NEIGHBORHOOD RACIAL COMPOSITION, NEIGHBORHOOD WEALTH, AND THE SURROUNDING FOOD ENVIRONMENT IN METRO ATLANTA AREA

A Dissertation
Presented to
The Academic Faculty

by

Mingyang Li

In Partial Fulfillment
of the Requirements for the Degree
MASTER IN CIVIL ENGINEERING AND MASTER OF CITY AND REGIONAL PLANNING in the
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING AND SCHOOL OF CITY AND REGIONAL PLANNING

Georgia Institute of Technology
DECEMBER 2016

NEIGHBORHOOD RACIAL COMPOSITION, NEIGHBORHOOD WEALTH, AND THE SURROUNDING FOOD ENVIRONMENT IN METRO ATLANTA AREA

Approved by:

Dr. Baabak Ashuri, Advisor
School of Civil and Environmental Engineering
Georgia Institute of Technology

Dr. Patrick McCarthy
School of Economics
Georgia Institute of Technology

Dr. Catherine Ross
School of City and Regional Planning
Georgia Institute of Technology

Date Approved: December 8, 2016

ACKNOWLEDGEMENTS

I would like to thank my family, without whose support I would not be here and be able to complete this work after all these years of study. I would also like to thank Dr. Baabak Ashuri, Dr. Patrick McCarthy, and Dr. Catharine Ross for their suggestions in refining this paper.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Black	Non-Hispanic African American residents (ratio)
Income	Median household income (million $)
Pov	Families living below the US poverty level (ratio)
Stamps	Households receiving Food Stamps/SNAP (ratio)
Unemp	Residents over age 16 that are unemployed (ratio)
EduL	Residents over age 25 with high school diploma or less (ratio)
EduH	Residents over age 25 with high school diploma or above (ratio)
Lone	Children under age 18 that live with one parent (ratio)
PopDen	Population density (thousand person/square mile)
PT	Residents over age 16 that use public transportation for commute (ratio)
Rent	Housing units that are renter occupied (ratio)
FePop	Female population (thousand person)
ChPop	Children population (thousand person)
Urban	Residents living in urban area per USDA classification (ratio)
Hwy	Presence of major highway? (0 - no, 1 - yes)
IntDen	Intersection density (thousand intersection/square mile)
North	Located to the North of Fulton County's centroid? (0 – No, 1 – Yes)
h	Number of healthy food outlets (supermarkets) in the associated catchment areas
u	Number of unhealthy food outlets (fast food restaurants) in the associated catchment areas
D	Subscript for the driver's scenario
ND	Subscript for the non-driver's scenario

i	Subscript for the block group of interest
s	Subscript for the study area

SUMMARY

Inequalities in accessibility to food outlets might be associated with the disproportionate burden of obesity among minority and low income communities. While a large body of literatures has focused on the disparities in accessibility to a certain type of food outlet (supermarket or fast food restaurant), few has accounted for the co-occurrence of food outlets in the food environment, leading to potential estimation bias. The objective of this study is to quantify the food environment in Metro Atlanta by examining the food outlet balance of supermarkets and fast food restaurants, and explored the association of the food outlet balance with key neighborhood characteristics. From the non-driver's perspective, Black-dominant neighborhoods were found to be less likely of having a healthy food outlet balance, compared to White-dominate neighborhoods. This trend, however, was reversed from the driver's perspective, where Black-dominant neighborhoods were found to be more likely of having a healthy food outlet balance. Meanwhile, Income was found insignificant in both the non-driver's and the driver's scenarios. These findings urge for future planning efforts to bring more food outlets, at a healthy balance, closer to Black-dominant neighborhoods.

CHAPTER 1. INTRODUCTION

Obesity has become a serious social issue in the US: According to American Heart Association (American Heart Association, 2016), nearly 78 million adults and 13 million children are suffering from negative health and emotional effects of obesity nationwide. Such burden, however, was found to be disproportionally distributed upon non-Hispanic African Americans and individuals with low socioeconomic status (Oliver & Hayes, 2005; Skelton, Cook, Auinger, Klein, & Barlow, 2009; Wardle, Waller, & Jarvis, 2002). The national study conducted by Skelton et al. (Skelton, Cook, Auinger, Klein, & Barlow, 2009) found that Black children and adolescents had the highest prevalence of severe obesity (BMI $\geq 99^{th}$ percentile), compared with the White population in the United States. Another Canadian national study has found that decreased neighborhood socioeconomic status was associated with an increased overweight prevalence, with 35% in low socioeconomic status neighborhoods vs. 24% in high socioeconomic status neighborhoods (Oliver & Hayes, 2005). Similar trend was also identified in England, where low socioeconomic status and economic deprivation were associated with an increased risk of obesity using the national Health Survey data (Wardle, Waller, & Jarvis, 2002).

Understanding that individual's dietary choices, one of the major behavioral factors in obesity, are affected by the environment surrounding them, a growing body of literatures have focused on the disparities in the contextual factors, such as neighborhood's surrounding food environment, across different racial compositions and income levels (James, Arcaya, Parker, Tucker-Seeley, & Subramanian, 2014; Morland, Wing, Roux, & Poole, 2002; Wrigley, Warm, & Margetts, 2003). The food environment is the combination of many food outlet types that are accessible to local residents. Among these food outlets, supermarkets and fast food restaurants were frequently selected as proxies of the food environment that supports healthy and unhealthy dietary choices, respectively (Lamichhane et al., 2013; Smoyer-Tomic et al., 2008).

Researchers have found inequalities in accessibility to supermarkets or fast food restaurants among minority and poor neighborhoods in United States. A study conducted by Morland et al. (Morland et al., 2002), for instance, found that 4 times more supermarkets were located in white-dominant neighborhoods compared to black-dominant neighborhoods in Mississippi, North Carolina, Maryland, and Minnesota. Another study in Metropolitan Detroit found that among the neighborhoods with the lowest socioeconomic status, Black-dominant neighborhoods were 1.1 miles further from the nearest supermarket, compared with White-dominant neighborhoods (Zenk et al., 2005). Such findings were later supported by Richardson et al. (Richardson, Boone-Heinonen, Popkin, & Gordon-Larsen, 2012) in their nationwide analysis, where inequalities in supermarket availability were identified across different racial compositions and income levels, especially in low-density urban areas. As for the accessibility to fast food restaurants, studies have showed that black-dominant neighborhoods were associated with greater density of fast food restaurants within the City of New Orleans, Louisiana and New York City (Block, Scribner, & DeSalvo, 2004; Kwate, Yau, Loh, & Williams, 2009). This trend was later supported by James et al. (James et al., 2014) in their national study, where black-dominant neighborhoods were found to have closer proximity to fast food restaurants. Additionally, neighborhoods with low socioeconomic status were associated with an increased availability of fast food restaurants in the State of Mississippi, North Carolina, Maryland, and Minnesota, and Los Angeles County, CA (Lewis et al., 2011; Morland et al., 2002).

