The Socio-Spatial Relationship between Los Angeles County Youth Health and Food Establishments

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Arts
in Geography

By
Geoffrey West

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The thesis of Geoffrey West is approved:

_______________________________________ ___________________
Dr. Soheil Bouroshaki Date

_______________________________________ ___________________
Dr. Regan Maas Date

_______________________________________ ___________________
Dr. Steven Graves, Chair Date

California State University, Northridge
Dedication

This thesis is dedicated to my parents Clarence and Lashea West, teachers, and loved ones. Without their endless love, support, and guidance I would not be able to complete this research.
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ABSTRACT

Investigating the Socio-Spatial Relationship between Los Angeles County Youth Health and Food Establishments

By

Geoffrey West

Master of Arts in Geography

This research assesses the relationship the health of youth in Los Angeles County and neighborhood access to food establishments. The California Department of Education Physical Fitness Tests were used in conjunction with census variables to assess the effect of easy accessibility to fast food restaurants has on the health of school aged children in Los Angeles County. Spatial statistics and GIS were used to measure the relationship. Location Quotient (LQ) was used to measure the relative access of neighborhoods to fast food restaurants and grocery stores in the county. Additionally, linear regression models and geographically weighted regression (GWR) were used to measure the effect of the built environment on youth health. The results indicate that access to fast food has a modest effect on health outcomes among young people in Los Angeles.

Key words: Geographically Weighted Regression, Food Deserts, Spatial Statistics, Geography, Youth Health and GIS
1. INTRODUCTION

Access to healthy food has been a popular topic in the social sciences in recent years. Studies have illumined the connections between socio-economic status and health, in addition to the types of food that are available and access. Previous studies have indicated positive correlations between healthy food accessibility and community health. By determining the spatial trends in the availability of nutritious foods, better decision-making power may arise from policy makers and stakeholders can occur which will perpetuate health care and regional planning policies and procedures.

Access to nutritional foods is integral for maintaining the health of a community. Throughout the United States, local health departments have stepped in to fight the battle against a number of public health detriments, including obesity. These health departments have initiated agendas to inform citizens about healthy food options. Additionally, the Los Angeles Department of Public Health has recently published a study on the prevalence of obesity and other associated diseases such as the prevalence of diabetes. The purpose of this study is to delineate the relationship between Los Angeles County food establishments and youth health by using a geographic information system (GIS) and spatial statistics. This thesis focuses on two major research questions. First, is there any correlation in fast food restaurant accessibility and youth health? Second, how can food access be defined better? Literature (Chen, et al., 2009, Morland, et al., 2006, Powell, et al., 2007, Fraser 2011) has indicated that the growth of the fast food industry has played a significant role in deteriorating youth health. This study tests a hypothesis that asserts that if a neighborhood has above average spatial access to fast food, then health indicators in those neighborhoods will be significantly worse. Additionally, this study seeks to determine if geographically weighted regression techniques are viable methods to delineate
spatial relationships between test variables and define methods of access. This study utilizes in a unique manner, location quotient (LQ), which is a measure of relative access to fast food. In this study, a food desert is characterized by any geographic area with a fast food restaurant LQ over 100 but a grocery market LQ under 100. Moreover, I propose to utilize location quotient as a standardized measurement for food access. The use of this statistic captures the economic climate wherein consumers shop and ultimately delineates spatial trends that affect a neighborhood. By using multivariate regression techniques, the effect of fast food access on health outcomes can be measured, while controlling for several socio-economic variables.

This thesis is divided into four additional chapters. Chapter Two contains a review of current research on the state on food accessibility and its association with multiple public health factors. Chapter Three reviews the state of GIS in food security and health research. Chapter Three also introduces the data and methods used in this research. An overview of socio-economic and spatially inherent variables is discussed. Chapter Four discusses the results from the analyses including location quotient values and the results from global and local regression models. The fifth chapter includes an analysis of the study results along with the limitations of the data and methods, future directions, and policy implications.
2. LITERATURE REVIEW

Recent literature (Fraser 2011; Lucan and Mitra 2011) has documented the utilization of geographic information systems (GIS) and spatial statistics as an increasingly popular and viable methodology in food security and public health research. By implementing these methods, researchers are able to identify and delineate spatial relationships between healthy food access and other socio-economic variables such as income and health indicators. This chapter investigates common themes in food security literature, such as definitions of food access and health implications in food security. Additionally, this chapter reviews responses to help alleviate food insecurity. Lastly, a review of GIS methodologies is presented which have been executed in similar studies.

Defining Access

As defined by the United States Department of Agriculture (USDA) food security is having adequate access to healthy food options, such as fresh or frozen fruits and vegetables (USDA 2012). There are many ways to define accessibility to healthy food options. McEntee and Ageyman (2006) defined geographic access as the proximity that an individual is within a store or location to acquire healthy or nutritional food options. They also identified informational access and economic access as important variables in the capacity to acquire healthy food options. Economic access refers to the affordability of food in addition to the expenses such as travel that it requires to acquire nutritional foods, while informational access encompasses a wide range of factors that relate to the educational, cultural, and social constraints that influence how and why people choose to eat certain foods. Clearly these three elements of access are synergistic. (Elwood 2006; McCoy 2010) have shown that technological advances such as participatory geographic information systems (PPGIS) and community based research practices
help alleviate socio-economic stressors such as food insecurity. In 2010, 14.5 percent (17.2 million) of American households were considered food insecure (Coleman-Jensen Page 2011). Additionally, it is reported that in 2007, 16 percent of households with children were food insecure throughout the year, and 80 percent of households with children, one or more of the children experienced very low food security. The latter is the most severe condition measured by the USDA (USDA 2012).

