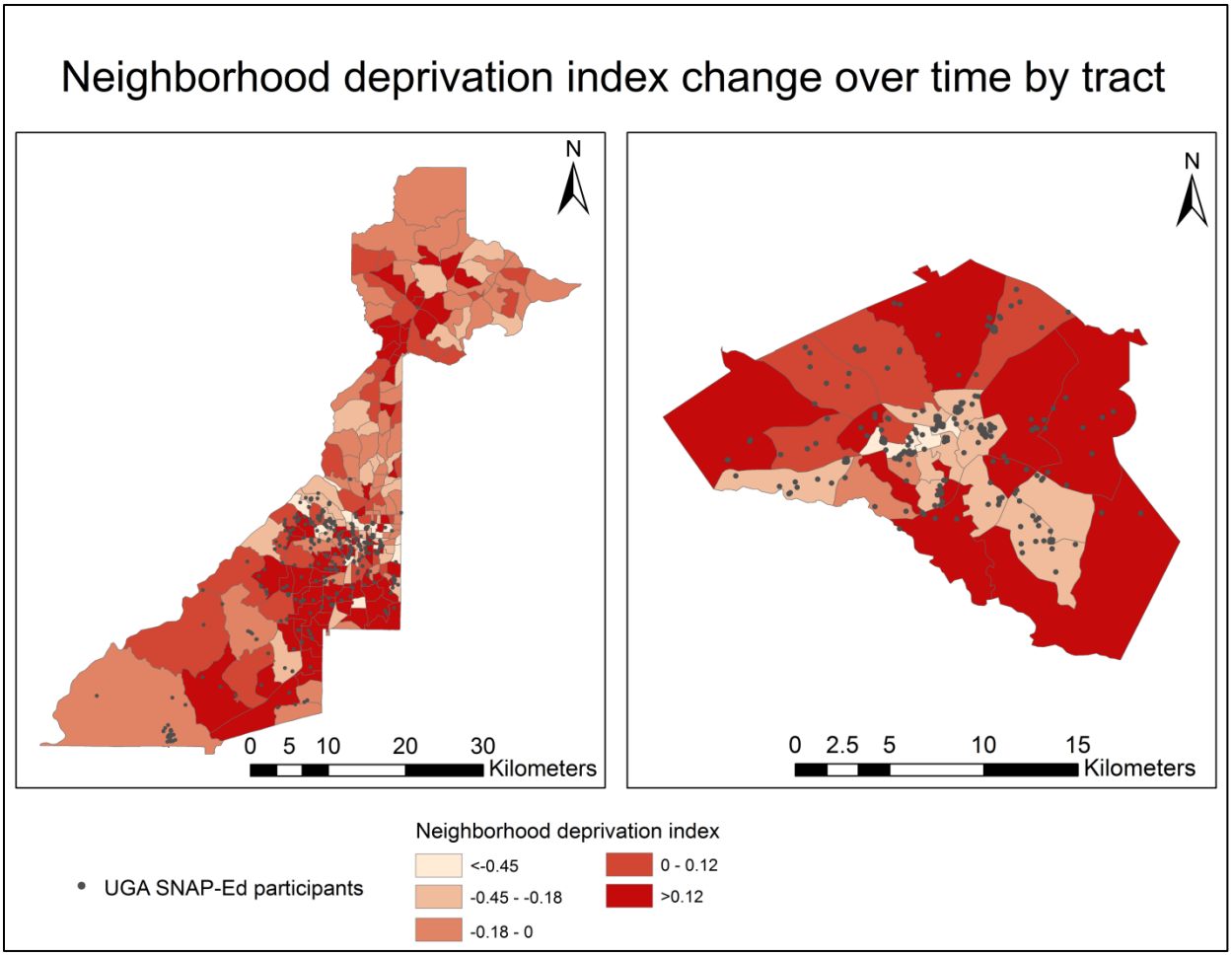


Figure 11. Spatial pattern of change of neighborhood deprivation index by time

4.3 Food Store Accessibility

Table 3 and Table 4 present the travel distance to the closest food store from residence in Fulton and Clarke Counties. Overall, people living in Fulton and Clarke Counties will need to travel further to big supermarkets (code 1) and specialty and meat stores (code 5) for food. In 2007, participants living in the two counties did not have access to warehouses (code 4), and they had less than 5 in the whole area in 2014, indicating they had less choices of warehouses in the surrounding environment.