While many existing studies examined on the disparities in the accessibility to supermarkets (Larsen & Gilliland, 2008; Richardson et al., 2012; Smoyer-Tomic et al., 2008) or fast food restaurants (James et al., 2014; Kwate et al., 2009; Walker, Block, & Kawachi, 2013), few, to the author's knowledge, has explored the food accessibility with consideration of both types of food outlets simultaneously. One noteworthy exception is the study conducted by Powell et al. (Powell, Chaloupka, & Bao, 2007), in which the proportion of fast food restaurants out of total restaurants were analysed. As suggested in Lamichhane et al. (Lamichhane et al., 2013), focusing on only one food outlet type fails to account for the co-occurrence of supermarkets and fast food restaurants in the food environment, leading to potential biases in estimation. Therefore, the purpose of this study is to quantify the neighborhood's accessibility to the food environment by examining the food outlet balance of supermarkets and fast food restaurants, and explored its relation to neighborhood-level demographic and socioeconomic variables in Fulton County, Georgia. This study will also contribute to the research of food accessibility in Metro Atlanta, the ninth biggest metropolitan area in the United State with more than half a million people stranded in food desert (Burns, 2014).

CHAPTER 2. METHODS

2.1 Study Area and Analysis Unit

This paper studies the food environment in Fulton County, a fast-growing and populated area in north-west Georgia, with large variations in demographic and socioeconomic status (See in Table 1 for descriptive statistics). Census block group was selected as the analysis unit, as it is the smallest geographic unit on Census website (population of 600 to 3000), and hence represents greater homogeneity in the demographic and socioeconomic characteristics (Richardson et al., 2012; United States Census Bureau, 2012). In this study, Census block groups also served as proxies of neighborhoods in Fulton County.

2.2 Key Neighborhood Demographic and Socioeconomic Variables

Most researchers have identified the neighborhood racial composition and the neighborhood wealth as two key variables in food accessibility studies (James et al., 2014; Powell et al., 2007; Zenk et al., 2005). In this study, racial composition was defined as the ratio of non-Hispanic Black residents of the block group (Block et al., 2004), and neighborhood wealth the median household income (Walker et al., 2013).

Little consensus, however, was built upon the selection of other neighborhood demographic and socioeconomic variables. In this study, the ratio of families living below the US poverty level and ratio of household receiving Food Stamps/SNAP was identified as two measures the poverty status of the block group (Binkley, 2006; Lamichhane et al., 2013). Unemployment rate was another socioeconomic variable of interest, defined as the ratio of residents over age 16 and were unemployed of the block group (Larsen & Gilliland, 2008). Many studies also consider the effect of the education attainment: Both ratio of residents over age 25 with high school diploma or less and ratio of residents over age 25 with high school diploma or above of the block group were used to measure the average education level (Lamichhane et al., 2013; Larsen & Gilliland, 2008). In addition, ratio of lone-parent children was included in previous study as a controlling variable because such households tend to be more sensitive to the food environment in which they reside (Larsen & Gilliland, 2008). Population density of the neighborhood was another demographic variable included in the analysis, as food outlets tend to locate themselves in areas easily accessible by potential customers (James et al., 2014). Variables such as the ratio of commuters using public transportation, the ratio of renter-owned housing units, the urbanicity level of the block group, and the presence of major highway, were also identified in other papers (Block et al., 2004; James et al., 2014; Powell et al., 2007; Richardson et al., 2012; Smoyer-Tomic et al., 2008).

In addition to the variables found in previous studies, the author explored the effects of four additional neighborhood-level variables: Intersection density, female population, children population, and location of the block group. The intersection density served as a proxy for commercial activity level, which was a variable included in Block et al. (Block et al., 2004). Female and children population were included because females tend to take on the responsibility of preparing food in a household, and children tend to be more selective for nutrition intake, making such population more vulnerable to the surrounding food environment. The location of the block group was defined as 1 if the block group is to the north of the centroid of Fulton County, and 0 the opposite. The intention of the variable was to capture the fix effect of the geographic locations (northern vs. southern Fulton County). The definition, descriptive statistics, and data source of these variables are presented in Table 1 below. Of the 544 Census block groups in Fulton County, 537 block groups were included in this study. Seven block groups were dropped due to missing information in population, income, or other socioeconomic variables.

Table 1 – Key neighborhood-level variables overview.

Variable	Symbol	Mean	SD	Data Source
Non-Hispanic African American residents (ratio)	Black	0.462	0.387	2014 American Community Survey 5-Year Estimates
Median household income (million $)	Income	0.067	0.048	
Families living below the US poverty level (ratio)	Pov	0.166	0.188	
Households receiving Food Stamps/SNAP (ratio)	Stamps	0.167	0.178	
Residents over age 16 that are unemployed (ratio)	Unemp	0.126	0.108	
Residents over age 25 with high school diploma or less (ratio)	EduL	0.286	0.206	
Residents over age 25 with high school diploma or above (ratio)	EduH	0.891	0.111	
Children under age 18 that live with one parent (ratio)	Lone	0.456	0.353	
Population density (thousand person/square mile)	PopDen	4.217	4.445	
Residents over age 16 that use public transportation for commute (ratio)	PT	0.098	0.120	
Housing units that are renter occupied (ratio)	Rent	0.475	0.290	
Female population (thousand person)	FePop	0.921	0.648	
Children population (thousand person)	ChPop	0.406	0.398	
Residents living in urban area per USDA classification (ratio)	Urban	0.994	0.056	2010 Census Data
Presence of major highway? (0 - No, 1 - Yes)	Hwy	0.310	0.462	Spatial analysis using ArcGIS 10.3
Intersection density (thousand intersection/square mile)	IntDen	0.386	0.418	
Located to the North of Fulton County's centroid? (0 – No, 1 – Yes)	North	0.466	0.499	

Number of block groups, N = 537

2.3 Construction of The Food Environment

The food environment, by definition, should include all food outlets accessible by the local neighborhoods (Center for Disease Control and Prevention, 2014). Due to data limitations in locating all food outlets, supermarkets and fast food restaurants were selected as proxies of the food environment supporting healthy and unhealthy dietary choices, respectively (Lamichhane et al., 2013; Smoyer-Tomic et al., 2008).