Food Deserts

An area where there is a less than adequate supply of healthy food is called a food desert (Malekty 2006; McCoy 2010; McEntee 2006; Opfer 2010). This term was first coined in Scotland in the early 1990s to describe poor access to an affordable or nutritional diet (Beaulac 2009). If these foods, such as fruits and vegetables, are made available they are found at a higher cost in price or accessibility. Food deserts may have a high concentration of retail establishments which specialize in the sale of foods high in starch and/or fats. These establishments include limited service restaurants (fast food) and convenience stores.

Food insecurity should not be thought as an overarching theme for a geographic area, the definition of a food desert in an urban neighborhood is generally noted as a low-income neighborhood where a substantial number or share of residents has poor access to a mainstream supermarket or large grocery store. Low-income refers to areas with poverty rates of 20 percent or higher, or a median family income at or below 80 percent of the region’s median family income. Poor access refers to at least 500 people and/or 33 percent of the neighborhood’s population residing more than one mile from a supermarket or larger grocery store. The aforementioned elements of an urban food desert apply to those that lie within rural areas too; aside from the minimum distance from a supermarket which qualifies the area is ten miles. This
discrepancy has caused a gap in research methodologies. Recent literature analyzing food deserts has generally illustrated the food insecurity of either a rural or urban area, not both. Thus, there has not been a method which ranges across the rural to urban spectrum to successfully capture the geographic and spatial elements which influence access to healthy food options.

In addition to the term food desert, has also been identified as geographic areas where there is less than an adequate supply of readily available nutritious foods. Rose et. al (2009). Authors describe food swamps as areas in which large relative amounts of energy-dense snack foods, inundate healthy food options. Their study of New Orleans, LA illustrated the discrepancy between the large number of convenience stores (and lack of supermarkets), where the availability of snack foods significantly outweighed that of healthy foods.

Health and Food Security

Food insecurity has been reported to have a significant impact on the overall health of individuals (USDA 2011). Food insecurity not only illustrates the lack of nutritional food options, but the availability of unhealthy food options, such as fast foods. Fast food is known to be energy dense, high in saturated fat and have low micronutrients content and its consumption is associated with other poor food choices such as low fruit, vegetable and milk intake. (Fraser 2011).

The prevalence of obesity has increased dramatically in the United States since the mid-1970s, and nearly two of three adult Americans are either overweight or obese (USDA 2011). The consumption of fast food has been associated with increased body mass index (BMI) and obesity (Fraser 2011). As noted by the Centers for Disease Control (CDC), BMI is a number calculated from a person’s weight and height provides a reliable indicator of body fatness for most people and is used to screen for weight categories that may lead to health problems. Davis
and Carpenter (2009) indicated that in a study which examined the relationship between fast food restaurants near schools and obesity among California middle and high school students that exposure to poor-quality food environments has important effects on adolescent eating patterns and obesity. Additionally, the authors noted that policy interventions limiting the proximity of fast-food restaurants to schools could help reduce adolescent obesity. In 2010, 40 percent of Los Angeles County Middle School students were overweight or obese (Los Angeles Times 2010). Additionally, the Los Angeles Times (2010) reported that 35 percent of all adults were obese.

The birth of the fast food restaurant and the exponential growth of the industry almost parallel the obesity epidemic according to reviewed literature (Fraser 2011). It was reported that 45 percent of restaurants in South Los Angeles were fast food restaurants (Los Angeles Times 2010). One reason for the weight gain may be that a single meal from one of these restaurants often contains enough calories to satisfy a person’s caloric requirement for an entire day. In a 2005 study, authors suggested fast-food consumption has strong positive associations with weight gain and insulin resistance, suggesting that fast food increases the risk of obesity and type-2 diabetes (Pereira and Kartashov 2005).

Additionally authors have used statistical models in exploring other health related indicators to food security. Stuff and colleagues (2004) used a linear regression controlling for income, gender, and ethnicity. The model showed interaction between food insecurity status and race was a significant predictor of fair/poor health and lower scores on physical and mental health. Household food insecurity is associated with poorer self-reported health status of adults in their rural, high-risk case study in the Lower Mississippi Delta.

While food choices may be a strong indicator of quality of health, literature has also indicated that diet is only one of several key indicators of one’s health status. Gordon-Larsen et.
al (2009) reported that the built environment also plays a vital role on the health of a population. Regular physical activity helps promote a healthy lifestyle and reduces common factors which are associated with poor nutrition. The built environment encompasses a range of physical and social elements that make up the structure of a community. For children, this might include both school and recreational space. For adults, environments of interest might include residential space, work space, and characteristics of the travel environment between work, shopping, and personal business, social and recreational activities and the residence. For example, the amount of time spent daily commuting between home and work, as well as the quality of a person’s daily commute, has drawn attention for their potential impacts on health (Papas et al. 2007).

**Responding to Food Deserts**

Individuals and groups at the local and national levels have taken the initiative to alleviate food insecurity. Public health departments across the United States have completed studies on the impact of food insecurity and health consequences to educate and inform populations on what has now become an epidemic in many regions. Such studies have led to political intervention on the opening of new fast food restaurants in neighborhoods. In July 2008, the City of Los Angeles passed a ban which prohibited new fast food restaurants from opening in some the city’s unhealthiest neighborhoods. The ban covered 32 square-miles including neighborhoods of Baldwin Hills, Leimert Park, and West Adams. Councilwoman Jan Perry of Los Angeles noted that the decision to impose a moratorium of fast food restaurants is indicative of good planning and land-use decisions that affect public health much akin to that of zoning for industrial zones and removal of brownfields.

It was reported (Philadelphia Department of Public Health) in 2010 that in 2008 64 percent of Philadelphia’s children between the ages of 3-11 were overweight or obese, while
57 percent of city’s adults were overweight or obese. Consequently Philadelphia’s Public Health department has instilled a 5-year goal to reduce childhood and adult obesity. By doing so, the city has developed an action plan which includes developing a network of over 600 corner stores that sell and market healthy foods and beverages, and they have piloted citywide certification program to help market and sustain 10 new farmers’ markets in low-income communities, in addition to other initiatives.