Table 3. Distance to the closest food store, Fulton

	Fulton					
(km)	Mean		Max.		St.dev	
	2007	2014	2007	2014	2007	2014
code 1	3.84	3.85	17.56	17.56	3.09	3.09
code 2	1.34	1.34	8.55	10.52	1.41	1.43
code 3	1.03	0.82	13.11	11.21	1.21	0.92
code 4	N/A	12.77	N/A	26.32	N/A	4.00
code 5	3.78	2.61	23.29	17.31	4.57	2.69

Table 4. Distance to the closest food store, Clarke

	Clarke					
(km)	Mean		Max.		St.dev	
	2007	2014	2007	2014	2007	2014
code 1	3.03	3.64	10.79	7.20	1.78	1.51
code 2	2.45	1.95	10.37	7.26	2.10	1.48
code 3	1.80	1.30	6.68	5.43	1.32	1.06
code 4	N/A	12.18	N/A	22.92	N/A	4.37
code 5	4.99	4.49	14.82	13.18	3.13	2.95

Table 5 present the percentage of participants by change of count of stores within the buffer area in Fulton and Clarke Counties. In Clarke County, participants had more choices of discount stores and convenience stores (code 3) surrounded from 2-km buffer to 5-km buffer over time; while for major supermarkets (code 1) and specialty stores and meat stores (code 5), less stores were accessed within buffer area for a small proportion of participants. And for the majority of participants, there is no difference in the count of stores if they travel for a same distance from 1-km to 5-km. In Fulton, it is notable that a relatively large proportion of participants experienced decrease in the count of groceries (code 2) compared to other types of

stores. Same as Clarke County, participants had more choices of discount stores, convenience stores (code 3) and specialty stores and meat stores (code 5) surrounded from 2-km buffer to 5-km buffer over time from 2-km to 5-km buffer area.

Table 5. Percentage of participants by change of count of stores over time

%	Clarke			Fulton		
	< 0	= 0	>0	< 0	= 0	>0
1-km buffer						
code 1	0.6	94.6	4.9	2.9	89.1	6.9
code 2	4.9	72.5	22.6	12.5	63.9	22.5
code 3	0.6	63.6	35.8	9.6	39.5	49.9
code 4	0.0	100.0	0.0	0.0	98.5	0.4
code 5	5.4	91.1	3.4	2.3	83.5	13.2
2-km buffer						
code 1	8.0	84.8	7.2	15.7	65.3	18.0
code 2	0.3	55.9	43.8	31.5	35.1	32.4
code 3	0.6	24.1	73.4	5.6	13.2	80.2
code 4	0.0	99.7	0.3	0.0	98.5	0.4
code 5	2.3	84.2	13.5	7.9	44.1	47.0
3-km buffer						
code 1	13.8	67.0	19.2	19.6	63.7	15.7
code 2	0.0	28.1	71.9	26.5	32.6	39.9
code 3	0.9	20.1	79.1	4.6	5.8	88.5
code 4	0.0	98.6	1.4	0.0	97.7	1.3
code 5	0.9	62.2	37.0	5.6	25.1	68.3
4-km buffer						
code 1	27.2	45.0	27.8	22.5	67.6	8.8
code 2	0.0	19.2	80.8	31.7	22.5	44.7
code 3	0.0	3.4	95.1	0.2	3.8	95.0
code 4	0.0	98.0	2.0	0.0	96.9	2.1
code 5	6.0	53.6	40.4	3.1	15.0	81.6
5-km buffer						
code 1	25.8	45.0	29.2	31.1	48.2	19.6
code 2	0.0	7.4	92.6	25.9	18.8	54.3
code 3	0.0	0.6	44.4	0.0	0.8	98.1
code 4	0.0	96.3	3.7	0.0	89.4	9.6
code 5	21.5	43.0	35.5	2.7	14.2	82.0