Previous studies have identified supermarkets as a major source for healthy dietary choice (Cannuscio et al., 2013). In this study, supermarkets were defined as large “chain” stores that sell a variety of price-competitive and healthy groceries including fresh produce and meat products (Morland et al., 2002). Examples of supermarkets are Kroger, Publix, Piggly Wiggly, Food Lion, Whole Foods, etc. Meanwhile, fast food restaurants caught researchers’ attention because fast food was often associated with high-calorie and high-sugary diets (Paeratakul, Ferdinand, Champagne, Ryan, & Bray, 2003). Specifically, fast food restaurants were defined as “chain” restaurants that have expedited food such as sandwich, hamburger, fried chicken, and pizza; have no server to individual table; and require payment made prior to receiving food (Block et al., 2004). Examples of fast food restaurants include McDonalds, Pizza Hut, Taco Bell, etc.

To capture most of supermarket and fast food restaurant locations accessible by the residents of Fulton County, the author contacted Atlanta Regional Commission (ARC), the regional planning and intergovernmental coordination agency in Metro Atlanta, to gather the names of supermarket and fast food restaurant chains that have the most establishments in the State of Georgia. Chain names were used instead of industry classification codes for identification of food outlets in this study. Previous study has suggested that this approach could reduce the risk of misclassification, and hence improve analysis accuracy (James et al., 2014). The original ARC supermarket list has 17 chain names. Among the chains, Harvey's Supermarket, BI-LO, and Clyde's Market were dropped off from the list because no open store was found in Metro Atlanta area as of September 2016. Next, the author added Walmart, Costco, Asian Supermarkets, and Farmer’s Markets to the list, considering that these stores, though not on the original list, also provide a wide range of fresh produce and meat products.

The original ARC fast food restaurant list has 36 fast food restaurant chain names. Only the chains with more than 100 establishments in Georgia were selected to capture the majority of fast food restaurant locations. Among these chains, Kroger Deli was deleted from the list because the Kroger Deli is usually located within the supermarket, and does not share the same features of a typical fast food restaurant as described before. After the procedure, 18 supermarket chains and 19 fast food restaurant chains were selected for this study, as shown in Table 2 below along with their market shares.

Table 2 – Selected supermarket and fast food restaurant chains and their market shares in Georgia.

Supermarkets	Market Share	Fast food restaurants	Market Share
Kroger	6.31%	Subway	4.06%
Publix Super Market	6.23%	Mc Donald's	2.52%
Ingles Market	2.96%	Waffle House	2.03%
Piggly Wiggly	2.85%	Wendy's	1.46%
Food Lion	2.35%	Pizza Hut	1.33%
Save-A-Lot	1.23%	Burger King	1.31%
Aldi	1.04%	Starbucks	1.24%
Winn-Dixie	0.96%	Domino's Pizza	1.12%
Food Depot	0.85%	Kfc	1.01%
IGA FoodLiner	0.42%	Chick-Fil-A	0.97%
Trader Joe's	0.31%	Dairy Queen	0.96%
Wayfield Foods Inc.	0.31%	Taco Bell	0.95%
Whole Foods Market	0.27%	Zaxby's	0.93%
Fresh Market	0.23%	Arby's	0.78%
Walmart	NA	Papa John's Pizza	0.71%
Costco	NA	Huddle House	0.62%
Asian Supermarkets	NA	Blimpie Subs & Salads	0.61%
Farmer’s market	NA	Krystal	0.61%
		Sonic Drive-In	0.60%

Source: Atlanta Regional Commission, reformatted by the author.

Location information of the supermarkets and fast food restaurants were obtained in two ways. POI-factory website (http://www.poi-factory.com) was the major data source in this study (accessed in August 2016). It provided regularly updated location information of all fast food restaurant chains and most of the supermarket chains that were included in this study. For Piggly Wiggly, Food Depot, IGA FoodLiner, Wayfield Foods Inc., and Fresh Market, whose location information was readily available on the POI factory website, the author geocoded the store locations within Georgia based on the information on their official websites (accessed in September 2016).

Since customers can travel beyond administrative boundaries (e.g. block groups) for food, previous studies have suggested that food accessibility studies should include food outlets even outside the geographic boundaries (James et al., 2014). Following this guidance, a total of 996 supermarkets and 4368 fast food restaurants within and near Fulton County were geocoded using ArcGIS 10.3 software, as shown in Figure 1 below.

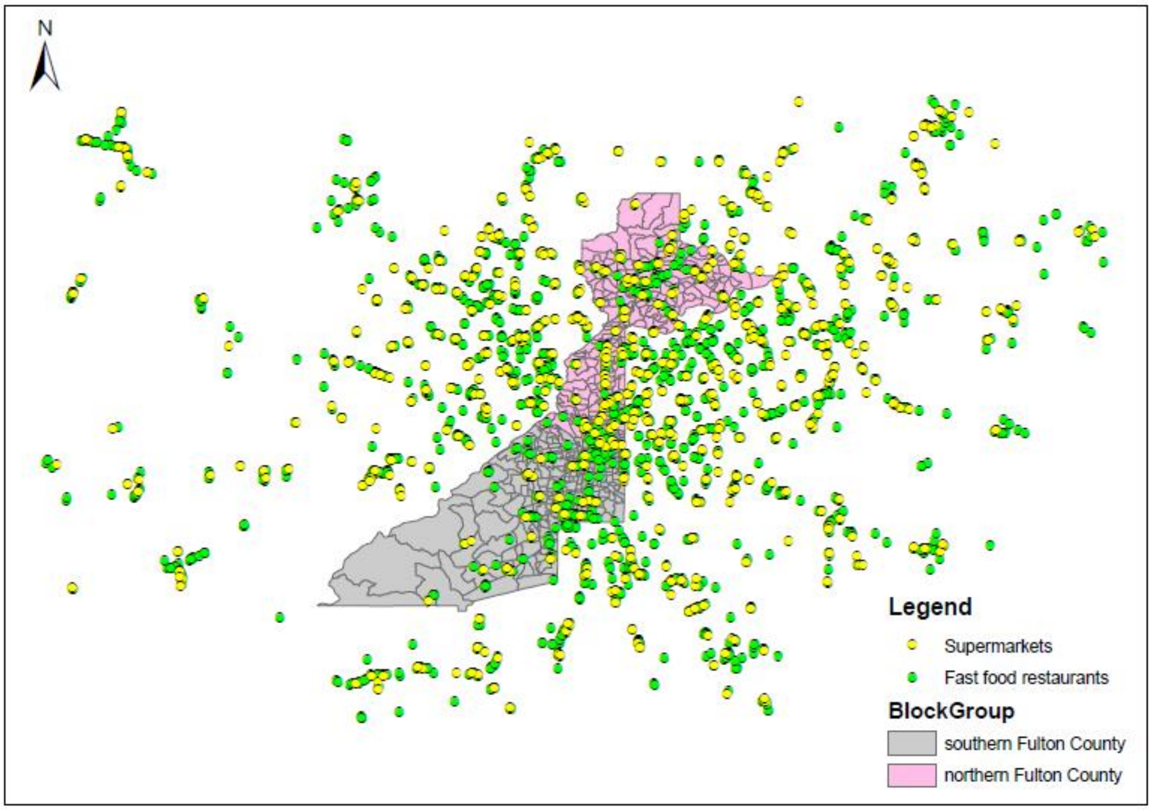

Figure 1 – Supermarkets and fast food restaurants included in this study.