At the national level, the USDA and Environmental Research Service have collaborated with geographic information system developers Environmental Systems Research Inc. (ESRI) to build a food desert locator to assist in the Healthy Food Financing Initiative (HFFI) healthy and affordable food program. The HFFI is part of Michelle Obama’s Let’s Move initiative which aims to expand the availability of nutritious foods to food deserts by developing and equipping grocery stores, small retailers, corner stores, and farmers markets with fresh and healthy food (USDA 2011).

Community food assessments are activities to systematically collect and disseminate information on selected community characteristics so that community leaders and agencies may devise appropriate strategies to improve their localities. CFAs are a first step in planning food security in a community. Community food security is a situation in which all community residents obtain a safe, culturally acceptable, nutritionally adequate diet through a sustainable food system that maximizes community self-reliance and social justice The impact of food insecurity in an area always affects more than one individual, thus the aforementioned components of food security dispels the idea that only a certain group of people have the capacity to end food deserts (Pothukuchi 2004).
Urban Agriculture involves the growing of crops and/or livestock within urban areas or at their periphery (Haletky 2006). While urban agriculture does not necessarily solve the problems of food insecurity in rural areas, it does however reemphasize the cultural, communal, and nutritional benefits available to city dwellers. Urban agriculture, such as community gardens, not only provide accessible, nutritional, and affordable foods to people, they also have the capacity to be a leading force in neighborhood revitalization by transforming vacant lots into farms or gardens while functioning as a community building activity. Additionally, in communities with high rates of joblessness and underemployment, urban gardens and farms have proved to be excellent vehicles for job training (Haletky 2006).

Spatial Statistics and GIS in Food Security Research

GIS and spatial statistics have proven to be extremely productive methods to measure spatial patterns of food access and related health indicators. Using a GIS aids not only in the analysis of health indicators, but makes possible compelling visualization of robust data sets to stakeholders including. Various statistics and analyses can be communicated alongside maps of neighborhood boundaries, topography and elements of the built environment.

Many studies (Matthews and Yang 2013; Opfer 2010, McEntee and Ageyman 2009) have used a buffer and point data to indicate the proximity of fresh food access from a centroid of a census tract or zip code. This method aids in the calculation of how many individuals are within a certain distance of a grocery store. Moreover, studies have also shown the utilization of techniques such as network analysis to indicate methods of vehicular and foot travel to reach health food options. Researchers at Michigan State University used a GIS to model individual transportation modes used by subjects to acquire fresh fruits and vegetables. The team gathered
data from 94 food retailers in Lansing, Michigan and used a 10-minute travel time threshold to show accessibility by vehicle or foot. The results indicated that individuals with vehicles have better access to fresh food options than those traveling by foot or other methods.

Spatial statistics have become increasingly popular in health, social, and demographic sciences. Geographically weighted regression (GWR) is a local spatial statistical technique used to analyze spatial non-stationarity, defined as when the measurement of relationships among variables differs from location to location (Mennis 2006). Lin and Wen (2011) utilized spatial statistics in ordinary least squares (OLS) and geographically weighted regression (GWR) to capture the non-stationarity of dengue cases in the cities of Kaohsiung and Fengshan. OLS is the precursor to GWR and captures a global, linear statistic. Thus, it does not relay spatial heterogeneity of relationships. Lin and Wen’s results indicated a GWR model can be used to geographically differentiate the relationships of dengue incidence with immature mosquito and human densities. Additionally, Yang and colleagues utilized an inventive technique in geographically weighted quantile regression (GWQR) to model the relationship between African-American Women’s BMI in Philadelphia with other socio-economic indicators. GWQR has been developed by integrating quantile regression (QR) with GWR, creating a synergy that makes it possible to simultaneously account for the heterogeneities across space and the distribution of a dependent variable (Yang, Matthews, and Chen 2012). QR is a statistical method which examines how predictors are associated with a dependent variable. GWR dissects the global spatial process into multiple local processes that are allowed to be heterogeneous across the research area and QR enables the examination of whether the associations between a dependent variable and predictors vary across a dependent variable’s distribution. The GWQR facilitates the comparison of relationships between BMI and the predictors across quantiles.
Literature reviewed illustrates methods such as location quotient and density counts to determine the concentration of a service or establishment available. Location quotient (LQ) is a useful tool to quantify the relative concentration of an activity in the analysis of area localization (Beyne and Moineddin 2005). LQ is an important measurement when quantifying the built environment for analysis. LQ has extensively been used by regional economists and economic geographers for making the comparison of an area's share of some activity with the share of some base aggregate such as employment, manufacturing, retail services, mortgage loans, health care services, etc. (Djira, Schaarschmidt, and Fayissa 2008). Graves and Peterson (2008) utilized LQ to investigate pay-day lending practices America’s “Bible Country” and examined religious views on such practices. Location quotient has the potential to offer an alternative measure of fast food density. A recent study by the RAND Corporation noted that other parts of Los Angeles have higher concentrations of fast food restaurants (Strum 2008). The RAND study captures the concentration of fast food restaurants per 100,000 residents, a per capita measure. By using LQ to delineate access to food availability, this study is essentially measuring fast food access in terms of business density, not human density. Additionally, a study conducted by public health advocacy group Community Health Councils Inc. reported that South LA has only 60 full-service grocery stores for an average of 22,156 residents. Techniques such as location quotient and density counts provide information which cannot easily be inferred using simple counts, or per capita measures of density. RAND (2008) found South Los Angeles to have a significantly lower concentration of fast food restaurants than the rest of the county. Per 100,000 residents, it has 19 fast-food chain establishments, compared with 29 in West Los Angeles and 30 in Los Angeles County. Additionally, the concentration of small corner grocery stores where
individuals may find unhealthy snacks is double the county average and triple that of West Los Angeles.
3. DATA AND METHODOLOGY

The data collection and methods used in this paper were simple and straightforward. Geography, socio-economic indicators, and built environment entities are discussed. These are all variables introduced in the literature review that provide a sound understanding of the spatial relationship between health, place, and quality of life. By implementing a GIS and employing spatial statistics, events of which change across a geography are identified. These observations have the capacity to explain epidemics in public health such as obesity, in addition to local business patterns. First, location quotient, an economic base analysis instrument which measures the concentration of businesses in Los Angeles County method is explained. Next, several spatial statistics which help delineate spatial patterns of the built environment in Los Angeles which may impact youth health are discussed. Geographically weighted regression is discussed as the primary methodology which is used to model relationships between Los Angeles County food establishments and youth health.