4.4 Statistical Analysis

Before conducting First-Difference estimator to study on relationship between the change of neighborhood deprivation index and change of food store accessibility, whether there is a correlation between neighborhood deprivation and food store accessibility was tested.

Table 6 presents the correlation coefficients between neighborhood deprivation index and food store accessibility (distance to the closest store). It is obvious to find that neighborhood deprivation exhibited a strong negative correlation with proximity to groceries (code 2) in both Fulton and Clarke Counties in 2007 as well as 2014, indicating that SNAP-Ed participants who live in Fulton County have a better access to grocery stores in a less deprived neighborhood, which is not unexpected. Similar pattern has been found for discount stores, convenience stores (code 3) and specialty stores and meat stores (code 5) in both two time points; while there is an exception for supermarkets (code 1) in Fulton, 2014.

Table 6. Correlation coefficients between neighborhood deprivation index and food store accessibility (proximity: distance to the closest food store)

	Fulton		**Clarke**	
	2007	2014	2007	2014
code 1	-0.41 (***)	-0.31 (***)	-0.15 (***)	0.35
code 2	-0.26 (***)	-0.26 (***)	-0.50 (**)	-0.43 (***)
code 3	-0.14 (***)	-0.14(***)	-0.33 (***)	-0.24(***)
code 4	N/A	0.08	N/A	-0.01
code 5	-0.45(***)	-0.47 (***)	-0.44(***)	-0.42 (***)

* Significant at the 10% level, **5%, and ***1% .

Table 7 presents the correlation coefficients between neighborhood deprivation index and food store accessibility (mean distance to the 3 closest stores). Similar to distance to the closest food store, neighborhood deprivation was found to be negatively correlated with mean distance to the 3 closest food stores to all types of stores in both Fulton and Clarke Counties in 2007 as

well as 2014 with an exception for supermarkets (code 1) in Clarke, 2009 and for warehouses (code 4) in 2014.

Table 7. Correlation coefficients between neighborhood deprivation index and food store accessibility (proximity: mean distance to the 3 closest food stores)

	Fulton		**Clarke**	
	2007	2014	2007	2014
code 1	-0.38 (***)	-0.33 (***)	0.009	0.23 (***)
code 2	-0.43 (***)	-0.46 (***)	-0.58 (***)	-0.50 (***)
code 3	-0.22 (***)	-0.19 (***)	-0.33 (***)	-0.22 (***)
code 4	N/A	-0.26 (***)	N/A	-0.002
code 5	-0.47(***)	-0.50 (***)	-0.49 (***)	-0.40 (***)

* Significant at the 10% level, **5%, and ***1% .

The results shown in Table 6 and Table 7 is consistent with previous research that accessibility to supermarkets decreases as one moves from central areas to peripheral neighborhoods (Apparicio et al., 2007). Besides, the results also suggested that neighborhood deprivation not only correlated with proximity to supermarkets, but also negatively correlated with groceries, discount stores, convenience stores and specialty stores and meat stores.

As for count of stores, since the numbers are measurement taken from ordinal scales and "0"s existed in the data, I chose to use Spearman correlation rather than Pearson correlation used in the first part of this process. We can find that at 1-, 2- and 3-km buffer radius, there is a significant correlation between neighborhood deprivation and food store accessibility for code 1 in both two counties, which is not significant anymore at 4- and 5-km buffer. Adversely, for code 5 in Clarke County, the correlation between neighborhood deprivation and food store accessibility which is not significant in 2014 at 1-, 2-km buffer became significant at larger buffer areas. These findings indicate that participants who lived in more deprived areas had more

food stores surrounded within the buffer area, which was not true for those who travelled more than 3 km to find a supermarkets in Fulton.