2.4 Accessibility to The Food Environment

Accessibility was defined in terms of availability in this study. Availability measures focus on the number of food outlets within a “catchment area”, usually represented by a buffer around the local neighborhood. Depending on the local settings, the radius of the buffer can vary from 500 meters to 1 mile, representing the walking distance in different local settings (Larsen & Gilliland, 2008; Morland et al., 2002; Richardson et al., 2012). The underlying assumption of availability measure is that the food outlets within the catchment area are equally accessible, while the food outlets outside being not accessible at all. Another assumption of availability measure is that supermarkets and fast food restaurants will have enough capacity to serve all potential customers within the catchment area. Thus, the store footage is not considered in food accessibility studies (Larsen & Gilliland, 2008; Morland et al., 2002; Richardson et al., 2012).

Ver Ploeg et al. (Ver Ploeg, Mancino, Todd, Clay, & Scharadin, 2015) found that average US households travelled 4.01 miles for grocery if they were drivers, and only 0.92 miles if they rely on walking, biking, or public transportation (non-drivers). To reflect the difference in the mobility between drivers and non-drivers, two accessibility measures were defined for the two scenarios in this study. The author first created 4.01-mile and 0.92-mile buffers around the geometric centroid of each block group in ArcGIS 10.3 software to represent the catchment areas for drivers and non-drivers, respectively. The number of supermarkets and fast food restaurants in the catchment areas were then counted using the “join data from another layer based on spatial location” function in ArcGIS 10.3 software. After that, two accessibility measures (Equation 1 and 2) were calculated to evaluate the balance of healthy and unhealthy food for drivers and non-drivers, respectively (Powell et al., 2007; Raja, Ma, & Yadav, 2008).

Driver's scenario:

$$\text{measure } 1 = \frac{\dfrac{h_{D,i}}{u_{D,i} + h_{D,i}}}{\dfrac{h_{D,s}}{u_{D,s} + h_{D,s}}} \tag{1}$$

Non-driver's scenario

$$\text{measure } 2 = \frac{\dfrac{h_{ND,i}}{u_{ND,i} + h_{ND,i}}}{\dfrac{h_{ND,s}}{u_{ND,s} + h_{ND,s}}} \tag{2}$$

where h and u represent the number of healthy food outlets (supermarkets) and unhealthy food outlets (fast food restaurants) in the associated catchment areas, subscript D and ND represent the driver's and non-driver's scenario, and subscript i and s represent the block group of interest and the entire study area (Fulton County), respectively. A higher value of the measure suggests a healthier balance of food outlet with relatively more supermarkets and relatively less fast food restaurants, and indicates a healthier accessible food environment. In addition, these two measures were normalized across the study area with a mean of one. Thus, a measure greater than one indicates a healthier food outlet balance compared to the entire study area, and a measure smaller than one the opposite.

2.5 Statistical Framework

Since the measures were normalized to a mean of one, the author created binary variables to categorize the food outlet balance of a neighborhood: “healthy balance” for neighborhoods whose measures were greater than one; and “unhealthy balance” for the rest.

The neighborhood differences between the healthy and unhealthy balance were evaluated using the Mann-Whitney Test[1] in the driver’s and the non-driver’s scenarios. In addition, the author used logistic regression to examine the associations of neighborhood food outlet balance (healthy vs. unhealthy) with neighborhood demographic and socioeconomic variables. Two models were estimated, one for the driver’s scenario, and the other for the non-driver’s scenario. For each regression, the “best-subset” technique was utilized to specify 200 preliminary models with the lowest AIC values using the neighborhood demographic and socioeconomic variables identified in Table 1. The r package called “bestglm” developed by A. I. McLeod and C. Xu (McLeod & Xu, 2010) was used to complete this task. After identifying the preliminary models, the author selected the models that included variable Black and Income, the two variables of interest in this study. Model diagnoses were then performed to select the final model with no specification errors or multicollinearity issues using STATA 14.

[1] Mann-Whitney Test is a nonparametric test used to compare differences in the means between two independent groups without assuming the variables are normally distributed.

CHAPTER 3. RESULTS

3.1 Descriptive Statistics

The descriptive statistics for in neighborhood characteristics in the driver's and non-driver's scenarios can be found in Table 3. For non-drivers, neighborhoods with unhealthy balance, on average, had a significantly higher ratio of black residents (0.512 vs. 0.375), lower median household income (0.063 vs. 0.072), higher ratio of families living below the US poverty level (0.184 vs. 0.135), higher ratio of household receiving Food Stamps/SNAP (0.179 vs. 0.145), higher unemployment rate (0.134 vs. 0.113), lower overall education attainment level, higher ratio of lone-parent children (0.489 vs. 0.400), lower population density (4.075 vs. 4.461), higher ratio of commuters using public transportation (0.105 vs. 0.086) , lower ratio of population living in urbanized area (0.992 vs. 0.998), higher intersection density (0.446 vs 0.368), and lower ratio of block groups in northern Fulton County (0.404 vs. 0.571), compared to neighborhoods with healthy balance. The differences in the other variables were not significant at 5% significance level.

Most of the trends were also identified for drivers, only to an even greater extent: Neighborhoods with unhealthy balance, on average, had a significantly higher ratio of black residents (0.580 vs. 0.264), lower median household income (0.052 vs. 0.091), higher ratio of families living below the US poverty level (0.216 vs. 0.082), higher ratio of household receiving Food Stamps/SNAP (0.221 vs. 0.076), higher unemployment rate (0.153vs. 0.0.082), lower overall education attainment level, higher ratio of lone-parent children (0.552 vs. 0.296), higher ratio of commuters using public transportation (0.124 vs. 0.055), higher intersection density (0.461 vs 0.182), and lower ratio of block groups in northern Fulton County (0.238 vs. 0.846), compared to neighborhoods with healthy balance. The only reversed trend was population density, where neighborhoods with unhealthy balance had significantly higher population density (4.422 vs. 3.876), compared to neighborhoods with healthy balance. Significant differences were also observed in other variables: Neighborhoods with unhealthy balance, on average, had higher ratio of renter-occupied housing units (0.528 vs. 0.384), lower female population (0.831 vs. 1.072), and lower children population (0.348 vs. 0.504). The differences in all other variables were not significant at 5% significance level.