Study Area

The study area for this thesis is Los Angeles County, California (figure 1). Los Angeles County is located in Southern California with a total population of around ten million. The county covers 4,752 sq. miles and is home to 88 cities and 15 City Council Districts in addition to a number of other county, census, and city defined boundaries. The analysis for this research was executed at the ZIP code level, due to the heterogeneity in socio-economic attributes at this geography. Smaller units, such as census tracts or block groups were not chosen largely because the action space in which most people operate is at the “neighborhood” level and ZIP codes
better approximate that space. Smaller units have the additional problem of excessive multicollinearity in regression modeling. It is important to note that exceptional topographic and climatic features figure prominently in the landscape of Los Angeles County, including several mountain ranges and the Mojave Desert. Care was taken to ensure proper consideration of these ecological factors which greatly affect accessibility in some parts of the county.

**Data**

The primary datasets were acquired from the Los Angeles Department of Public Health (DPH) and California Department of Education (DOE). The DPH data includes a list of active restaurants and retail food markets in January and February 2013. The tabular datasets include the address list of all restaurants (n= 27,172) and markets (n= 12,216) that were open for business at the time the data was collected. These comprehensive datasets include the address, city, state, ZIP code, county supervisorial district, Department of Public Health (DPH) Service Planning Area (SPA), and census tract of each establishment. Additionally, the restaurant dataset includes the number of seats in each establishment while the markets dataset includes the square footage of each building. To identify restaurants which may have an impact on youth health in Los Angeles County, a pivot table was created in Microsoft Excel to generate the number of restaurant per ZIP code. Additionally, a pivot table was used to identify the most popular fast food chains in Los Angeles. The top ten restaurants identified match the definition of a fast food restaurant in the 2008 South Los Angeles fast food ordinance as any establishment which dispenses food for consumption on or off the premises, and which has the following characteristics a limited menu, items prepared in advance or prepared or heated quickly, no table orders, and food served in disposable wrapping or containers (City of Los Angeles 2008).
DPH identifies a food retail establishment here food is stored, prepared, served, packaged, transported, or otherwise handled for dispensing or sale directly to the consumer. This includes, but is not limited to, liquor stores, bakeries, grocery stores, meat markets, restaurants, cocktail lounges, soda fountains, coffee shops, vitamin stores, food or herbal supplement stores, food banks, employee in-plant feeding operations (cafeterias), food market retail in association with custom slaughterers (County of Los Angeles 2008).

The top ten restaurants are identified in Table 2. There were a total of 1,593 restaurants among the top 10 fast food restaurant franchises in Los Angeles County. These restaurants were manually sorted due to the variations of names for the same restaurant in the dataset. Several of these restaurants were used by Richardson and colleagues (2011) study which measured neighborhood fast food availability and consumption. The top ten fast food chains were used in the study at the ZIP code level as a proxy variable for fast food availability. In order to calculate the market and fast food location quotients census ZIP code business patterns were used for Los Angeles County (2010). This tabular data includes the number of businesses per ZIP code.

Similar studies (e.g., McCoy 2010) have utilized data from the US Census Bureau. The US Census’ County Business Patterns data uses the North American Industrial Classification System (NACIS) data to classify establishments. The NAICS system uses a 6 digit code to identify every establishment in by the United States by industry and for some, one or more industrial subcategories. While this data set has proven viable in other studies, the utilization of DPH’s dataset allows for a more accurate count of restaurants and food markets than available from the US Census’ County Business Patterns. DPHs data includes more local boundaries such as SPAs which were created to help local officials provide more relevant public health and clinical services targeted to the specific health needs of the residents in these different areas.
There are eight SPAs in Los Angeles County. By recognizing spatial trends in data that are aggregated at this level, resources and funds may be better allocated to enhance public health.

The dependent variable in the study is a measure of physical fitness among fifth graders in the public schools within Los Angeles County. The 2011 California Board of Education physical fitness test results for Los Angeles County were downloaded from the California Board of Education website. The Board of Education administers a physical fitness test (PFT) for California students, in grades 5, 7, and 9. The test designated for this evaluation is the Fitnessgram. The Fitnessgram was designed by the Cooper Institute, a non-profit research and education institution dedicated to preventive medicine. The PFT provides a standardized criterion to evaluate youth health. These standards represent minimum levels of fitness known to be associated with those health and physical characteristics that offer protection against diseases resulting from physical inactivity. Achievement of the fitness standards is based upon a score falling in the Healthy Fitness Zone (HFZ) for each of six fitness areas. The HFZ represents levels of satisfactory achievement on the tasks. The goal is for students to score within the HFZ for all six fitness areas of the physical fitness test (The Cooper Institution 2011).

