Spatial disparities and socio-economic conditions: A food desert analysis of greater Des Moines, Iowa

David Jensen

University of Northern Iowa

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SPATIAL DISPARITIES AND SOCIO-ECONOMIC CONDITIONS: A FOOD DESERT ANALYSIS OF GREATER DES MOINES, IOWA

An Abstract of a Thesis

Submitted

In Partial Fulfilment

Of the Requirements for the Degree

Master of Arts

David Jensen

University of Northern Iowa

May 2018
ABSTRACT

Current research suggests that socioeconomic makeup of geographic areas within a city has implications on location and accessibility of food retail stores. Disadvantaged areas with relatively poor access to healthy and affordable food are what literature has identified as “food deserts”. The purpose of this research is to explore the relationships between geographic areas with relatively low socioeconomic characteristics and food stores within the greater Des Moines, Iowa area. By way of survey, grocery and convenience stores are measured on their healthy food quality, advertisements, and other factors. GIS techniques are then used to measure accessibility to stores by low cost means of transportation (walking and the public bus system).

The results produced from this study indicate that there are areas of concern within the city of Des Moines in regards to food accessibility. Also, there were strong negative correlations between distance from stores and walking and bussing access to stores. Aside from bussing, there were little to no correlations between socioeconomic distress and levels of store accessibility.
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This Study by: David Jensen

Entitled: Spatial Disparities and Socio-Economic Conditions: A Food Desert Analysis of Greater Des Moines, Iowa

Has been approved as meeting the requirements for the Degree of Master of Arts

Date Dr. Tim Strauss, Chair, Thesis Committee

Date Dr. Alex Oberle, Thesis Committee Member

Date Dr. Lisa Millsaps, Thesis Committee Member

Date Mr. John DeGroote, Thesis Committee Member

Date Dr. Patrick Pease, Dean, Graduate College
DEDICATION

This thesis is dedicated to my mother, Shannon, my father, John, and my brother, Nick. Your unwavering support during my time in graduate school was not unnoticed. I would not exchange you guys for the world.
ACKNOWLEDGEMENTS

I would like to first and foremost acknowledge my graduate cohort, who made my experiences in graduate school one of the most rewarding and memorable moments of my life. I would also like to individually acknowledge Aaron Padilla, whose help throughout school was immeasurably valuable.

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I am extremely grateful for my thesis committee: Alex Oberle, John DeGroote, Lisa Millsaps, and Tim Strauss. Their support, advice, and encouragement was extremely beneficial throughout my journey in graduate school. I hope to keep in contact with all of you in the years to come.

Finally, I would like to acknowledge the University of Northern Iowa and the Geography department for providing me with an assistantship, resources, and opportunity to complete this degree. My experiences here will be cherished forever.

Everything in this thesis may be all wrong, but that is all right.
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CHAPTER 1

INTRODUCTION

Research in food accessibility and food deserts has gained rapid ground in the past couple of decades (Beaulac, Kristjansson, & Cummins, 2009; Fife, 2012; Bilková, Krížan, Horňák, Barlík, & Kita, 2017; Block & Subramanian, 2015). Many food activists consider access to healthy food a basic human right and insist policies that affect our food system should be implemented for everyone to have access to healthy food (Mattessich & Monsey, 1992). Measuring healthy food accessibility is extremely complicated and multifaceted, attracting researchers of varying academic disciplines to help resolve patterns in spatial inequalities in food access. Sociologists, psychologists, economists, and geographers have all been involved in researching food deserts. Current research tends to measure areas, whether urban or rural, that have relatively low “food security.” Food security is described as “when people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious foods that meets their dietary needs and food preferences for an active and healthy life” (Overseas Development Institute, 1996). The term that defines these areas that have low food security are called “food deserts.”

Food deserts tend to be located in urban and rural areas where residents within certain neighborhoods lack the resources necessary to obtain healthy food relative to the population in surrounding neighborhoods (Walker, Keane, & Burke, 2010). This limited access poses risks that include, but are not limited to, diabetes, cardiovascular disease,
and obesity. Correlating health outcomes in individuals that reside in food desert areas is still an ongoing field of study, but the current literature suggests that there is a strong relationship between the two (Stack, 2015). People with low access tend to resort to food that is deemed junk food or “calorically dense,” thus raising obesity rates. People that live in areas with low socioeconomic characteristics tend to stay in these areas (Swinburn, Caterson, Seidell, & James, 2004). The low income and lack of resources do not allow them to relocate to areas where they have access to healthy food, thus leaving people and their future generations in a vicious cycle of constantly lacking access to healthy food.

The purpose of this study is to analyze the food desert landscape using Geographic Information Systems (GIS) in the city of Des Moines, the largest city in Iowa. The study seeks to identify spatial relationships between designated healthy food stores and neighborhoods within Des Moines that have relatively low socioeconomic status relative to other areas within the city. Accessibility to these healthy food stores (“healthy food stores” as defined within this study) was measured by taking the city’s road network data layer and using Network Analyst in ArcMap to create a map that designated areas of food access based on low-cost means of transportation (e.g., walking, buses). These areas of accessibility, or service areas, were then used for further analysis when incorporating socioeconomic data. The modes of transportation that were analyzed are walking and bussing. Walking is the most common mode of transportation examined in food desert studies when transportation is considered. Bussing, on the other hand, is overlooked in food desert studies as a viable means of traveling to food stores, as convenient and well utilized as it is (Larsen & Gilliland, 2008). This study strives to
demonstrate the importance of using public transportation like bussing when studying food deserts. The findings for this study have the potential to be immensely useful for urban planning purposes and prioritizing efforts to minimize the negative social and health effects of food deserts in the future.

Research Questions

1. What spatial disparities exist in the locations of adequate food stores?
2. What are the spatial relationships between the locations of adequate food stores and distress levels?
3. What socioeconomic disparities exist in access to adequate food stores via low cost means of transportation?

Research Aim

The aim of this research to contribute to the study of food deserts by using GIS processes in confirming the ongoing theory of relationships among the locations of quality food stores, levels of accessibility, and socioeconomic conditions of residents within an urban area.

Objectives of the Study

1. Locate all food stores in Des Moines as defined by North American Industry Classification System and index them based off of an in-person survey commonly used in measuring the food environment.
2. Measure relative socioeconomic distress at the census tract level.

3. Use GIS processes to assess the accessibility of said healthy food stores based off of bussing and walking.

4. Measure the statistical relationships of distance between food stores deemed “healthy,” based on the survey, and centroids of socioeconomically defined geographic areas.

5. Evaluate the relationship between bus and walk accessibility to healthy food stores and the varying socioeconomic levels throughout the city of Des Moines.

**Significance of Study**

The study of food deserts is becoming increasingly important in evaluating healthy food retail landscape. The term “food desert” is relatively new, and the biggest hurdle in food desert research is validity (Beaulac et al., 2009). Studies of this nature use different perspectives and methodologies to move toward a more systematic way of identifying food deserts, which increasingly have shown that these geographic areas do exist (McEntee & Agyeman, 2010). This study sheds more light on how GIS methods can contribute to the study of food deserts, and it focuses on the importance of how societal and economic conditions can greatly impact one’s health and access to healthy food.

The next chapter will outline the relevant literature that will set the stage for the study. Chapter 3 explains the research methodology used and the necessary steps taken to collect, process, and analyze the data. Chapter 4 shows the final results and their
interpretation. Chapter 5 outlines implications, limitations of the study, and future research in the food desert realm.
CHAPTER 2

LITERATURE REVIEW

Defining Food Deserts

The term “food desert” originates from a British study by the Low Income Project Team (Shaw, 2003). This publication highlighted the problems of areas that lack adequate access to healthy and affordable food, and it brought the topic of food deserts to the policy planning forefront. It has since become a key component in urban planning. For the first decade the term was exclusively used in urban areas, but was expanded in 2006 to the study of food access in rural Mississippi (Morton & Blanchard, 2007). Today, food deserts, food access, and food policy theory are studied in communities all over the world with varying questions, variables, and procedures used for defining these geographical phenomena.