3.2 Logistic Regression Models

3.2.1 Non-driver's scenario

The final model for the non-driver's scenario was built using 6 variables: ratio of non-Hispanic African American residents, Median household income, ratio of families living below the US poverty level, ratio of households receiving Food Stamps/SNAP, female population, and the dummy variable indicating the location of block group (see model 1 in Table 4). Controlling for other variables, model shows that, on average, a one percent increase in the ratio of non-Hispanic African American residents (Black) and the median household income (Income) were associated with a 0.445% and 0.19% decrease in the log odds of the neighborhood having a healthy vs. unhealthy food outlet balance for non-drivers, respectively. However, only the ratio of non-Hispanic African American residents was significant at the 1% significance level. The median household income did not appear to be significant (p-value = 0.095). Holding other variables at their respective means, the predicted probability of having a healthy food outlet balance with changes in variable Black and Income can be found in Figure 2 below. The variance inflation factor

(VIF) of the independent variables in Table 4 suggested no severe multicollinearity issues (Kutner, Nachtsheim, & Neter, 2004).

3.2.2 Driver's scenario

The final model for driver was built using 9 variables: ratio of non-Hispanic African American residents, median household income, ratio of households receiving Food Stamps/SNAP, ratio of residents over age 25 with high school diploma or above, population density, ratio of residents over age 16 that use public transportation for commute purposes, children population, intersection density, and the dummy variable indicating the location of block group (see model 2 in Table 4). Controlling for other variables, the model shows that, on average, a percent increase in the ratio of non-Hispanic African American residents (Black) and the median household income (Income) were associated with 1.088% and 0.098% increase in the log odds of the neighborhood having a healthy food outlet balance vs. unhealthy balance in the driver's scenario, respectively. Similar to the model for non-drivers, only ratio of non-Hispanic African American residents was found significant at the 5% significance level. Income did not appear to be significant (p-value = 0.407). Holding all other variables at their respective means, the predicted probability of having a healthy food outlet balance with changes in variable Black and Income can be found in Figure 3 below. The variance inflation factor (VIF) of the independent variables in Table 4 suggested no severe multicollinearity issues (Kutner et al., 2004).

3.2.3 Comparison of two models

The ratio of non-Hispanic Black resident (Black) was a significant variable identified in the models for driver's and for non-driver's. The impact of this variable, however, is in opposite directions: Black was negatively associated with the odds of a neighborhood having a healthy food outlet balance for non-drivers (elasticity = -0.445%), but was positively associated with the odds of having a healthy food outlet balance for drivers (elasticity = 1.088%). The median household income (Income) also demonstrated reversed trends in the elasticities of two models (-0.19% for non-drivers vs. +0.098% for drivers). But Income was identified as an insignificant variable in both models.

Besides Black and Income, two other variables (ratio of households receiving Food Stamps/SNAP, dummy variable indicating whether the block group is located in northern Fulton County) were included in both models. Ratio of households receiving Food Stamps/SNAP was found significant in both models. Meanwhile, the dummy variable indicating the location of the block group was found significant in the model for drivers, but not in the model for non-drivers.

As for the other variables, the ratio of families living below the US poverty level and female population were only included in the model for non-drivers, with the former variable found significant at 5% significance level. The ratio of residents over age 25 with high school diploma or above, population density, ratio of residents over age 16 that use public transportation for commute, children population, and intersection density were only included in the model for drivers, with population density and intersection density being significant at the 5% significance level.

3.2.4 Model Robustness

To ensure robust parameter estimations, the author used the "Linktest" to diagnosis potential model specification errors (Pregibon, 1981) in STATA 14. Using the fitted parameters, the Linktest command firstly calculates the expected values of the binary dependent variable, *_hat*, and the corresponding square term, *_hatsq*. Next, the program fits the binary dependent variable with variable *_hat* and *_hatsq*. When the model is robustly specified, *_hat* should appear to be significant, while *_hatsq* should not. Test results in Table 5 suggested no evidence of specification error.

Table 3 – Mean and Standard deviation (in parentheses) of neighborhood characteristics by food outlet balance categories

Neighborhood characteristics	Non-driver's scenario		Driver's scenario	
	healthy balance	**unhealthy balance**	**healthy balance**	**unhealthy balance**
Non-Hispanic African American residents (ratio)	0.375 (0.365)***	0.512 (0.390)***	0.264 (0.328)***	0.580 (0.371)***
Median household income (million $)	0.072 (0.048)*	0.063 (0.048)*	0.091 (0.052)***	0.052 (0.039)***
Families living below the US poverty level (ratio)	0.135 (0.167)***	0.184 (0.196)***	0.082 (0.121)***	0.216 (0.202)***
Households receiving Food Stamps/SNAP (ratio)	0.145 (0.171)*	0.179 (0.181)*	0.076 (0.119)***	0.221 (0.186)***
Residents over age 16 that are unemployed (ratio)	0.113 (0.100)*	0.134 (0.111)*	0.082 (0.072)***	0.153 (0.116)***
Residents over age 25 with high school diploma or less (ratio)	0.254 (0.207)**	0.304 (0.203) **	0.186 (0.157)***	0.345 (0.208)***
Residents over age 25 with high school diploma or above (ratio)	0.899 (0.118)*	0.886 (0.107)*	0.942 (0.073)***	0.860 (0.119)***
Children under age 18 that live with one parent (ratio)	0.400 (0.334)**	0.489 (0.359)**	0.296 (0.292)***	0.552 (0.351)***
Population density (thousand person/square mile)	4.461 (3.495)***	4.075 (4.916)***	3.876 (3.967)*	4.422 (4.702)*
Residents over age 16 that use public transportation for commute (ratio)	0.086 (0.117)*	0.105 (0.121)*	0.055 (0.089)***	0.124 (0.127)***
Housing units that are renter occupied (ratio)	0.470 (0.276)	0.477 (0.298)	0.384 (0.305)***	0.528 (0267)***
Female population (thousand person)	0.857 (0.525)	0.959 (0.708)	1.072 (0.647)***	0.831 (0.632)***
Children population (thousand person)	0.372 (0.330)	0.426 (0.432)	0.504 (0.429)***	0.348 (0.366)***
Residents living in urban area per USDA classification (ratio)	0.998 (0.023)*	0.992 (0.068)*	0.996 (0.028)	0.993 (0.066)
Presence of major highway? (0 - No, 1 - Yes)	0.280 (0.452)	0.320 (0.468)	0.320 (0.467)	0.300 (0.459)
Intersection density (thousand intersection/square mile)	0.396 (0.368)**	0.381 (0.446)**	0.260 (0.182)***	0.461 (0.495)***
Located to the North of Fulton County's centroid? (0 – No, 1 – Yes)	0.571 (0.496)***	0.404 (0.491)***	0.846 (0.362)***	0.238 (0.427)***
N	198	339	201	336

Note: Asterisk indicates significant difference in mean using Mann-Whitney Test. ***p<0.001, **p<0.01, *p<0.05

Table 4 – "Best-subset" logit models for neighborhood food outlet balance (healthy vs. unhealthy) with neighborhood characteristics.