Each public school administered physical fitness tests to students in the grade five, and the results of these tests were downloaded into a geodatabase. The database was joined to a map of schools in Los Angeles County, so that the fitness levels could be visualized cartographically. Next, the average percentage of students in the HFZ for each ZIP code was calculated using GIS software. The six fitness areas are designed to measure three broad components of fitness areas in aerobic capacity, body composition, and muscle strength, endurance, and flexibility. The associated tests are shown in table 2. This dataset also includes socio-economic indicators such as ethnicity and economic disadvantage and Department of Education assigned school codes and
districts. A California public (n= 3,518) school dataset was also acquired from the California Department of Education. This tabular dataset include the address, city, state, ZIP code, and County-District-School (CDS) Code of each school. The percent of students in the HFZ at the ZIP code level helps illuminates the relationship between neighborhood health the lack of fresh fruits and vegetables and availability to fast food restaurants. This dataset was filtered for fifth grade (n = 1,762) indicators.

In addition to the data acquired from DPH, the 2007-2011 American Community Survey (ACS) data was leveraged for a number of socio-economic indicators at the ZIP code level. These indicators included population for youth in the age range of 9-17, percent receiving food stamps, median income, and percent of African-American, Asian, Hispanic, and White. This dataset includes all California Licensed Health Care Facilities by location. These facilities are licensed by the State of California, Department of Health Services.
Methodology

This study utilizes geographic information systems (GIS), spatial statistics, and an economic base analysis in location quotient (LQ). The implementation of these techniques provides for an integrative model for quantitatively measuring socio-economic characteristics of the sample population.

First, a GIS was used to map the variables of this study in fast food restaurants, schools, and a number of socio-economic indicators. The initial step in the utilization of GIS is to geocode the retail food establishments and schools in Los Angeles County using ESRI’s ArcGIS online geocoding service. This locator is unique to the Los Angeles County street network, and provides for more efficient geocoding of large datasets. Geocoding is a process whereby address data is converted to latitude and longitude coordinates that are subsequently plotted on a map as points.

To determine the concentration of all restaurants, fast food restaurants, and retail food markets at the ZIP code level a location quotient (LQ) is calculated. LQ is a spatially extensive technique that allows for the comparison of local area characteristics such as industry or establishment concentration to the larger area. The technique has been widely used by economic geographers and regional economists since 1940 (Moineddin, Beyene, and Boyle 2003). For this study the “local area” refers to different ZIP codes within Los Angeles County, while the “larger area” refers to all of Los Angeles County. LQ is expressed as a number and the formula is as follows:
\[ LQ = \frac{e_i/e}{E_i/E} \times 100 \]

Where:
- \( e_i \) = Local employment in industry \( i \)
- \( e \) = Total Employment in industry
- \( E_i \) = Reference Area Employment in industry \( i \)
- \( E \) = Total Reference Area Employment

If the LQ of an area is greater than or equal to 100, then the area of interest is said to be specialized in that industry. So, if ZIP code \( X \) in Los Angeles County yields an LQ greater than or equal to 100 for fast food restaurants, then it can be asserted that ZIP code \( X \) has a relatively higher concentration of fast food restaurants compared to the rest of Los Angeles County ZIP codes. This method aids in understanding economic patterns which are associated to community health more effectively than a simple per capita measure of spatial concentration. It also helps mitigate the skewing effect that touristy or business-heavy ZIP codes, such those in Santa Monica and downtown would have on the study. By using LQ, one can identify those locations where fast food outlets are an unusually prominent component of the business or retail landscape.

GIS is also used in this thesis to execute model the spatial relationship between health and place. Spatial statistics in the form of an exploratory regression, Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) are used. These statistical analyses permitted a robust modeling of the interaction between a number of variables within both the local and global areas of interest.

Ordinary Least Squares Regression is the precursor to the GWR analysis. OLS is the best known of all regression techniques. It is also the proper starting point for all spatial regression
analyses. It provides a global model of the variable or process in question; it creates a single regression equation to represent that process.

An OLS may be expressed as
\[ y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_n x_{ni} + \epsilon_i \]

Geographically weighted regression (GWR) is a local spatial statistical technique used to analyze spatial non-stationarity, defined as when the measurement of relationships among variables differs from location to location (Mennis 2006).

Each GWR maybe expressed as:
\[ y^i = a0(ui, vi) + \sum k ak(ui, vi) x_{ik} + \epsilon_i \]

Where \( y^i \) is the estimated value of the dependent variable for observation \( i \), \( a0 \) is the intercept, \( ak \) is the parameter estimate for variable \( k \), \( x_{ik} \) is the value of the \( k \) variable for \( i \), and \( \epsilon_i \) is the error term. The coordinate location of \( i \) maybe captured with \((ui, vi)\).

One bandwidth method was chosen to indicate the goodness of fit for each model. The Akaike Information Criterion (AIC) was utilized as a goodness of fit measure. When comparing two models it has been noted that the model with the lower the smaller AIC value is said to be trusted when comparing models (Yu and Wei 2012). Previous studies (Matthews 2012, Mennis 2006, Ghosh and Manson 2008) have shown innovative methods for mapping GWR results. Authors propose methods that the best way to map GWR results are with choropleth maps. Additionally, by visualizing statistics with choropleth mapping a number of characteristics may be captured. Yang and Matthews (2012) present two methods in presenting results. One, in showing local parameters in separate maps and another in overlaying specific values as contour
lines to show two measures at once. This thesis utilizes separate choropleth maps to show statistics captured by a GWR.

Utilizing spatially extensive and intensive techniques allows for sound inferences in model interpretation that events of spatial heterogeneity. A spatially extensive statistic is one which does not depend on the size of the geographic area. To determine if an extensive technique such as LQ is a viable variable in a GWR, the coefficient for location quotient is used in the analysis. These values measure the reliability of each coefficient estimate in the model. Confidence is higher when standard errors are small in relation to actual coefficient values.

Using these techniques collaboratively helps capture the impact that the built environment has on human health and well-being in addition the non-stationarity of human/environment interaction.