The inherently complex and interdisciplinary nature of the study of food deserts makes it a complicated field of study. The research scope for food deserts is very large, which can allow for a more comprehensive understanding of these areas, and no one best practice has been determined. However, it is challenging to establish a systematic way of locating and analyzing these food deserts. Applying different methods of locating food deserts to the same study area could produce varying results depending on the variables analyzed and methodologies used. Different results can create problems when implementing policies to help alleviate the food desert problem because the people truly in a food desert may not be identified by a certain method used (Rose et al., 2009).
Definition of the term food desert tends to be assigned by what methods are being performed by the researcher, so the term remains more conceptual than operational (Reisig & Hobbiss, 2000). Research on food deserts tend to look at both the economic and physical accessibility of supermarkets (Walker et al., 2010; Cummins & Macintyre 2002). Areas that are lacking both of these are generally thought to be a food desert. This is a driving force behind this study’s inclusion and focus on the physical access via low cost modes of transportation (walking and public transit) and economic access via socioeconomic status.

The Supermarket Industry and the Automobile

Food deserts do not exist in a vacuum. Key historical developments, like the rise of the supermarket industry, have significantly contributed to the food desert phenomenon (Schafft, Jensen, & Hinrichs 2009). Supermarkets are considered essential by modern standards to the food retail landscape and offer the most significant source for healthy food items like fruits and vegetables. The mid-19th century food industry was most commonly formed of numerous, small, and independently owned super markets, which served the needed role in providing healthy food to local neighborhoods within the city. By the turn of the 20th century, food retailers had started to organize grocery store chain outlets (Wrigley, 2002). Over time, the supermarket companies started to consolidate and steadily increased in building size, while the total number of stores had decreased (Clarke, Eyre, & Guy, 2002).
Megastores like Walmart and Target entered the supermarket industry as well and have gained substantial market power by doing so (Larsen & Gilliland, 2008). Large supermarkets rely on industrialized food production facilities and centrally located distribution centers, which allows them to keep prices relatively low compared to smaller grocery stores. These resources are not available to independent food stores as they cannot afford the associated costs, resulting in the failure of these small businesses (Pothukuchi, 2005). Over time, supermarkets have moved from the urbanized central city areas to the growing suburbs to follow the movement of the wealthier suburban residents. Food retailers generally put higher priority on profit margins than trying to satisfy everyone’s hunger (Jones & Simmons, 1993).

Transportation technology plays a massive role in how cities are shaped. Urban transportation systems of urban areas in the early 20\textsuperscript{th} century consisted of railways, streetcars, horses, and carriages (Sovacool, 2009). The 20\textsuperscript{th} century introduced the automobile at an affordable price for the middle class, causing a major transformation in city development. Cities sprawled outward as mobility increased, and people began settling on the outskirts of the cities now called suburbs (Melosi, 2010). As the suburban population increased, the now consolidating supermarkets saw a market in this population and quickly moved outwards. Moving to the suburbs made it easier to transport goods from the distribution center to the grocery stores as the big semi-trucks could rely more on the freeways and highways and did not have to worry about driving through the middle of congested cities to deliver goods. This outward movement in the location of grocery stores created a void in the middle of cities, leaving people with low
socioeconomic status and no personal means of transportation with limited means of getting healthy food (Pothukuchi, 2005).

**Social Construction Theory**

Broadly speaking, all citizens are to be considered equal before the law, but many groups receive very different treatment in public policy. The social construction theory helps identify who benefits and who loses from policy (Pierce et al., 2014). This theory maintains that agents who implement public policies often inadvertently assign social value to groups of people that can identify these groups in a positive or negative light. “Policy designs affect participation through rules of participation, messages conveyed to individuals, resources such as money and time, and actual experiences with policy as it is delivered” (Sabatier, 2007).

The formation of social constructions are in accordance to two dimensions: political power and positive or negative construction. There are four classifications that groups can be placed in: advantaged, contenders, dependents, and deviants. Most people experiencing poverty and hunger are placed in the dependents category (Franks, 2014). They are commonly perceived as deserving in a moral sense but they often lack the political leverage to effectively demand more benefits. This is not to say that these groups are completely homogenous or that policy makers view these groups the same as the general public. However, the literature states that policy makers tend to construct policies based on their view of certain groups (Franks, 2014).
Local governments are usually left with the difficulty of determining who will not be served or who needs their services the most (Franks, 2014). Credits of deservedness are most often linked to the needs of the most disadvantaged, or the dependents. Local governments also make judgments of personal competence and contribution in their decision-making. These behaviors shape how particular groups may be viewed, regardless of whether particular groups potentially have the capacity to advocate for their own needs. The social construction framework attempts to increase understanding about why certain policies are executed and how they shape public participation and political orientation (Sabatier, 2007). It is important to note that implementing public policy is hardly on the basis of objective metrics and cannot “even the playing field” for everyone within a local place. Metrics used in this research should not be seen as an objective stance on who is disadvantaged and who is not. The variables used are based on their use in past studies and general influences that are commonly seen in people who are disadvantaged by experts in this field.

**Barriers to Accessing Healthy Food**

Households that are experiencing “low food security” report reduced quality, variety, or desirability of diet with little or no indication of reduced food intake (Metallinos-Katsaras, Sherry, & Kallio, 2009). Apart from this are households that experience “very low food security” that equate to households just not getting enough food altogether. These families report multiple signs of disrupted eating patterns and reduced food intake (Metallinos-Katsaras et al., 2009). Conversely, the United States is
experiencing a major obesity epidemic. According to a National Health and Nutrition Examination Survey, two in three adults and one in three children ages 6-19 are considered to be overweight or obese (Ogden, Carroll, Kit, & Flegal, 2014). The state of Iowa has the 12th highest obesity rate at 32.1% of the total population being obese (Braveman, Cubbin, Egerter, Williams, & Pamuk, 2010). People with lower incomes are more prone to be obese than those in the middle and upper class (Schmeiser, 2009). It may seem contradictory, but these concerns stem from the same fundamental problem, which is an increasing number of individuals and families finding it difficult or impossible to maintain a healthy diet.

Healthy food is often more difficult to obtain as well as more expensive than food that is considered “calorically dense”, or food with high caloric content with little nutritional value (Furey, Strugnell, & McIlveen, 2001). This results in families within lower income groups not getting sufficient nutrients compared to families in higher income brackets. Healthy food may also be scarcer for low income households because food purchases are made in smaller quantities. Lower income families are also more likely to see healthy foods such as fruits, vegetables, and fish as more expensive means of obtaining calories and they are often viewed as luxury items (Morland, Wing, Roux, & Poole, 2002). The price of healthy food and the variation between prices among different grocery stores are a major concern for those living on low incomes.

These health concerns emphasize the importance of a better understanding of the complexities of our food environments. An intricate combination of variables such as cost, convenience, choice, and nutrition affects people’s food choices. Health
inequalities, as pointed out in medical literature, are prevalent between certain socioeconomic and ethnic groups, and more recently, between geographic groupings of individuals (Anderson, Bulatao, Cohen, & Bulatao, 2004). Social disparities have long been debated as to whether they are a result of individual choice or societal factors. It is becoming more apparent that certain inequalities are inherent to our society. The acceptance of certain inequalities labels people with less opportunity as dependents, but it does not take into account that some individual decisions could affect their lifestyle like motivation level, education, and poor eating habits. More recently, studies have shifted from the analysis of looking at how personal and societal perspectives have affected health to how physical or environmental factors may contribute to individuals’ accessibility to food (Caswell & Yaktine, 2005; Kawachi & Subramanian, 2007; Whitacre, Tsai, & Mulligan, 2009).