Neighborhood characteristics	OR	Standardized OR	Elasticity	VIF
Model 1: non-driver's scenario				
Non-Hispanic African American residents (ratio)	0.253**	0.587**	-0.445**	4.47
Median household income (million $)	0.009	0.796	-0.190	2.33
Families living below the us poverty level (ratio)	0.147*	0.698*	-0.223*	2.71
Households receiving food stamps/snap (ratio)	15.276*	1.626*	0.308*	4.30
Female population (thousand person)	0.737	0.821	-0.184	1.05
Located to the north of Fulton county's centroid? (0 – no, 1 – yes)	1.598	1.264	0.119	2.62
Constant	1.346	NA	NA	NA
N	537			
Model 2: driver's scenario				
Non-Hispanic African American residents (ratio)	20.015***	3.186***	1.088***	5.55
Median household income (million $)	20.633	1.158	0.098	2.77
Households receiving food stamps/snap (ratio)	0.033*	0.545*	-0.472*	3.81
Residents over age 25 with high school diploma or above (ratio)	10.923	1.305	1.286	2.20
Population density (thousand person/square mile)	1.071*	1.359*	0.191*	1.43
Residents over age 16 that use public transportation for commute (ratio)	7.236	1.267	0.154	1.93
Children population (thousand person)	1.648	1.220	0.109	1.14
Intersection density (thousand intersection/square mile)	0.135**	0.433**	-0.578**	1.77
Located to the north of Fulton county's centroid? (0 – no, 1 – yes)	45.853***	6.753***	0.570***	3.32
Constant	0.003**	NA	NA	NA
N	537			

Note: Asterisk indicates significance level. ***p<0.001, **p<0.01, *p<0.05

Table 5 – Linktest results.

Model 1: non-driver's scenario	
	p-value
_hat	0.046
_hatsq	0.626
Model 2: driver's scenario	
	p-value
_hat	0.000
_hatsq	0.088

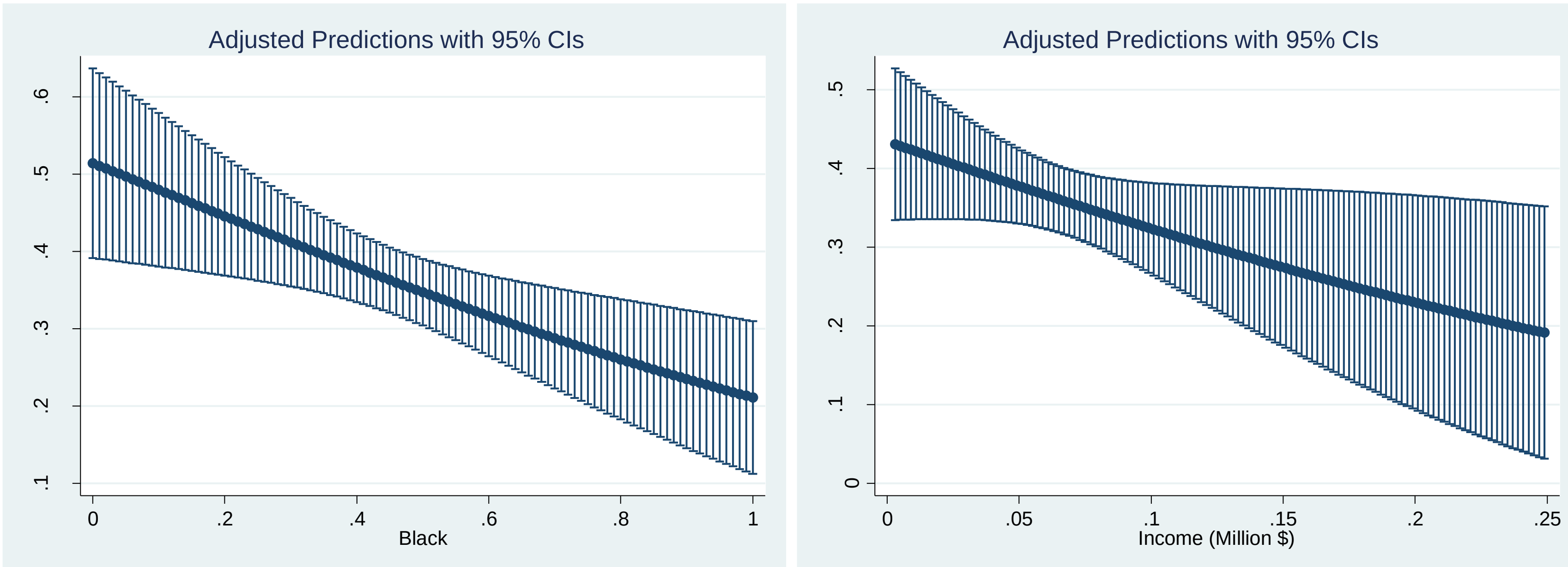

Figure 2 – The probability and the 95% confidence interval of having a healthy food outlet balance for non-drivers with changes in Income and Black.