<table>
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<th>Variable Definition</th>
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<td>Avg. number of 5th grade students who are in HFZ per ZIP code</td>
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<tr>
<td>POP911</td>
<td>Explanatory Variable</td>
<td>Number of Children ages 9-11 per ZIP code</td>
</tr>
<tr>
<td>POVERTY</td>
<td>Explanatory Variable</td>
<td>Percent of households in poverty per ZIP code</td>
</tr>
<tr>
<td>FOODSTAMPS</td>
<td>Explanatory Variable</td>
<td>Percent of households receiving food stamps per ZIP code</td>
</tr>
<tr>
<td>AAPOP</td>
<td>Explanatory Variable</td>
<td>Percent of African-Americans per ZIP code</td>
</tr>
<tr>
<td>HISPOP</td>
<td>Explanatory Variable</td>
<td>Percent of Hispanics per ZIP code</td>
</tr>
<tr>
<td>FFLQ</td>
<td>Explanatory Variable</td>
<td>Location Quotient of Fast Food Restaurants</td>
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Table 1
<table>
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<th>Upper Body Strength and Endurance</th>
<th>Body Composition</th>
<th>Trunk Extensor</th>
<th>Flexibility</th>
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</thead>
<tbody>
<tr>
<td>PACER (Progressive Aerobic Cardiovascular Run)</td>
<td>Curl-Up</td>
<td>Push-Up</td>
<td>Skinfold Measurements</td>
<td>Trunk Lift</td>
<td>Back-Saver Sit and Reach</td>
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<td>Modified Pull-Up</td>
<td>Body Mass Index</td>
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<td>Walk Test (Ages 13 and Older)</td>
<td>Flexed-Arm Hang</td>
<td>Bioelectric Impedance Analyzer</td>
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Table 2
<table>
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<tr>
<td>Subway n = 585</td>
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<tr>
<td>McDonald’s n = 278</td>
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<td>Baskin Robbins’ n = 111</td>
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<tr>
<td>Burger King n = 140</td>
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<tr>
<td>El Pollo Loco n = 151</td>
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<td>Panda Express n = 133</td>
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<td>Jack-In-the-Box n = 211</td>
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Table 3
4. RESULTS

This chapter provides an array of results which aid in understanding the relationship between access to fast food and youth health Los Angeles County. To determine the concentration of fast food restaurants, and thereby geographic access, location quotient is used. Location quotient captures a relative industry measurement per zip code in Los Angeles County. This measurement was also calculated for all markets in the county. The resultant location quotients are used as variables in modeling the spatial relationships between youth health and fast food in conjunction with other socio-economic indicators. Geographically weighted regression and ordinary least squares are used to show the stationary and non-stationary events across the county.

Location Quotient

Location quotient (LQ) was executed on the DPH market and restaurant dataset to assess the concentration of fast food restaurants in each zip code. The average location quotients per zip code for the market and fast food datasets are above 100 which indicates that the average zip code in the county has more than optimal access to markets, or stores which carry nutrient rich foods, such as fruits and vegetables in addition to less nutrient foods, in the form of limited service restaurants. The average top ten fast food LQ is 136.27, while the average LQ for the market dataset is 170.78. Figures 1 and 2 show the location quotient for zip codes in Los Angeles County. The areas of the county with largest location quotient for fast food are in the northwestern parts of the county.
Exploratory Regression

Exploratory regression analysis is a useful preliminary to multivariate analyses, and so several exploratory regression analyses were conducted. Exploratory regression was utilized to determine the best combination of explanatory variables to use for spatial regression models. The summary of statistics returned in an exploratory regression model include frequency of variable significance, summaries of collinearity, models of goodness of fit, and tests for spatial autocorrelation. For the purposes of this thesis, the Akaike Information Criterion was used to determine each model’s goodness of fit. The (AIC) measures the relative entropy of each model. It is best practice to select the model with the lowest AIC score value when comparing alternative model combinations. Table 4 indicates the exploratory regression analyses results. In addition to the AIC, the adjusted R2 for each regression model was analyzed, in addition to the significance of multicollinearity among the potential regressors. The figure shows the best combination of explanatory variables for the dependent variable - percentage of 5th grade students that are in the healthy fitness zone per zip code.
Table 4

Choose 1 of 13 Summary

Highest Adjusted R-Squared Results

\[
\begin{array}{cccccc}
\text{AdjR2} & \text{AICc} & \text{JB} & \text{K(BP)} & \text{VIF} & \text{SA} \\
0.28 & 1540.49 & 0.00 & 0.73 & 1.00 & 0.00 +POP911*** \\
0.27 & 1542.85 & 0.00 & 0.47 & 1.00 & 0.00 +POP1214*** \\
0.27 & 1543.27 & 0.00 & 0.33 & 1.00 & 0.00 +POP1517*** \\
\end{array}
\]

Passing Models

\[
\begin{array}{cccccc}
\text{AdjR2 AICc JB K(BP) VIF SA Model} \\
0.28 & 1540.49 & 0.00 & 0.73 & 1.00 & 0.00 +POP911*** \\
0.27 & 1542.85 & 0.00 & 0.47 & 1.00 & 0.00 +POP1214*** \\
0.27 & 1543.27 & 0.00 & 0.33 & 1.00 & 0.00 +POP1517*** \\
\end{array}
\]

Choose 2 of 13 Summary

Highest Adjusted R-Squared Results

\[
\begin{array}{cccccc}
\text{AdjR2} & \text{AICc} & \text{JB} & \text{K(BP)} & \text{VIF} & \text{SA} \\
0.32 & 1528.80 & 0.00 & 0.58 & 1.57 & 0.00 +POP911*** +PERHISP*** \\
0.32 & 1529.60 & 0.00 & 0.40 & 1.53 & 0.00 +POP1214*** +PERHISP*** \\
0.32 & 1530.95 & 0.00 & 0.32 & 1.57 & 0.00 +POP1517*** +PERHISP*** \\
\end{array}
\]