Informational barriers are also a dimension worth examining when analyzing food deserts (McEntee & Agyeman, 2010). Informational access can involve a wide range of factors that can relate to the educational, cultural, and social constraints that influence how and why people choose to eat certain foods (Wrigley, 2002). The linkage between food item selection and nutritional knowledge is evident, but the correlations are often difficult to draw based off the compounding effects of other subjective matters. Informational barriers are often held under scrutiny, as it is highly debated on whether or not individuals that do not experience economic and geographic barriers are purchasing unhealthy food based on lack of nutritional knowledge. The reality is that there will always be those who choose to eat unhealthily despite unlimited resources.
The Use of Geographic Information Systems and its Application to Food Deserts

Geographic Information Systems, or GIS, is a system of hardware and software designed to capture, store, query, analyze, and display geographically referenced data. The use of GIS has roots in traditional spatial analysis of mapmaking, but has increasingly become more and more complex and sophisticated since the introduction of technology like computers, software, and data collection tools. Over the past couple decades, GIS has proven to be an extremely useful tool applicable to both commercial endeavors and scientific research. Its use in research expands to not only geography, but to almost any academic discipline where spatial analyses are useful to the research.

GIS, in the context of this research, is familiar to the field of health/medical geography. GIS techniques can be used to measure public health populations by assessing their environmental makeup and potentially identifying characteristics that correlate to positive or negative health outcomes. In fact, one of the first successful cases of using spatial analyses was in epidemiology, where an English physician, John Snow, used hand-drawn cartographic techniques to examine a serious cholera outbreak that occurred in the mid-1850s in a suburb of London. He was able to pinpoint the source of the cholera, a specific water pump in the city, by mapping the cholera deaths over the city’s water sources and examining the spatial patterns of deaths and water pumps. Rendering that pump inactive rapidly decreased the cholera outbreak, which eventually helped lead the medical community to conclude that cholera was a water-borne disease (Eyler, 2001).
The use of GIS to study food deserts is not uncommon. Most studies follow similar forms of criteria when measuring food store: measuring physical access via means of low cost transportation and economic access via socioeconomic metrics. Traditional analysis of measuring transportation access to grocery store is usually done using the “buffer” or “container” approach (McMaster, Leitner, & Sheppard, 1997; Mohai & Saha, 2006). These types of studies use a circular buffer around stores to show the areas that have access to supermarkets. However, this does not accurately represent the population with access because people usually do not travel in a straight line directly towards the supermarket. The circular buffer technique does not take into consideration how people move on a street level and how it can affect levels of access. A more accurate representation would call for using a network analysis service area that uses sidewalks and roads where people usually travel by foot and car (Larsen & Gilliland, 2008).

**Measuring Socioeconomic Status**

Socioeconomic status (SES) indicates one’s access to wanted resources, such as physical goods, money, power, person-to-person networks, leisure time, or educational opportunities. The accessibility of these resources enables individuals to better prosper in the contemporary socio-cultural world. There is an inherent social stratification among people in the world and, general speaking, people seem to recognize it (Smith, Mulder, Bowles, & Hill, 2011). Social mammals appear to at least recognize social hierarchies and their position in them (Sapolsky, 2005).
There is no agreed upon definition of SES; the SES structure involves political ideologies about existing and desired social structures. Some scholars focus on one dimension of SES by just looking at annual income (Oakes, 2012). The Gini coefficient and the Theil Index use direct measures of inequality such as income or wealth, and are used to summarize measures of variance or dispersion. The relative simplicity of these models raise questions on the accuracy since only one dimension of SES is considered. The validity of inequality measures is not only based on their computational utility but also on their underlying conception of SES, which is clearly multifactorial. Others believe obesity rate or ethnicity should be included because of the high correlations of those variables and SES (Oakes, 2012). Some believe health status should be a part of an SES measure since SES and health are so highly correlated. Though, creating metrics in measuring health offer its own issues in defining what is appropriately “healthy” and what is not. Essentially, SES is highly debated among researchers on what is actually appropriate when creating a structural definition of how to measure it.

Measurement of SES of a geographical region is fundamental to the social and health sciences for several reasons. First, measures of SES are necessary to further understand the severity of stratification and social inequality in or between areas. Second, without the measures of SES, it is impossible to understand changes to the structure of society, like the rise of women in the workplace or the isolation of African Americans from the opportunities for professional advancement (Oakes, 2012). Understanding the change of social status over time cannot be done without accurately measuring SES. Without the accurate measure of SES, it is impossible to understand the change of social
status over time. Knowing the variance in SES is critical to understanding generational changes in the social structure. Lastly, SES matters because it has been related to health and life outcomes for as long as social groups existed. The more status or higher-rank a person or group, the better the chances it has for a long and healthy life (Braveman et al. 2010).

Measuring SES can be broken down into two branches: proxy measures and composite measures. Proxy measurements typically use only one variable like annual earned income and are used to reflect one’s cumulative SES (Oakes, 2012). Composite measures attempt to involve separate variables (e.g., income, education) into a singular quantity. The aim of composite measurement is to combine information or data and weight them appropriately to calculate and rank or index. The data variables used and how they are weighted matter the most, and are the most controversial part of any composite measure.

Composite SES measures are built by combining information about several SES measures like income, employment, education, communications, home ownership, etc. Composite measures can be separated into two basic categories: Those that measure material and social deprivation like the Townsend Index and Carstairs Index, and those that measure social standing or prestige such as the Hollingshead Index of Social Prestige or Position and Duncan’s Socioeconomic Index (SEI) (Hauser & Warren, 1996). Material and social deprivation has been defined as the lack of goods and conveniences such as a car or television, resources that are customary in some societies.
SES measures used with United States populations tend to focus on social class rather than measurements of material and social deprivation. No single composite measure is overwhelmingly used to measure SES within the United States (Shavers, 2007). The SEI has been extremely popular U.S. research literature, but it does not directly measure access to resources. SEI is an occupation prestige-based measure that depends on the level of education and the income associated with an occupation.

Because this research is focused towards measuring accessibility to resources, in this case food, the index that seems most appropriate for the study is the Socioeconomic Factor Index (SEFI-2). This index was specifically designed to utilize census data for calculating SES within the context of public health and health status. To estimate the SES of an area, SEFI-2 incorporates four census variables: Unemployment rate, average household income, proportion of single parent households, and proportion of population without high school graduation. These variables are used because these characteristics strongly relate to health outcomes (Chateau, Metge, Prior, & Soodeen, 2012).

Measuring socioeconomic status in the context of this study is important because of the high correlation between SES and the three major determinants of health: access to health care, environmental exposure, and health behavior. Additionally, chronic stress associated with lower SES may also increase morbidity and mortality (Adler & Newman, 2002). This study assigned appropriate socioeconomic status level based on the SEFI-2 Index to Census tracts in order to generalize overall socioeconomic distress of said area. This, in conjunction with GIS analyses to locate distances from grocery stores, is the overarching theme to identify “food deserts.”
Food Desert Studies in Iowa

Food desert studies in Iowa are few and far between, and the ones that do exist focus on finding low food security areas in rural areas (Bitto, 2005). The studies found have all been qualitative analyses using focus groups (Bitto, Morton, Oakland, & Sand, 2003; Smith & Morton, 2009).

Bitto et al.’s 2003 study examined how low-income urban and rural areas differ in accessing food. The main findings were that urban areas often rely on the redistribution economy, like food pantries, to obtain food, and low-income rural areas often rely on neighbors or family members with better access or gardens to obtain healthy food.

Bitto’s 2005 research examined four rural counties of Iowa that were considered food deserts based on measures defined within the studies. Surveys were distributed to the residents of those counties that asked questions on how the low number of grocery stores impacted their access to food. The questions sought to answer how poverty, wealth inequality, and per capita income correlate to food security. The major findings of this research concluded that the rural population participated and relied on personal connections, identified as “the countermovement,” in order to alleviate the stress caused by the lack of big chain grocery stores that dominate the food market.

Smith and Morton’s 2009 study furthers Bitto’s research by a more in-depth analysis on how people in rural food deserts rely on civic structure to alleviate the stress of low access to food. They found that people with high civic structures are significantly
less likely to be food insecure, and that investing in strengthening the social structure of rural communities, along with strategies to increase income, can alleviate households from low food access.