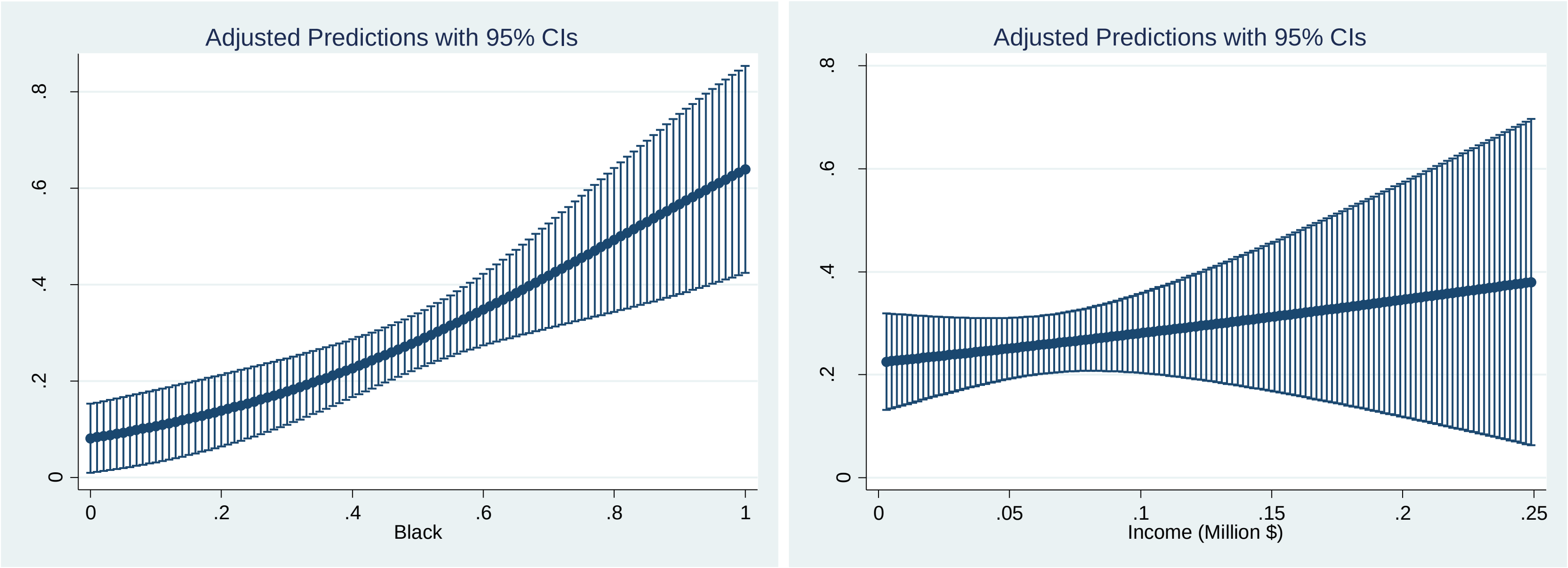

Figure 3 – The probability and the 95% confidence interval of having a healthy food outlet balance for drivers with changes in Income and Black

CHAPTER 4. DISCUSSION

The results of this study suggest that differences exist in the accessible food environment (healthy vs. unhealthy food outlet balance) by neighborhood characteristics. Controlling for other variables, the finding regarding the decreased odds of having healthy food outlet balance in Black-dominant neighborhoods for non-drivers show a consistent trend with previous studies, as researchers have found that Black-dominant neighborhoods, on average, had greater accessibility to fast food restaurants (Block et al., 2004; James et al., 2014; Powell et al., 2007) and worse accessibility to supermarkets (Morland et al., 2002; Zenk et al., 2005).

The increased odds of having healthy food outlet balance in Black-dominant neighborhoods for drivers, on the other hand, offers new insights in food accessibility studies. This finding suggests that owning a personal vehicle can mitigate, and even reverse the trend in which the disparities exist. By expanding the catchment area, people in Fulton County are actually more likely to find a healthy food outlet balance if they reside in Black-dominant neighborhoods. This is an encouraging finding, as households in Metro Atlanta owned, on average, about two vehicles (Atlanta Regional Commission, 2011).

While neighborhood income level was identified as a significant factor in the accessibility to supermarkets (Larsen & Gilliland, 2008; Morland et al., 2002), and to fast food restaurants (Lewis et al., 2011; Morland et al., 2002), the result regarding the insignificant impact of median household income on the odds of a neighborhood having healthy vs. unhealthy food outlets balance for both drivers and non-drivers indicates that, should the income level have significant influence (regardless of the direction) on the accessibility to supermarkets or fast food restaurants, such influence should be one directional, such that the food outlet balance would not be significantly impacted. This implication is consistent with Lamichhane et al. (Lamichhane et al., 2013), where the authors identified an increased availability of both supermarkets and fast food restaurants in affluent neighborhoods.

The results of this study also suggest that compared to the income level, the racial composition is a more determining factor in a neighborhood's food outlet balance. These findings might reflect the site selection strategies of supermarkets and fast food restaurants, and the way how these chains identify "profitable" area to locate themselves. Therefore, future planning efforts should focus on incentives or programs that bring more food outlets, especially those that sell fresh produce, to a closer proximity of Black-dominant neighborhoods. A recent practice by MARTA, the major public transportation system that serves primarily non-Hispanic Black population (78% of the ridership) in Metro Atlanta area, has demonstrated some opportunities in this area (Hess, 2012). In Fall 2015, MARTA launched a weekly fresh market program at the West End MARTA Station trying to bring more fresh produce to local communities (Simmons, 2015). The fresh market had, on average, more than 700 items sold on a weekly basis (King, 2016). Receiving positive responses from local residents, MARTA planned to expand this fresh market program to more stations in 2016 to get more communities involved (Williams, 2016). The extent to which this program might impact the food outlet balance, however, remains unclear. One research objective for future research could be to investigate the impact of transforming a transit hub into a fresh market on the food outlet balance in Metro Atlanta area at different stages (early test stage, intermediate stage, full build-out stage, etc.), and identify the best expansion plan for MARTA.

CHAPTER 5. CONCLUSIONS

This study accounted for the co-occurrence of supermarkets and fast food restaurants by analyzing the food outlet balance in Fulton County, Georgia. The author found that the racial composition is a significant factor in determining the neighborhood's food environment in Fulton County: Black-dominant neighborhoods are more likely to have an unhealthy food outlet balance for non-drivers. Such disparity, however, is offset and even reversed from a driver's perspective. In addition, no significant impact was found of the neighborhood income level on the neighborhood's food outlet balance, regardless of the car ownership status. Considering these findings, future planning efforts should focus on incentives and programs that attract more food outlets, especially those who sell fresh produce, to a closer proximity of Black-dominant neighborhoods. MARTA's fresh market program is a potential solution that warrants further investigation.

CHAPTER 6. ACKNOWLEGEMENT

This material is based upon work supported by the National Science Foundation under Grants nos. 1300918 and 1441208.

REFERENCES

American Heart Association. (2016). Understanding the American Obesity Epidemic. Retrieved from http://www.heart.org/HEARTORG/HealthyLiving/WeightManagement/Obesity/Understanding-the-American-Obesity-Epidemic_UCM_461650_Article.jsp#.V_2ZYvkrKUk

Atlanta Regional Commission. (2011). 2011 Transportation fact book. Retrieved from http://documents.atlantaregional.com/transportation/TPD2011factbook_v04.pdf

Binkley, J. K. (2006). The effect of demographic, economic, and nutrition factors on the frequency of food away from home. *Journal of consumer Affairs, 40*(2), 372-391.