Passing Models

\[
\begin{array}{cccccc}
\text{AdjR2 AICc JB K(BP) VIF SA Model} \\
0.32 & 1528.80 & 0.00 & 0.58 & 1.57 & 0.00 +POP911*** +PERHISP*** \\
0.32 & 1529.60 & 0.00 & 0.40 & 1.53 & 0.00 +POP1214*** +PERHISP*** \\
0.32 & 1530.95 & 0.00 & 0.32 & 1.57 & 0.00 +POP1517*** +PERHISP*** \\
\end{array}
\]

Choose 3 of 13 Summary

Highest Adjusted R-Squared Results

\[
\begin{array}{cccccc}
\text{AdjR2} & \text{AICc} & \text{JB} & \text{K(BP)} & \text{VIF} & \text{SA} \\
0.34 & 1524.15 & 0.00 & 0.24 & 1.61 & 0.00 +POP911*** -PERAA** +PERHISP*** \\
0.33 & 1526.09 & 0.00 & 0.19 & 1.55 & 0.00 +POP1214*** -PERAA** +PERHISP*** \\
0.33 & 1527.24 & 0.00 & 0.14 & 1.60 & 0.00 +POP1517*** -PERAA** +PERHISP*** \\
\end{array}
\]

Passing Models

\[
\begin{array}{cccccc}
\text{AdjR2 AICc JB K(BP) VIF SA Model} \\
0.34 & 1524.15 & 0.00 & 0.24 & 1.61 & 0.00 +POP911*** -PERAA** +PERHISP*** \\
0.33 & 1526.09 & 0.00 & 0.19 & 1.55 & 0.00 +POP1214*** -PERAA** +PERHISP*** \\
0.33 & 1527.24 & 0.00 & 0.14 & 1.60 & 0.00 +POP1517*** -PERAA** +PERHISP*** \\
\end{array}
\]

Choose 4 of 13 Summary

Highest Adjusted R-Squared Results

\[
\begin{array}{cccccc}
\text{AdjR2} & \text{AICc} & \text{JB} & \text{K(BP)} & \text{VIF} & \text{SA} \\
0.34 & 1524.88 & 0.00 & 0.39 & 1.61 & 0.00 +POP911*** -FOODSTAMPS -PERAA** +PERHISP*** \\
0.34 & 1523.10 & 0.00 & 0.17 & 2.41 & 0.00 +POP911*** +POVERTY -PERAA** +PERHISP** \\
0.34 & 1526.05 & 0.00 & 0.37 & 1.61 & 0.00 +POP911*** +HEALTFACNT -PERAA** +PERHISP*** \\
\end{array}
\]

Passing Models

\[
\begin{array}{cccccc}
\text{AdjR2 AICc JB K(BP) VIF SA Model} \\
0.34 & 1524.88 & 0.00 & 0.39 & 1.61 & 0.00 +POP911*** -FOODSTAMPS -PERAA** +PERHISP*** \\
0.34 & 1523.10 & 0.00 & 0.17 & 2.41 & 0.00 +POP911*** +POVERTY -PERAA** +PERHISP** \\
0.34 & 1526.05 & 0.00 & 0.37 & 1.61 & 0.00 +POP911*** +HEALTFACNT -PERAA** +PERHISP*** \\
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Choose 5 of 13 Summary
Highest Adjusted R-Squared Results

<table>
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<th>JB</th>
<th>K(BP)</th>
<th>VIF</th>
<th>SA</th>
<th>Model</th>
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</tbody>
</table>

Table Abbreviations
AdjR2 Adjusted R-Squared
AICc Akaike's Information Criterion
JB Jarque-Bera p-value
K(BP) Koenker (BP) Statistic p-value
VIF Max Variance Inflation Factor
SA Global Moran's I p-value
Model Variable sign (+/-)
Model Variable significance (* = 0.10
Ordinary Least Squares

Ordinary Least Squares analyses were executed on the data set. This statistic measures the global relationship between dependent and explanatory variables. Based on the results of the exploratory regression, the dependent variable is percentage of 5th grade students that are in the healthy fitness zone per zip code, and the explanatory variables are population of 9-11 years per zip code, percent of households receiving food stamps, percent African-American population and percent Hispanic population. Additionally, to show the impact that fast food restaurants have on youth health the fast food location quotient for each zip code was used as an explanatory variable in a second model.

The global goodness of fit or $R^2$ for the first OLS is 0.32. This indicates that the model is moderately strong in explaining at least 32 percent of the regional variation between Los Angeles County health indicators and the explanatory variables. The most statistically significant coefficient which explains this relationship is the percent in poverty per zip code. Table 5 indicates the results from the first OLS model.

A second OLS model was constructed using the strongest set of variables from the exploratory regression model in addition to fast food location quotient per zip code as an explanatory variable. Although the exploratory regression model did not indicate this variable as a strong parameter, it possesses the better Akaike Information Criterion (AIC) value at 1721.824305. The initial OLS model has a 1924.967857. AIC is a relative measure and can be used to compare different models which have the same independent variable. It is a measure of the ‘relative distance’ between the model that has been fitted and the unknown ‘true’ model. Models with smaller values of the AIC are preferable to models with higher values.
Geographically Weighted Regression

Geographically weighted regression was executed on the abovementioned variables to assess the spatial heterogeneity of childhood health indicators in Los Angeles County, such that each variable should be weighted within local contexts. Two GWR models were constructed. The first model uses the parameters from the exploratory regression output. The adjusted $R^2$ for this model is 0.33. The AIC for the model is 1922.252068. This explains a third of the spatial variation among variables used in the study. The coefficients for this model vary in significance. Most notably, the variable with the most statistical significance is percent Hispanic population per zip code. The mean coefficient number for this variable is 0.126314. The local strength of the model is located in figure 6. This figure shows that the strongest adjusted $R^2$ are near the central and western portions of the county. This model indicates that the stronger the percent Hispanic coefficient is, the stronger the $R^2$.