Although furthering the food desert literature, qualitative analyses can have few survey respondents and have the possibility of not truly representing the study area in question (Evans et al., 2015; Harding, 2012). The use of GIS can cover large areas for analyses in a quantitative matter, and have the possibility of advancing the theory that systematic or structural attributes of areas can inherently be food deserts given that they are outside the designated area of a store that sells affordable and healthy foods. The utility of qualitative research in food deserts should not be ignored, though, as it gives a more “ground level” approach and perspective to measuring food access.

The United States Department of Agriculture Economic Research Service has created an interactive map of the United States that highlights the 2015 census tracts deemed food deserts based on distances from super markets exceeding one-mile distance for urban areas and a ten-mile distance for rural areas and low incomes. Tracts are deemed low income if the poverty level is above 20% or the tract’s median household income is 80% or less of median family income for the state. Low access is defined by having a third of the tract population living one mile away from a grocery store or ten
miles away in rural areas (green polygons) or half mile in urban areas and ten miles rural areas (orange polygons).

This map offers informative insights, but is simply too basic for analysis because it only takes into account proximity and low income. Census tracts, especially in urban areas, can be heavily populated, and saying a whole tract is a food desert simply is not a good representation of the tract. The metrics used, distance and income level, are also
fairly simplistic. Poverty level alone is a good measure of socioeconomic status, and studies have found correlations in populations with low healthy and high poverty levels (Woolf et al., 2015). However, using multiple variables provided by census data can allow us to calculate a more robust socioeconomic level per area. A past study looked at car ownership along with other variables like poverty rate, income, and household type that census block data was able to provide (Jiao, Moudon, Ulmer, Hurvitz, & Drewnowski, 2012). The combination of variables allows for a more comprehensive and distinct makeup of the areas in question. The use of census block data also is more precise than the more spatially aggregated census tract data.
CHAPTER 3

METHODS

Introduction

Based on a review of the literature, methodological techniques were chosen to maintain continuity with existing research, as well as to extend/modify them to address identified shortcomings of previous studies. Methodologies and parameters were also chosen to most accurately measure food desert status given Des Moines’s urban characteristics. The following section reiterates the research questions being examined in this study.

Research Questions

1. What spatial disparities exist in access to adequate food stores?
2. What are the spatial relationships between the locations of adequate food stores and distress levels?
3. What socioeconomic disparities exist in access to adequate food stores via low cost means of transportation?

Study Area

The area of study is the Des Moines metropolitan area, Iowa. Des Moines is the largest metro area in Iowa by both population (634,725) and area (90.65 square miles) (Census Bureau, 2015). The characteristics of Des Moines make it an interesting place in food desert study for a few reasons. Over the past couple of years Des Moines has been
the fastest growing metro areas in the Midwest in population, job growth, and GDP, specifically in the suburban areas (Elmer, 2017). As discussed in Chapter 2, this suburban phenomena is considered related to the formation of food deserts within the inner city. Quality food stores are more inclined to move to wealthier areas for higher profits instead of the inner city where wealth is relatively lower. Figure 2 shows the metropolitan area as defined by the United States Census Bureau (USCB).
Figure 2 USCB defined metropolitan area of Des Moines
The study area within Des Moines was determined using 2016 census data at the census tract level. Census tract data was set to overlay the defined metro area, as depicted in Figure 2, to determine which census tracts to use for the study. Tracts were chosen for the study if the metro area took up more than 50% of the tract in question. Figure 3 shows the study area and the examined stores. The hatched area in the southernmost part of the study area is the city’s airport and labelled as non-residential. It was included in the study area based on the defined parameters, but will not be included in the accessibility/socioeconomic analyses. Also, note that some stores are located outside of the study area. These stores were included in the study because they have the possibility of being accessible by people within the metropolitan area. Excluding these stores could potentially skew the final results in measuring accessibility to adequate food stores. In all, 252 stores were included in this research.
Classifying the Study Area Based on Census Data

Census tract and socioeconomic data were gathered from the United States Census Bureau website and put into a spatially referenced database to explore the spatial aspects of food deserts. From here, the SEFI-2 composite index was used in conjunction with each census tract to measure relative socioeconomic distress.

*Figure 3* Study area and examined stores
The SEFI-2, as noted, was used to measure the relative socioeconomic status of census tracts in Des Moines. This composite index of four socioeconomic variables was chosen based on its general agreement of accurately measuring “disadvantaged” or “deprived” neighborhoods and its ability to measure areas with multiple indicators of stress derived from standardized values (z-scores) (Carstairs & Morris, 1991; Ley & Smith, 2000; Ricketts & Sawhill, 1988). The index is comprised of four variables taken from the 2016 American Community Survey directed by the United States Census Bureau: low educational attainment (proportion of individuals that have not graduated high school), lone parenthood (proportion of lone parent families compared to the total number of families), unemployment (unemployment rate), and incidence of low income (proportion of individuals that fall below 200% of the federal poverty line).

Data was taken from the United States Census Bureau data website. Tables of each of the four indicators for all the examined census tracts were gathered and then aggregated into a single table into Excel. The z-scores, or number of standard deviations away from the mean of the dataset, were then calculated for each indicator based on the unweighted mean and standard deviation. The four z-scored indicators associated for each census tract were then added together to represent relative socioeconomic distress for the tracts. Three categories were established (low distress, moderate distress, and high distress) in three equal intervals for comparison and analysis. Figure 4 is a map of the spatial result of the z-scored data measuring socioeconomic distress by census tract using the SEFI-2.
Food Stores

Food stores that were analyzed were chosen using 2017 data from the North American Industry Classification System, or NAICS (US Census Bureau Classification Development Branch, 2015). NAICS classifies small and large business establishments
by code to collect and analyze business data relevant to the United States economy at the time. The codes used for this study were 445110 for “Supermarkets and Other Grocery (Except Convenience) Stores” and 445120 for “Convenience Stores.” These two codes were chosen because most people go to supermarkets, grocery stores, and convenience stores to buy food. Convenience stores were included in this study for two reasons. One is that businesses like Kwik Trip or Kwik Star are labeled as convenience stores, but also offer grocery store items like fresh produce, eggs, and frozen food. The other reason for including convenience stores is because there has been evidence of dollar stores like Dollar General and Dollar Tree expanding their food selection to cater to people of lower income as well as residents resorting to these types of stores because it is their closest option for food (Elmer, 2017; Hines, 2012).

Through the NAICS website, 252 stores were identified within the scope of the study area. The stores were then geocoded so that they could be used for further GIS data processing, and then vetted for location accuracy by comparing each store location to Google Maps. Google Maps were also able to provide additional information on what stores were still open from the NAICs dataset, as some of the stores within the data set had closed since the data was published.

Measuring Food Store Quality

Many GIS food desert studies do not take into account the quality of the food retailers that are being examined (D’Acosta, 2015; Larsen & Gilliland, 2008; McEntee & Agyeman, 2010). These studies take grocery store locations from a pre-existing database,
like the NAICS website, under the assumption that those stores sell quality healthy food to the surrounding population. What is missed in these studies is that all stores, including chain supermarkets, are seen as equal in providing healthful food in both quality and quantity, which can skew results when measuring food accessibility (Larsen & Gilliland, 2008).

To mitigate this issue, an adaptation of a well-established retail food store survey, called the CX$^3$, was used to measure the healthful food content, surrounding environment, and marketing of each non-chain food retailer and a selectively randomized sample of each chain food retailer.

The survey utilized for measuring the stores is called Communities of Excellences in Nutrition, Physical Activity, and Obesity Prevention, or CX$^3$, and was designed as a tool with weighted scoring used as an indicator of the food environment by surveying stores and their contents with an emphasis on healthy food content. It was created by the California Department of Public Health as a framework of healthy community indicators and has been reported as the most useful form of communication in neighborhood findings by health departments (Ghirardelli, Quinn, & Sugerman, 2011). The initial purpose of the survey was to generate data that could be used to promote healthy food activism through neighborhood improvement projects, health advocates, and local governments.