Block, J. P., Scribner, R. A., & DeSalvo, K. B. (2004). Fast food, race/ethnicity, and income: a geographic analysis. *Am J Prev Med, 27*(3), 211-217. doi:10.1016/j.amepre.2004.06.007

Burns, R. (2014). Stranded in Atlanta's Food Deserts - Atlanta Magazine. Retrieved from http://www.atlantamagazine.com/great-reads/stranded-in-atlantas-food-deserts/

Cannuscio, C. C., Tappe, K., Hillier, A., Buttenheim, A., Karpyn, A., & Glanz, K. (2013). Urban food environments and residents' shopping behaviors. *American journal of preventive medicine, 45*(5), 606-614.

Center for Disease Control and Prevention. (2014). General Food Environment Resources. Retrieved from https://www.cdc.gov/healthyplaces/healthtopics/healthyfood/general.htm

Hess, A. (2012). Race, Class, and the Stigma of Riding the Bus in America. Retrieved from http://www.citylab.com/cityfixer/2012/07/race-class-and-stigma-riding-bus-america/2510/

James, P., Arcaya, M. C., Parker, D. M., Tucker-Seeley, R. D., & Subramanian, S. V. (2014). Do minority and poor neighborhoods have higher access to fast-food restaurants in the United States? *Health Place, 29*, 10-17. doi:10.1016/j.healthplace.2014.04.011

King, H. (2016, March 9, 2016). [MARTA Market Produce Summary 2015].

Kutner, M. H., Nachtsheim, C., & Neter, J. (2004). *Applied linear regression models*: McGraw-Hill/Irwin.

Kwate, N. O. A., Yau, C.-Y., Loh, J.-M., & Williams, D. (2009). Inequality in obesigenic environments: fast food density in New York City. *Health & place, 15*(1), 364-373.

Lamichhane, A. P., Warren, J., Puett, R., Porter, D. E., Bottai, M., Mayer-Davis, E. J., & Liese, A. D. (2013). Spatial patterning of supermarkets and fast food outlets with respect to neighborhood characteristics. *Health Place, 23*, 157-164. doi:10.1016/j.healthplace.2013.07.002

Larsen, K., & Gilliland, J. (2008). Mapping the evolution of 'food deserts' in a Canadian city: supermarket accessibility in London, Ontario, 1961-2005. *Int J Health Geogr, 7*, 16. doi:10.1186/1476-072X-7-16

Lewis, L. B., Sloane, D. C., Nascimento, L. M., Diamant, A. L., Guinyard, J. J., Yancey, A. K., & Flynn, G. (2011). African Americans' access to healthy food options in South Los Angeles restaurants. *American journal of public health*.

McLeod, A. I., & Xu, C. (2010). Bestglm: Best Subset GLM - R. Retrieved from https://cran.r-project.org/web/packages/bestglm/vignettes/bestglm.pdf

Morland, K., Wing, S., Roux, A. D., & Poole, C. (2002). Neighborhood characteristics associated with the location of food stores and food service places. *American journal of preventive medicine, 22*(1), 23-29.

Oliver, L. N., & Hayes, M. V. (2005). Neighbourhood socio-economic status and the prevalence of overweight Canadian children and youth. *Canadian Journal of Public Health/Revue Canadienne de Sante'e Publique*, 415-420.

Paeratakul, S., Ferdinand, D. P., Champagne, C. M., Ryan, D. H., & Bray, G. A. (2003). Fast-food consumption among US adults and children: dietary and nutrient intake profile. *Journal of the American dietetic Association, 103*(10), 1332-1338.

Powell, L. M., Chaloupka, F. J., & Bao, Y. (2007). The availability of fast-food and full-service restaurants in the United States: associations with neighborhood characteristics. *American journal of preventive medicine, 33*(4), S240-S245.

Pregibon, D. (1981). Logistic regression diagnostics. *The Annals of Statistics*, 705-724.

Raja, S., Ma, C., & Yadav, P. (2008). Beyond food deserts measuring and mapping racial disparities in neighborhood food environments. *Journal of Planning Education and Research, 27*(4), 469-482.

Richardson, A. S., Boone-Heinonen, J., Popkin, B. M., & Gordon-Larsen, P. (2012). Are neighbourhood food resources distributed inequitably by income and race in the USA? Epidemiological findings across the urban spectrum. *BMJ Open, 2*(2), e000698. doi:10.1136/bmjopen-2011-000698

Simmons, A. (2015). Fresh MARTA Market a 'success,' plans for expansion. Retrieved from http://commuting.blog.ajc.com/2015/07/14/fresh-marta-market-a-success-plans-for-expansion/

Skelton, J. A., Cook, S. R., Auinger, P., Klein, J. D., & Barlow, S. E. (2009). Prevalence and trends of severe obesity among US children and adolescents. *Academic pediatrics, 9*(5), 322-329.

Smoyer-Tomic, K. E., Spence, J. C., Raine, K. D., Amrhein, C., Cameron, N., Yasenovskiy, V., . . . Healy, J. (2008). The association between neighborhood socioeconomic status and exposure to supermarkets and fast food outlets. *Health Place, 14*(4), 740-754. doi:10.1016/j.healthplace.2007.12.001

United States Census Bureau. (2012). 2010 Geographic Terms and Concepts - Block Groups. Retrieved from https://www.census.gov/geo/reference/gtc/gtc_bg.html

Ver Ploeg, M., Mancino, L., Todd, J. E., Clay, D. M., & Scharadin, B. (2015). Where do Americans usually shop for food and how do they travel to get there? Initial findings from the national household food acquisition and purchase survey. *US Department of Agriculture, Economic Research Service, Washington, DC*.

Walker, R. E., Block, J., & Kawachi, I. (2013). The Spatial Accessibility of Fast food Restaurants and Convenience Stores in Relation to Neighborhood Schools. *Applied Spatial Analysis and Policy, 7*(2), 169-182. doi:10.1007/s12061-013-9095-6

Wardle, J., Waller, J., & Jarvis, M. J. (2002). Sex differences in the association of socioeconomic status with obesity. *American journal of public health, 92*(8), 1299-1304.

Williams, D. (2016). MARTA Expanding Fresh Markets Program. Retrieved from http://www.bizjournals.com/atlanta/news/2016/09/12/marta-expanding-fresh-markets-program.html

Wrigley, N., Warm, D., & Margetts, B. (2003). Deprivation, diet, and food-retail access: Findings from the Leeds ‘food deserts' study. *Environment and Planning A, 35*(1), 151-188.

Zenk, S. N., Schulz, A. J., Israel, B. A., James, S. A., Bao, S., & Wilson, M. L. (2005). Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *American journal of public health, 95*(4), 660-667.