Table 8. Spearman's rank correlation rhos between neighborhood deprivation index and food store accessibility (density)

		Fulton		Clarke	
		2007	2014	2007	2014
Count of stores within 1-km buffer	code1	0.005	-0.28 (***)	-0.24 (***)	-0.33 (***)
	code2	0.19 (***)	0.31 (***)	0.45 (***)	0.20 (***)
	code3	0.18 (***)	0.10 (**)	0.28 (***)	0.03
	code4	N/A	-0.05	N/A	N/A
	code5	0.14 (**)	0.12 (***)	0.13 (*)	-0.07
Count of stores within 2-km buffer	code1	0.30 (***)	-0.19 (***)	-0.03	-0.42 (***)
	code2	0.29 (***)	0.30 (***)	0.54 (***)	0.39 (***)
	code3	0.35 (***)	0.15 (***)	0.25 (***)	0.19 (***)
	code4	N/A	-0.05	N/A	-0.08
	code5	0.27(***)	0.23 (***)	0.13 (**)	0.08
Count of stores within 3-km buffer	code1	0.26 (***)	-0.14 (***)	-0.06	-0.38 (***)
	code2	0.38 (***)	0.30 (***)	0.63 (***)	0.35 (***)
	code3	0.26 (***)	0.15 (***)	0.22 (***)	0.16 (***)
	code4	N/A	-0.03	N/A	-0.12 (**)
	code5	0.16(***)	0.08 (*)	0.20 (***)	0.20 (***)
Count of stores within 4-km buffer	code1	0.12	-0.03	-0.05	-0.43 (***)
	code2	0.36 (***)	0.32 (***)	0.62 (***)	0.40 (***)
	code3	0.35 (***)	0.27 (***)	0.30 (***)	0.19 (***)
	code4	N/A	0.0009	N/A	-0.16 (***)
	code5	0.25 (***)	0.21 (***)	0.27 (***)	0.26 (***)
Count of stores within 5-km buffer	code1	0.05	-0.02	-0.07	-0.37 (***)
	code2	0.32 (***)	0.33 (***)	0.62 (***)	0.42 (***)
	code3	0.27 (***)	0.27 (***)	0.39 (***)	0.30 (***)
	code4	N/A	-0.09 (**)	N/A	-0.22 (***)
	code5	0.28 (***)	0.33 (***)	0.34 (***)	0.24 (***)

* Significant at the 10% level, **5%, and ***1% .

Having found the correlation between neighborhood deprivation and food store accessibility, since there was an overall increase in total stores throughout study areas, but there were also store closures during the four-year period, it is valuable to investigate the differences between neighborhoods and the fluctuations in the food environment over time.

Table 9 and Table 10 provide the results of FD estimator. For both counties, no predictive model found between change of neighborhood deprivation index and change of food store accessibility over time.

In both counties, larger neighborhood deprivation index is associated with decreases in travel distance to the closest supermarkets and warehouses, which was an unexpected finding. A negative association has been found between neighborhood deprivation and travel distance to the closest grocery stores in Clarke, and warehouses in Fulton.

Table 9. First-difference estimator results for change of neighborhood deprivation and change of food store proximity over time

		Clarke		**Fulton**	
		Estimate	R-squared (p-value)	Estimate	R-squared (p-value)
Distance to the closest facility	code1	-1210.5	0.01549 (*)	-2804.1	0.06005 (***)
	code2	-374.5	0.05314(***)	-70.4	0.0001143
	code3	32.8	0.001009	-532.6	0.008697 (*)
	code4	N/A	N/A	-10426.0	0.06379(***)
	code5	-298.5	0.005482	750.5	0.001049
Mean distance to the 3 closest facilities	code1	136.2	0.000834	-1276.0	0.0235(***)
	Code 2	44.2	0.0007577	-160.3	0.0009197
	code3	29.1	0.0006537	-70.6	0.0002425
	code4	N/A	N/A	17.9	7.861e-07
	code5	891.1	0.0641(***)	483.2	0.0009736

* Significant at the 10% level, **5%, and ***1% .