This study used the survey as an integral piece in measuring food accessibility while still maintaining the integrity of the survey in what it initially seeks to do:
measuring the food retail environment. A sample for each chain store was used given the large number of stores in this study. Selection of chain store samples to be surveyed was based on identifying every store of a particular chain that resided in the same classified socioeconomic distress area, as defined within this study, and surveying one third of that store population. This was done under the assumption that food retail stores of the same chain company that reside in similar socioeconomic distressed environments will have more alike scores than stores from the same chain in a different socioeconomically distressed area. The median score of the surveyed sample was then taken and assigned to all of the other chain food retailers of similar socioeconomic characteristics that were not surveyed.

The initial weighted scoring system was developed in a way to emphasize availability of healthful food. Nine main categories were outlined when surveying the stores that are fed into a 100 point total score. Access and availability of healthy food were designated as the most crucial factors and therefore were assigned 70 points. The remaining 30 points were allocated towards marketing and product placement.

Stores received points on what supplemental nutrition program they are involved in and if they displayed signage for it. The two programs examined in this survey were WIC (woman, infant, and children) and FS (food stamps). Four points each were awarded if they were supported, with an additional one point if signage was displayed that indicated the store’s implementation of the program.
The variety of fruits and vegetables was scored based on how many different types of fruit and vegetables were available to consumers. One point was assigned for every different fruit and vegetable available to consumers, up to twelve points for both the fruit and vegetable categories in the survey. For example, a store with four different kinds of vegetables would be assigned a “Limited” label and be awarded 4 points for that category. The quality of fruits and vegetables was quantified using a scale of 1-4 with a higher score indicating a higher quality. A score of one or two on quality was awarded 0 points, and scores of three and four were awarded six and eight points, respectively. Quality was defined using descriptors like wilting, decay, shrivel, and color changes to the fruit and vegetable population.

“Availability of other healthful food” was defined within subcategories: Low/reduced fat dairy or soy beverage, lean meat protein or canned fish, non-meat protein category, skim milk, whole grain bread/cereal/oatmeal, canned fruit or vegetables, frozen fruit or vegetables, and baby food. One point total was awarded for each subcategory, and the number of items that a store sold per subcategory was not taken into consideration.

Marketing and product placement was considered in the context of this study to address the informational barriers that people experience when accessing healthy food (McEntee & Agyeman, 2010). Advertisements have been proven to be extremely powerful in influencing consumers’ buying behavior, and there is no exception in the food retail domain (Rai, 2013). This survey sought to identify both interior and exterior ads, and assigned points to each surveyed store based on size of ad, number of ads, and
whether they are designated towards healthy or unhealthy products. Stores with ads geared towards healthy food products were given a higher score than stores with ads for unhealthy food products. Advertisement size was roughly depicted as: small = postcard size, medium = ≥3 feet by ≥3 feet.

The store’s surrounding environment was also scored based on its “walkability.” This included the evaluation of any hazards that might put any residents in harm’s way on sidewalks or entryways. The presence of sidewalks leading up to the store was also taken into consideration as well as the types of roads that surround the store (residential, highway, arterial, etc.).

The original survey, broken down into 9 subcategories, awarded points for each and then added up for a total score. For this study, all but one of the criteria for the CX³ were used to measure food stores. The only element left out was the pricing criterion. According to a reliability analysis study of the CX³:

The pricing subcategory was designed to assign points for reasonable produced prices when prices found in stores were under a ‘county average’ calculate price. Calculated prices for the county where the survey was conducted were created for each of the 7 produce items using commercially available retail scanner data for comparable varieties. (Ghirardelli et al., 2011)

It should be noted that the CX³ was designed specifically for supermarkets and grocery stores, and the pricing component of the survey assumes that each store surveyed has at least seven produce items to conduct a pricing analysis. Because this study includes gas stations and other convenience stores that will not break the threshold of at
least seven produce items, this subcategory was intentionally left out for this study. This leaves a maximum potential score of 90 points for each store. The original CXP has a “meet standards” criterion where a store scoring 75 total points or higher out 100 is considered an adequate store for providing healthy food. To keep the integrity of the original survey criteria, a score that is 75% or higher out of 90 points is considered to “meet standards” for this study.

Data collecting conditions focused on the evaluation of the stores’ food content and environment rather than the humans in the stores, thus institutional review of data collection was not necessary for this study. Breakdown of the survey questions and their respective point assignments are in Table 1.

Table 1 *Modified CXP³ survey used for measuring quality of food stores*

<table>
<thead>
<tr>
<th>Scoring Criteria</th>
<th>Points Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Store accepts WIC and FS, displays signage</strong></td>
<td>Maximum score=10&lt;br&gt;Meets standards ≥ 5</td>
</tr>
<tr>
<td>• Accepts WIC</td>
<td>• Yes = 4 No = 0</td>
</tr>
<tr>
<td>• Displays WIC signage</td>
<td>• Yes = 1 No = 0</td>
</tr>
<tr>
<td>• FS Vendor</td>
<td>• Yes = 4 No = 0</td>
</tr>
<tr>
<td>• Displays FS signage</td>
<td>• Yes = 1 No = 0</td>
</tr>
<tr>
<td><strong>Store sells a wide range of good quality fruit</strong></td>
<td>Maximum score = 20&lt;br&gt;Meets standards ≥ 18</td>
</tr>
<tr>
<td>• Availability of fresh fruit</td>
<td>• None = 0</td>
</tr>
<tr>
<td>• Quality of fruit</td>
<td>• Limited = 4</td>
</tr>
<tr>
<td></td>
<td>• Moderate = 8</td>
</tr>
<tr>
<td></td>
<td>• Wide Variety = 12</td>
</tr>
<tr>
<td></td>
<td>• Poor = 0</td>
</tr>
<tr>
<td></td>
<td>• Mixed/Poor = 0</td>
</tr>
<tr>
<td></td>
<td>• Mixed/good = 6</td>
</tr>
<tr>
<td></td>
<td>• Good overall = 8</td>
</tr>
<tr>
<td><strong>Store sells a wide range of good quality vegetables</strong></td>
<td>Maximum score = 20&lt;br&gt;Meets standards ≥ 18</td>
</tr>
<tr>
<td>• Availability of fresh vegetables</td>
<td>• None = 0</td>
</tr>
<tr>
<td></td>
<td>• Limited = 4</td>
</tr>
</tbody>
</table>

Table continues
<table>
<thead>
<tr>
<th>Scoring Criteria</th>
<th>Points Assigned</th>
</tr>
</thead>
</table>
| • Quality of vegetables | • Moderate = 8  
• Wide Variety = 12  
• Poor = 0  
• Mixed/Poor = 0  
• Mixed/good = 6  
• Good overall = 8 |
| Store sells wide range of other healthful food  
• Availability of other healthful food | Maximum Score = 10  
Meets Standards = 8  
• Low/reduced fat dairy or soy beverage = 1  
• Lean meat protein or canned fish = 1  
• Non-meat protein category = 1  
• Skim milk = 2  
• Whole grain bread, cereal, or oatmeal = 2  
• Canned fruit or vegetables = 1  
• Frozen fruit or vegetables = 1  
• Baby food = 1 |
| Healthy Eating/Activity Information Score  
• Ads or promotional products designated towards physical activity or exercise  
• Health promotional items around fruit and vegetable displays | Maximum Score = 4  
Meets Standards ≥ 3  
• Yes= 3  
• No=0  
• Any= 1  
• No= 0 |
| Exterior marketing  
• Number of ads for healthful products  
• Store exterior conditions (product bins, other food products on sidewalks, vending, advertising images, murals  
• Number of ads for unhealthful products | Maximum Score= 8  
Meets Standards ≥ 4  
• None= 0  
• Any small= 0.5  
• Any medium = 0.5  
• Any large= 1  
• Maximum = 4  
• None= 2  
• No large = 0.5  
• ≤ 2 medium= 0.5  
• ≤ 2 small= 0.5 |
| Interior marketing | Maximum score = 8  
Meets standards ≥ 4  
• None = 0 |