A second GWR was executed on the aforementioned dataset with fast food location quotient as an added parameter. Although this model was not suggested by the exploratory regression model, the AIC is stronger, which is indicative of a more realistic fit. The adjusted $R^2$ for this model is 0.32, while the AIC is 1720.274474. Figure 7 shows resultant map of the adjusted $R^2$ for this model. The percent of Hispanic population per zip code is also the most significant coefficient for this model. The mean coefficient number is 0.124285. The fast food location quotient is not statistically significant. The coefficient for fast food LQ for this model is 0.000305. The northwestern part of the county, including the San Fernando Valley and the Antelope Valley exhibit the strongest fast food location quotient coefficient numbers. For this model, the maximum coefficient is 0.013424. Similar to the first model, this model also indicates the stronger the Hispanic population coefficient, the higher the local $R^2$. However, this model
does not indicate a linear distribution when comparing the fast food location quotient to \( R^2 \) values. The range of fast food location quotient coefficients vary from negative to positive with varying \( R^2 \) values. This assessment indicates that access to fast food restaurants is not a primary candidate in explaining childhood health in Los Angeles County. A linear regression was executed in Microsoft Excel to test for the dependence of PFT scores to fast food location quotients for zip codes in Los Angeles County. Using fast food location quotient as the explanatory variable and the HFZ indicator as the dependent, the results show that there is a linear relationship between the two. Table 7 shows the summary of statistics for this model. The adjusted \( R^2 \) is 0.04.
Figure 2
Figure 3
<table>
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<th>VARIABLE</th>
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**Model Statistics**

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*Indicates coefficient is statistically significant at (p< 0.05)

Table 5
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**Model Statistics**

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*Indicates coefficient is statistically significant at (p< 0.05)

**Table 6**

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<td>Adjusted R Square</td>
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<td>Standard Error</td>
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<td>Observations</td>
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</table>

**Table 7**
Figure 4
Figure 6
Figure 7
Figure 8

Geographically Weighted Regression With FFLQ
Local R2
- 0.285724 - 0.316023
- 0.316024 - 0.333921
- 0.333922 - 0.345182
- 0.345183 - 0.353818
- 0.353819 - 0.367410
- NoData
5. CONCLUSION

General Findings

This study has illumined the connection between access to fast food and Los Angeles County Youth Health indicators in the form of state administered Physical Fitness Tests. The LQ results indicate that the majority of the county has optimal access to fast food restaurants and markets. The results of each GWR and OLS models show that there is a positive association (and not statistically significant between access to fast food and youth health in the county. Additionally, other socio-economic variables have shown a positive correlation to the variability of youth health within the county. The percentage of households receiving food stamps and percent Hispanic population both resulted in high correlations for these models. The resultant adjusted $R^2$ of the models range between 0.31-0.33 shows that these variables explain roughly one-third of local/global variation as well.

The major finding of this research is that there are a number of variables which influence the health of youth in Los Angeles County as noted by the exploratory regression results. This suggests that including these parameters in future directions may be a viable option for discovering underlying influences which explain childhood health disparities. Moreover, by asserting that if a neighborhood has a location quotient of over 100, then the physical fitness test score for that neighborhood is lower assumes a linear relationship. Results show that this is indeed a linear relationship. This explains less than five percent of the variation.
Study Limitations

This study examines how the spatial accessibility to fast food in Los Angeles County for youth in grade five affects their health. Although important, this does not explain the complete context of “access”. As noted by Ageyman and McEntee (2011), access may be defined in information, economical, or geographical standards when concerning food deserts. This study examines two aspects of study in the form of economic and geographic. To assess informational access, it is vital to note local knowledge, and other parameters which may affect an individual’s choice of nutritional intake for the day. Informational access broaches a non-spatial dimension, it is important to consider for future research directions, how food security maybe characterized by other variables other than geographical access and economic access. Additionally, this study does not look at obesity specifically, which has been indicated in literature as one of the primary consequences to fast food consumption (Fraser 2011).

Future Research

While this study broaches many aspects of food security and access, there is an array of directions which this study may be continued. By interpreting the location quotient as a general form of industry or fast food access, it allows for a more regionalized/local quantification. Studies which have previously investigated food access in Los Angeles County have used compositional data in the form of per capita ratios to show access to fast food in South Los Angeles and Santa Monica. As indicated by (Lloyd, Pawlowksy-Glahn, and Egozcue 2012) population data should not be used on a compositional or ratio scale. Compositions contain information on relative frequencies, not absolute. As indicated earlier in this paper, in a 2008
RAND study, the authors proposed that South Los Angeles actually has fewer fast food restaurants per 100,000 people than Santa Monica. Although this might be plausible to assess how many people visit fast food chains, this does not assess any form of food access other than as the number of people increases, so does the number of fast food chains (but the per capita density may or may not fall).

For this study, a number of other important indicators may be looked at to truly understand the impact that nutrition has on childhood health across geography, such as school academic performance indices, road networks, and crosswalk routes. Moreover, elements of corporate and political responsibility should be considered. While it is generally seen as the responsibility of the parent or individual to select the best nutritional for their child, corporations and political parties have also taken a stride in promoting healthy lifestyle choices. However, by examining the types of foods that are generally made available to low-income, minority households who use food stamps or other governmental assistance, stronger and more decisive conclusions could be made in the form of policy. Lastly, this thesis may be incorporated into a number of other epidemiological surveys that assess personal health and nutritional choices.
REFERENCES:


Macvean, Mary. 2010. Panel seeks to use L.A.’s abundance of fresh food in fight against childhood obesity. *Los Angeles Times*. 4 October:


Opfer, P. 2010. Using GIS Technology to Identify and Analyze "Food Deserts on the Southern Oregon Coast"