Same as food store proximity, no predictive model has been found between changes of neighborhood deprivation and change of food store density. For Clarke County, it is found that an increase in change of neighborhood deprivation index is associated with a decrease in change of count of grocery stores (code 2), discount stores and convenience stores (code 3) within a 1-km to 5-km buffer area; while for Fulton County, the association is inversed, that is, an increase in change of neighborhood deprivation index is associated with an increase in change of count of stores, which is interesting to find. Additionally, in Fulton County, the association between change of neighborhood deprivation and change of food store density for specialty stores and meat stores is inversed to that of warehouses and discount stores and convenience stores.

Table 10. First-difference estimator results for change of neighborhood deprivation and change of food store density over time

		Clarke		**Fulton**	
		Estimate	R-squared (p-value)	Estimate	R-squared (p-value)
Count of stores within 1-km buffer	code1	0.005	5.998e-05	0.051	0.002654
	code2	-0.106	0.005821(***)	0.798	0.06476 (***)
	code3	-1.200	0.06742 (***)	0.925	0.02856(***)
	code4	N/A	N/A	0.0005	6.904e-06
	code5	0.121	0.02078 (**)	-0.442	0.06844 (***)
Count of stores within 2-km buffer	code1	0.095	0.007419	0.137	0.00439
	code2	-0.354	0.02391(**)	2.001	0.09207(***)
	code3	-3.472	0.1655(***)	0.549	0.001597
	code4	-0.00159	0.0001109	0.0005	6.904e-06
	code5	-0.194	0.03055(**)	-0.334	0.01119(*)
Count of stores within 3-km buffer	code1	-0.046	0.000784	0.233	0.008401(*)
	code2	-1.315	0.1161(***)	2.763	0.0703(***)
	code3	-8.792	0.2283(***)	2.530	0.01308(*)
	code4	0.012	0.001323	0.018	0.002471
	code5	-0.625	0.1768 (***)	-0.086	0.0003472

* Significant at the 10% level, **5%, and ***1% .

Table 10. First-difference estimator results for change of neighborhood deprivation and change of food store density over time (Cont.)

		Clarke		Fulton	
		Estimate	R-squared (p-value)	Estimate	R-squared (p-value)
Count of stores within 4-km buffer	code1	0.005	5.998e-05	0.051	0.002654
	code2	-0.107	0.005821(***)	0.798	0.06476 (***)
	code3	-1.200	0.06742 (***)	0.925	0.02856(***)
	code4	N/A	N/A	0.0005	6.904e-06
	code5	0.121	0.02078 (**)	-0.442	0.06844 (***)
Count of stores within 5-km buffer	code1	0.095	0.007419	0.137	0.00439
	code2	-0.354	0.02391(**)	2.001	0.09207(***)
	code3	-3.472	0.1655(***)	0.549	0.001597
	code4	-0.002	0.0001109	0.0005	6.904e-06
	code5	-0.194	0.03055(**)	-0.334	0.01119(*)

* Significant at the 10% level, **5%, and ***1% .

The reasons for the observed differences between neighborhood deprivation and the changes in the food store accessibility cannot be determined using the data provided (Filomena et al., 2013). Economic factors may have influenced the stability of the food environment. For example, it is possible that a decrease in real estate value influenced the number of store openings. There is no predictive model found between changes of neighborhood deprivation and the changes in the food store accessibility, however, there is significant association between them for warehouses, discount stores and convenience stores, specialty stores and meat stores. Although the trends observed in Fulton and Clarke Counties during the study period may not be generalizable to any other four-year period, the findings are important for considering the impact of food retail fluctuations on the shopping patterns of affected participants. The findings highlight the need to understand how participants modify their food shopping patterns to adapt to the changing environment. For those who live in an unstable food environment, they may spend

more time adjusting their shopping routines than those in more stable food environments. They may need to travel further, or target at different types of food stores for shopping, or even change their diet.