Table continues
<table>
<thead>
<tr>
<th>Scoring Criteria</th>
<th>Points Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Presence of ads or promotions for healthful products</td>
<td>• 1 or 2 items = 1</td>
</tr>
<tr>
<td></td>
<td>• 3 or 4 items = 2</td>
</tr>
<tr>
<td>• Healthful products at checkout</td>
<td>• None = 0</td>
</tr>
<tr>
<td>• Presence of ads or promotions for unhealthful products at checkout</td>
<td>• 1 or 2 items = 1</td>
</tr>
<tr>
<td></td>
<td>• 3 or 5 items = 2</td>
</tr>
<tr>
<td>• Unhealthful products at checkout</td>
<td>• None = 2</td>
</tr>
<tr>
<td></td>
<td>• 1-2 Items = 1</td>
</tr>
<tr>
<td></td>
<td>• 3 or 4 items = 0</td>
</tr>
<tr>
<td>• Presence of ads or promotions for unhealthful products at checkout</td>
<td>• None = 2</td>
</tr>
<tr>
<td></td>
<td>• 1 or 2 items = 1</td>
</tr>
<tr>
<td></td>
<td>• 3-5 items = 0</td>
</tr>
</tbody>
</table>

| Store located in safe, walkable areas                                           | Maximum score = 10                   |
|                                                                                 | Meets standards ≥ 7                  |
| • Walkability                                                                   | • No walking hazards= 3              |
| • Bars on windows or doors                                                      | • Sidewalks to store= 3              |
|                                                                                 | • Residential road to store= 2       |
| • Yes = 0 No = 2                                                                |                                       |

| Subtotal Store Score                                                            | Maximum Score = 90                   |
|                                                                                 | Meets standards ≥ 67.5               |

**Survey Implementation**

The survey was integrated into Survey123, an Esri product designed to create and distribute surveys through devices connected to the internet. Survey123 was utilized through a smartphone by the individual researcher travelling by car to each store. Before the initial data collection of the Des Moines metropolitan area, a pilot survey was conducted for Cedar Falls, Iowa food stores. A sample size of five stores ranging from grocery stores, convenience stores, and gas stations was intentionally chosen in order to work out any issues that data collection might experience when surveying the different types of stores. After the prospective faults in data collection were resolved, data collection in Des Moines began on October 14, 2017 and ended November 11, 2017. A
single survey completion initially took roughly ten minutes to complete, but decreased over the collection period to five minutes.

Addresses of the store locations to be surveyed (n=121) were put into an Excel spreadsheet and organized to maximize efficiency when travelling from store to store. In all, 121 of the stores were surveyed of the 252 stores that were identified through the NAICS code database to decrease time in the field collecting data. It was assumed that the stores from the same corporation that resided in similar socioeconomic indexed areas, as defined within this study, would be similar enough in survey responses that visiting all of the stores would not be necessary. For example, a third of all the Casey’s General stores that were located in the “High Distress” neighborhoods (tracts) were randomly selected and surveyed. Then a third of all the Casey’s General stores located in the “Medium Distress” neighborhoods were randomly selected and surveyed. The same thing was done for the “Low Distress” neighborhoods.

The median score of each sample population was calculated and then applied to the remaining stores of the same company that were not subject to surveying. This type of sampling was only done for chain stores, not the unique small family owned or ethnic grocery stores where generalizations cannot be made. The chain stores that underwent this kind of sampling were ALDIS, Casey’s General Store, Dollar General, Dollar Tree, Family Dollar Store, Fareway, Git-N-Go, Hy-Vee, Kum-N-Go, Quik-Trip, and Walmart. Figure 5 shows the locations of the surveyed stores in relation to the SEFI-2 defined census tracts.
After the surveyed stores were scored, the scores were extrapolated and assigned towards the stores that were not surveyed. From here the researcher identified each score that met the $\geq 75\%$ criterion. Figure 6 shows the locations of each store that is defined “adequate” through the CX$^3$ ($n=44$).
Measuring Spatial Relationships Between Store Location and Distress Levels

Network Analyst was used to find the distance to the nearest adequate food store for each centroid of every census block along the road network. This analysis was then aggregated to the census tract level to compare average distances in feet to adequate food stores among the socioeconomically distressed areas. Also, service areas of 3500 feet
were implemented around every block centroid to find the number of stores within every service area associated with each block. The data was then aggregated to the tract level for socioeconomic distress comparison. This aims to illustrate the average number, or different options, of food stores that block residents have access to via walking within each socioeconomically defined area.

**Measuring Accessibility**

Measuring accessibility in food desert contexts varies from study to study based on research objectives and questions. Bussing and walking were chosen for this study because they are two of the cheapest modes of transportation when getting to a store. Des Moines offers a robust bus system that cannot be ignored when measuring accessibility, and walking is the most cost efficient way of getting to a food store. The following sections outline how these two modes of transportation are used in this study.

**Walking Accessibility**

Previous U.S. studies have shown that even people living in relatively distressed socioeconomic tracts often drive to get groceries (Clifton, 2004). However, Des Moines has seen an increase of the number families without access to healthy food due to lack of transportation, specifically among the refugee population after being placed in subsidized housing by the City of Des Moines (Elmer, 2017). To assess spatial difference in food accessibility, Des Moines was divided into the three socioeconomically distressed areas (Figure 4). GIS processes, specifically the Network Analyst extension in ArcMap, were
used to determine the accessibility of food stores by foot and public transit for each of the three socioeconomic distress-defined areas.

Two recent Canadian food desert studies used a distance of 1000 meters to equate to 10 to 15 minutes of walking when measuring accessibility to stores (Apparicio, Cloutier, & Shearmur 2007; Smoyer-Tomic, Spence, & Amrhein 2006). For this study, the Imperial system was used, so 3500 feet was used to represent a 10-15 minute walk to a food store (1066.8 meters). The Network Analyst extension in ArcGIS was used to create a service area of 3500 feet around each adequate food store using street network data provided by the City of Des Moines GIS data library.
Figure 7 Service areas of 3,500 feet used around each store to find walk accessibility

**Bus Accessibility**

The bus system, DART, aims to make transportation around the Great Des Moines area easier, but DART has faced some hardships in recent years (Elmer, 2016). Three designated areas are to be pulled out of the DART system in the coming years due
to increasing costs and the limited number of people using the bus. However, DART’s long range plan calls for increasing the number of routes and frequency of stops to increase access by the inner city (Elmer, 2016). It is important that a study of this nature is done now, so future food deserts studies in Des Moines have data to examine how the change in bus route system can change the accessibility of healthy food. Data for the DART system was accessed through DART’s Developer Resources page on the bus system’s dedicated website (www.ridedart.com). Bus access was determined by a 10 minute bus ride, or 2.2 miles, without transfers (determined by bus schedules and route data) combined with a 5 minute walk (1100 feet) to and from the end of the bus trip. ModelBuilder was used to parse each bus route to be analyzed individually with the given parameters. Census blocks with bus accessibility from each route were then combined into one feature layer for further analyses. Figure 6 shows the DART route system with the adequate food stores.
Aggregated Accessibility

Population counts at the census block level were used to identify the population with accessibility within each service area for both walking and bussing because they are the smallest geographic unit for which population counts data are available. If the geographic center of the block fell within a supermarket/bus stop service area, the
population of that block was seen as having food store access. This method calculates how many people live within a walkable/bussable distance to a food store. The census block accessibility analyses were then aggregated at the census tract level to analyze the three socioeconomically distressed areas.

**Summary**

The comprehensive approach of combining socioeconomic distress and walking/bussing accessibility should provide a better picture of where disparities in food accessibility exist compared to traditional methods of identifying food deserts. Also, the survey used to measure a store’s food content and quality is a dimension often overlooked in food desert studies that needs to be addressed. Chapter 4 illustrates the results that align with the research questions and represent these proposed methods.
CHAPTER 4

RESULTS

What Spatial Disparities Exist in the Location of Adequate Food Stores?