Researchers, policymakers, and others might consider how they can utilize fluctuations in the food environment to further the goal of improving access to healthy foods. For example, these data demonstrate that discount stores and convenience stores are the most prevalent. Also, a large proportion of the participants experienced increase in the count of these stores. On the one hand, these changes may indicate tremendous opportunity for public health policy to work with store owners and government to influence the availability of healthy foods in these neighborhoods, as has been suggested by others (Bodor et al., 2008; Story et al., 2008). Also, such changes may be promising to consumers who are looking for new options. Therefore, changes in the food environment may provide an opportunity for both store owners and residents.

As with all research, there are limitations associated with this study. First, in the survey, respondents mainly lived in the central parts of the two counties, however, population density can vary across urban areas (Richardson, et al., 2014). We addressed neighborhood deprivation by imputing it to individual level by calculating in census tract level. Second, this analysis is limited to the count of stores where participants may access to, without investigating the availability of certain food items at those stores, or their prices and quality. Several studies have investigated these factors and found that smaller stores and low-income neighborhoods are associated with poorer quality of produce (Powell et al., 2007; Andreyeva et al., 2008). Finally, since an urban foodscape differs from other environments in terms of the density of population

and stores, our findings may not be generalizable to other areas of the United States or internationally.

This study provides information on the local food environment of Fulton County and Clarke County, GA, including store proximity analysis and neighborhood deprivation analysis. Broader impacts of the proposed project are twofold. First, the research will be used to make constructive recommendations to the SNAP-Ed. This study provides needed information on geographic and socioeconomic patterns in food environment that can help direct efforts to improve food environments, especially for SNAP-Ed participants who lack of individual cars, across Fulton, Clarke and other counties. Secondly, the study makes use of the results of the survey data to create a detailed analysis for UGA SNAP-Ed participants.

As convenience store industries grow nationally, disadvantaged populations may be at higher risk than advantaged populations to buy the cheap and convenient food that are not healthy (Richardson, et al., 2014). Increasing specialty markets and meat stores and reducing convenience stores access may improve the food environment for those who lived in a more deprived area.

CHAPTER 5

CONCLUSIONS

The primary intellectual merit of this study lies in its deepen look at SNAP-Ed participants' home address rather than using centroid of the residents' census tracts as a proxy for it. This study is exploring the longitudinal food environment in Fulton County and Clarke County, GA, and examining the pattern of food store accessibility and neighborhood deprivation in 2007 and 2014.

Using a unique set of data covering 823 SNAP-Ed participants, we found that change of neighborhood deprivation index over time have a relationship with the change of food store accessibility over time for some of the food store types (warehouses, discount stores, convenience stores, specialty stores and meat stores). Overall, the results of this research suggest that both neighborhood deprivation index and food store accessibility are of importance in shaping neighborhood food environments; however, these influences vary by store type and store size. As is consistent with other studies, socioeconomic status is strongly (and inversely) related to supermarket accessibility in Fulton County (Anchondo, Teresa and Ford, 2011). In contrast, the change of neighborhood deprivation index over time is more sensitive to the density of warehouse, discount stores, convenience stores, specialty markets and meat stores. Combined, these results suggest that within urban and a combination of urban and suburban communities, it is critical to examine multiple influences of neighborhood deprivation on the accessibility of different types of stores in order to understand the food environment. Finally, the fluctuations in food environment points to an opportunity for public health policymakers and city planners to

work with store owners and governments to develop more sustainable programs like SNAP-Ed program marketing fresh and affordable foods that promoting health.

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