The results from the survey were put into Microsoft Excel to add up the scored categories to produce a total score. Figure 9 shows the average score of the measured stores divided into four categories: Chain grocers (Hy-vee, ALDI, Fareway, etc.), gas stations (Casey’s General Store, Quik Trip, Kum & Go, etc.), dollar stores (Dollar General, Dollar Tree), and ethnic grocery stores. Chain grocery stores were the only category whose average score was above the defined threshold of “adequate food stores.” Out of all of the stores that were deemed adequate (n=44), all of them were chain grocery stores with the exception of one Hispanic ethnic grocery store. Neither dollar stores nor gas stations met the criteria.

Figure 9 Bar graph of average survey score of stores
Based on initial analyses of plotting the adequate food store points, it was evident that there were some disparities in store location of the metro area. Specifically, the north central, southern, and central zones of the study area had little to no stores (Figure 6). The Kernel Density tool within ArcMap was to get a better picture the spatial disparities that exist within the study area. The population field within the tool dialogue window was populated with the stores’ survey scores, so that the scores were weighted in the spatial analysis. Figure 10 shows the result of the tool, and it becomes clear that our initial analysis holds true as the north central, southern corner by the non-residential area, and central areas show a lack of adequate stores. Therefore, these areas may be considered “food deserts” upon further analyses.
What are the Spatial Relationships Between the Locations of Adequate Food Stores and Distress Levels?

To explore the spatial relationships between the locations of stores and the distress levels, the distance to the closest food store was calculated for each census block and then aggregated to the census tract level to find the average distance per block at the census tract level. Figure 11 displays the results found. The Northeast/East portion of the
study area had significantly greater distances to the stores as did the southern region around the non-residential area compared to the rest of the metro area.

*Figure 11* Average distance to store from census block centroid aggregated to census tract level
Comparing these distances to the tracts’ respective socioeconomic distress classification shows that there are some differences in distances to stores and distress levels, which is portrayed in Table 2. High distress areas had the highest average distances to food stores, indicating that these areas of low socioeconomic status could potentially have residents that have low access to healthy food relative to other areas of the city. The next highest average distances to stores were the low distress areas, but these low distress areas are sparsely populated relative to the inner city areas with higher distress. Moderately distressed areas had significantly lower distances to stores than the other two distress categories.

Table 2 *Distances in feet to store by distress level*

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>9,131</td>
<td>7,481</td>
<td>9,253</td>
</tr>
<tr>
<td>Median</td>
<td>8,013</td>
<td>6,647</td>
<td>9,286</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>5,726</td>
<td>4,713</td>
<td>4,053</td>
</tr>
<tr>
<td>Variance</td>
<td>32,771,861</td>
<td>22,204,232</td>
<td>16,417,682</td>
</tr>
</tbody>
</table>

Another perspective that taken into consideration to measure the spatial relationships between the locations of stores and distress levels. A 3,500 foot service area (walking distance) was employed around each block centroid to find the number of stores that resided within the service areas per block. These numbers were then aggregated to the tract level by the average number of stores within walking distance of every census block within each census tract (Figure 12).
The western region of the study areas sees the highest average number of stores, which could be inferred from the high density of stores within the areas indicated by Figure 10. The inner city, southern, and northeast areas see the lowest average number of stores. Table 3 compares the average number of stores with the distress levels. High
distress areas saw the lowest average number of stores, followed by low distress and moderate distress, a pattern that follows Table 2.

### Table 3 Number of stores within 3,500 feet by distress level

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.224</td>
<td>0.327</td>
<td>0.131</td>
</tr>
<tr>
<td>Median</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.507</td>
<td>0.534</td>
<td>0.356</td>
</tr>
<tr>
<td>Variance</td>
<td>0.257</td>
<td>0.285</td>
<td>0.127</td>
</tr>
</tbody>
</table>

What Socioeconomic Disparities Exist in Access to Adequate Food Stores via Low Cost Means of Transportation?

Finding the relationships between locations of food retailers and distress levels gives us a perspective on what areas might be considered food deserts, but it does not take into consideration modes of transportation of getting to adequate stores. This study looked at two of the cheapest modes of transportation, walking and bussing, to measure the actual accessibility of these stores. Walking was chosen because it is the cheapest form of transportation. However, people usually are not willing to traverse miles and miles to go to the store, which is why bussing was also taken into consideration (Elmer, 2017).

Figure 13 shows walking accessibility to adequate food stores based on a 3,500 foot service area, or a 10-15 minute walk, around each store, as outlined in Chapter 3. Population counts from census block areas were deemed accessible if their centroid
resided within the service area. Percentages were then calculated from the blocks with walk accessibility and the entire tract population to provide the map that is shown.

*Figure 13* Proportion of population with walking access to stores per census tract
Figure 13 presents a geographical look on walking accessibility, but does not give a good comparison on how this lines up to socioeconomically distressed areas. Figure 14 lays the results from Figure 13 over the distress levels of the study area. The most significant component of this map is the speculative correlation of the high distress tracts and the less than 10% walking accessibility to stores overlaying on each other. All but four high distress tracts have less than 10% walking accessibility to stores.
The same approach was done to analyze bus accessibility. As said in Chapter 3, parameters for bus accessibility included a five minute walk to a bus stop (1100 feet), a ten minute bus ride without transfers (2.2 miles), and a five minute walk from bus stop to the store. Figure 15 provides the spatial distribution of the percentage of population with bus access per census tract.

Figure 14 Proportion of population with walking access to stores by SES distress levels
Results provided from Figure 15 were laid over the distress level tracts to visualize bus accessibility against distress levels (Figure 16). Bus route accessibility appear to permeate through most of the high distress areas aside from the Southeast high
distress tract. Bus accessibility for low distress seems to be low, but these areas have a higher chance of the population owning a car, which would alleviate the need for bus services in those areas.

*Figure 16 Proportion of population with bus access to stores by SES distress levels*
Table 4 is a tabular representation of the results from Figure 14 and Figure 16 to provide a better understanding of the actual accessibility levels for walking and bussing for each distressed area. The entire study area (Metro Area) was also included in the measurement for both modes of accessibility. Low and high distressed areas had similar levels of walking accessibility to stores while moderate distressed areas had significantly higher walking access. High distressed areas had the most bus accessibility, which comes to no surprise as most of the bus routes pass through the majority of those tracts. Low distressed areas see the least bus access, but is still accessible to over half of that population.

Table 4 Walk and bus accessibility by distress level

<table>
<thead>
<tr>
<th>Distress Level</th>
<th>% Population with Walking Access</th>
<th>% Population with Bus Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>14.25%</td>
<td>50.74%</td>
</tr>
<tr>
<td>Moderate</td>
<td>30.93%</td>
<td>80.39%</td>
</tr>
<tr>
<td>High</td>
<td>15.17%</td>
<td>92.94%</td>
</tr>
<tr>
<td>Metro Area</td>
<td>20.5%</td>
<td>68.34%</td>
</tr>
</tbody>
</table>

Table 5 measures the correlation coefficients of every census tract value that this study analyzes. Most notably, the strongest positive correlations are between distress level (a) and bus access (e) and between average number of stores within 3,500 feet (c) and walk access (d). The strongest negative correlations appear between the average number of stores within 3,500 ft. (c) and average distance to nearest store (b) and between walk access (d) and average distance to nearest store (b).
Table 5 *Correlations among distress level, store location, and store accessibility*

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Distress Level</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Average distance to nearest store (ft.)</td>
<td>-0.023</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Number of stores within 3,500 ft.</td>
<td>-0.009</td>
<td>-0.754**</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>(d) % Population with walking access</td>
<td>0.088</td>
<td>-0.724**</td>
<td>0.885**</td>
<td>x</td>
</tr>
<tr>
<td>(e) % Population with bus access</td>
<td>0.444**</td>
<td>-0.553**</td>
<td>0.271*</td>
<td>0.371**</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

The results as presented are aligned in a way to best answer the research questions of this study. Chapter 4 is simply the product of the methodologies as outlined in Chapter 3. The following and final chapter discuss the interpretation of the data and the justification of the methodology used to best answer the research questions as well as the study’s limitations. Chapter 5 also evaluates the study on the whole and mentions future research possibilities that could supplement this study and the study’s implications.
CHAPTER 5

DISCUSSION

The results of this study offer some interesting insights for both the city’s food desert dilemma as well as the study’s contribution to food desert academic literature. Some of the results contribute to ongoing geographic food desert theory by producing similar results of past studies, which bolster the proposed arguments on what is actually a food desert and what attributes food desert areas consist of. This includes the correlation between distances to stores and level of accessibility for both walking and bussing. Despite these results, this study produced results contrary to past research that make the pursuance of giving “food deserts” a systematic definition an incredibly difficult endeavor. The most notable result from this study comes from the lack of correlation between overall socioeconomic distress level and all of the other attributes, besides bussing, examined in this study (column (a) in Table 5).

Despite including dollar stores and gas stations in the study to observe their content of adequate fresh produce and other healthful foods, they still fell short in accordance to a tried and tested food store survey designed specifically to measure and promote healthy food and their environment (Figure 9). All but one ethnic food store made the 75% percent threshold as defined within the survey. While ethnic stores usually do not prioritize healthy food content, and focus more on foods that are easily transported from across the globe (frozen and dehydrated food, canned goods, etc.), the distinction of adding these stores in the study is critical. As outlined in the Des Moines Register article,
a lot of Des Moines’s residents that experience a lack of healthy food accessibility are refugees from different nations that are placed by the city in unfortunate locations that affect their accessibility to healthy food (Elmer, 2017). And while not every foreign resident of Des Moines is in a food desert, they are more likely to shop in their ethnic grocers due to their familiarity with the food, people, and culture of the stores.

Figure 10 most notably shows a heavy density of healthy food stores in the western region of the study area, an area that has seen the most growth in population and economic development within the metropolitan area (West Des Moines: Economic Development Strategic Plan, 2010). Although this study does not address the direct correlation between the economic growth and food store location, it can be inferred based on the literature and Figure 4 that this phenomenon is occurring due to the suburbanization of the city of Des Moines; where stores are more likely to locate themselves in more economically favorable environments to maximize profits. Figure 10 also reveals what areas are lacking adequate food stores, specifically the south/southeastern, northeastern, and central parts of the study area.

The method of averaging the distance and number of stores within walking distance of each block centroid for each tract was used to find the spatial relationships between location of stores and distress levels, although there are many approaches a researcher could take to address this question. This method was chosen specifically due to its nature of using the road network to best exemplify travelling to the store and offering a quantitative measure of geographic location. Table 2 and Table 3 indicate that high distressed areas have the farthest average distance to travel to adequate stores (9,253 ft.)
and have the least average number of stores within walking distance of their block centroids (0.132). However, Table 5 indicates there is no correlation or statistical significance between average distance/average number of stores and distress levels. An interesting result that remains to be seen is if this particular approach appropriately measures the relationship between location and distress, or if it is just a unique characteristic of the study area. As for Question 2 (What are the spatial relationships between the locations of adequate food stores and distress levels?), there is no discernable relationship between the location of stores and distress level.

Table 4 identifies the accessibility levels to stores for both walking and bussing. Interestingly, low and high distressed areas share similar levels of walking accessibility, 14.25% and 15.17% respectively. However, it should be noted that low distressed areas have a significantly larger area size that hold 45% of the adequate store sample compared to the percentage of stores in high distress, containing roughly 5% of stores, and its drastically lower area size. As predicted, high distressed areas saw the most bus accessibility to stores due to most of the routes residing within those areas. Table 5 reflects this as well with 0.444 correlation and a 0.01 statistical significance. Column (b) in Table 5 indicates the correlation between distance and walking and bussing accessibility, meaning the farther away from a store one is, the less likely one is to have bus or walk access to store. Another interesting note to make of Table 5 is the lack of association between walking access and distress level (0.088), indicating that differing distress levels do not affect walking accessibility for Des Moines. Overall,
This study’s results differ from other similar studies in that socioeconomic characteristics have little to no relationship in the store’s geographic location and in walking accessibility. The results do coincide with other studies in that increasing distances from stores decrease accessibility and the positive relationship between bus accessibility and walk accessibility.

**Limitations**

A few limitations within this study should be addressed. While this study has a unique take on addressing food deserts from a GIS standpoint, it is not readily equipped to provide an exact diagnosis on what areas within Des Moines are actually deprived of healthy food due to the extremely complex nature of what drives people’s diets. This study approaches food desert research from a quantitative perspective, and does not provide a full picture of what areas are lacking healthy food accessibility.

This study also does not take into account automobile ownership, a perspective that begs to be looked at in food desert research, especially in the context of this study where transportation was measured. This study generalizes the overarching themes of food deserts (proximity to stores and socioeconomic characteristics). While these two things are considered two important keys to analyzing food deserts, there is a lot more at play that considerably affect one’s diet (culture, preference, etc.). This study also assumes
that healthy food can only be obtained through food stores, and neglects that fact that people can obtain healthful food through other avenues like local farmer’s markets or gracious neighbors.

Future Research

Research to best supplement this study would go along the lines of getting at the “ground-level,” so to speak, and conduct interviews with residents in areas deemed at risk for low access of healthy food. This way, a more comprehensive view can be formulated between the quantitative aspects of food accessibility, like this study, and the qualitative conditions that drive the peoples, diets (psychological, economical, geographical, etc.). These two paired together have the potential to be more transparent in finding the underlying issues that drive food desert formation.

Implications

It can be argued that food deserts are a product of cities undergoing their natural evolution of sprawling out. Stores are being built in suburban areas and avoid inner city areas merely due to the economic conditions. Owners of supermarkets are not necessarily concerned with feeding the people, but rather maximizing their profits by going to where the people with favorable economic characteristics are at (suburbia). Although this study sheds light on what areas could possibly benefit the most with a healthful food store, owners are likely to place their stores where they can prosper the most financially.
Perhaps the resolution is not to add incentives to attract food stores to areas that need it, but rather change transit to address the areas that need healthy food the most. DART has made public that they would like to address the problem of placed refugees not having access, but they are struggling financially. In all, a municipal decision must be made whether to incentivize stores to locate in certain areas or to change transit options to better serve underprivileged populations.

**Conclusion**

This study explored the spatial relationships of attributes identified as contributing to food deserts and the overall health environment of the metropolitan area of Des Moines, IA. The findings show that there are some areas within Des Moines that have significantly better access to healthful food stores than others. Specifically, the areas that seem to lack accessibility the most are the southern and southeastern parts of city, where there is relatively high socioeconomic distress, lack of store proximity, and low access to bussing.

Another major contribution that this study provides are new techniques in evaluating food store accessibility and measuring food store quality. This study builds off of previous studies by including public transit and measuring food store quality in the analyses and evaluation of food desert research. The dimension of public transportation in accessibility to food should not be ignored as it has the possibility of serving an important role in getting residents to stores at a low cost. The act of evaluating stores via
survey also serves a critical role in evaluating the health landscape because it allows the researcher to form a better perspective of what the stores provide for the city’s residents.

The literature shows that the formation of food deserts does not seem to be slowing down as health disparity continues to gain momentum of becoming a critical issue within both urban and rural environments. However, this research hopefully serves a purpose of raising awareness of the dangers of food deserts to society as a whole. Ultimately, it is the responsibility of local governments to realize and assess these issues, as the food retail environment has huge implications on the health and well-being of already at-risk populations.
REFERENCES


Ghirardelli, A., Quinn, V., & Sugerman, S. (2011). Reliability of a Retail Food Store Survey and Development of an Accompanying Retail Scoring System to


