

2014

Disparities in accessibility to pharmacies: a case study in East Baton Rouge Parish, Louisiana

Samina Zahid Ikram

Louisiana State University and Agricultural and Mechanical College, sikram3@tigers.lsu.edu

Follow this and additional works at: https://digitalcommons.lsu.edu/gradschool_theses



Part of the [Social and Behavioral Sciences Commons](#)

Recommended Citation

Ikram, Samina Zahid, "Disparities in accessibility to pharmacies: a case study in East Baton Rouge Parish, Louisiana" (2014). *LSU Master's Theses*. 4000.

https://digitalcommons.lsu.edu/gradschool_theses/4000

This Thesis is brought to you for free and open access by the Graduate School at LSU Digital Commons. It has been accepted for inclusion in LSU Master's Theses by an authorized graduate school editor of LSU Digital Commons. For more information, please contact gradetd@lsu.edu.

DISPARITIES IN ACCESSIBILITY TO PHARMACIES: A CASE
STUDY IN EAST BATON ROUGE PARISH, LOUISIANA

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Masters of Science

in

The Department of Geography and Anthropology

by

Samina Z. Ikram

B.A., Khulna University, Khulna, Bangladesh, 1998

B.A., Peace College, Raleigh, NC, 2004

May 2014

This research is dedicated to my family, because without their support and inspiration, I would not be in such a blessed position to pursue my studies.

I also remember those people who showed me light in this earth and taught me how important education is; those memories brought me here to fulfill my unfinished work!

Love you all.

ACKNOWLEDGMENTS

I'm gratified to Almighty Allah, who helped me to get started on my journey.

I started my journey in spring 2012; I am really thankful to Dr. Fahui Wang and Dr. Barry Keim for the opportunity to pursue graduate studies at LSU. Dr. Fahui Wang, my advisor, gave me valuable advice about handling the challenges in graduate school and my journey into graduate level research. His advice and assistance in understanding the subject matter including technical challenges were always inspiring to me. I am thankful to Dr. Lei Wang, and Dr. Rohli; their coursework helped me throughout my research including preparing the dissertation report. I extend my sincere thanks to Yujie Hu, Shahriar Pervez, and Dana Sanders for their assistance in overcoming technical challenges throughout my research work.

Special thanks to my children Ethan Zahid (12) and Raaiqa Zahid (10) for their never-ending enormous love, encouragement, and support for pursuing my journey at LSU. Finally I am thankful and grateful to my husband Dr. Anwar Zahid for support and help throughout these difficult years. You all were always with me and sacrificed so many beautiful moments to help me complete my journey.

TABLE OF CONTENTS

ACKNOWLEDGMENTS	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
ABSTRACT.....	viii
CHAPTER 1: INTRODUCTION	1
1.1 Background of the Study	1
1.2 Objectives of the Study	2
1.3 Organization of the Thesis	3
CHAPTER 2: LITERATURE REVIEW	4
2.1 Accessibility to Services	4
2.2 Accessibility to Pharmacies	6
2.3 Spatial Accessibility Measures.....	8
CHAPTER 3: STUDY AREA AND DATA PROCESSING.....	10
3.1 Study Area.....	10
3.2 Road Network and Pharmacy Stores.....	12
3.3 Demographic Data.....	13
CHAPTER 4: THE PROXIMAL AREA ANALYSIS.....	18
4.1 The Proximal Area Analysis by Euclidean Distance	18
4.2 The Proximal Area Analysis by Travel Time	20
4.3 Disparities among Demographic Groups by the Proximal Area Method	22
CHAPTER 5: ACCESSIBILITY ANALYSIS BY THE 2SFCA METHOD	25
5.1 The 2SFCA Method for Measuring Spatial Accessibility	25
5.2 Disparities among Demographic Groups by the 2SFCA Method.....	29
CHAPTER 6: STATISTICAL ANALYSIS OF ACCESSIBILITY DIFFERENCES BETWEEN DEMOGRAPHIC GROUPS	32
6.1 Regression Model for Analysis of Accessibility Differences between Demographic Groups	32
6.2 Results and Discussion.....	33
CHAPTER 7: CONCLUSION	38

REFERENCES	41
VITA.....	44

LIST OF TABLES

Table 3.1 Descriptive Statistics for Block Groups, by Ethnic Group and Age: East Baton Rouge Parish, 2010	15
Table 4.1: Population Served by Nearest Pharmacies Based on Euclidean Distance	20
Table 4.2: Population Served by Nearest Pharmacies Based on Travel Time.....	22
Table 4.3: Weighted Average Distance and Travel Time to the Nearest Pharmacy for Various Population Groups	23
Table 5.1: Weighted Average 2SFCA Accessibility Scores for Various Population Groups	30
Table 6.1: Demographic Groups in Areas beyond and within the Average Distance	35
Table 6.2: Demographic Groups in Areas beyond and within the Average Time.....	35
Table 6.3: Demographic Groups in Areas above or below the average 2SFCA Accessibility Score	36

LIST OF FIGURES

Figure 3.1 : Location and road network of East Baton Rouge Parish.....	11
Figure 3.2 : Locations of Pharmacies and Census Block Groups in East Baton Rouge Parish	13
Figure 3.3 : Percentage of population by racial-ethnic group in East Baton Rouge Parish 2010: (A) White, (B) African-American, (C) Hispanic.....	16
Figure 3.4 : Percentage of population by age group in East Baton Rouge Parish 2010: (A) < 5, (B) 65-74, (C) 75-84, (D) 85+	17
Figure 4.1: Euclidean Distance from the Nearest Pharmacy in East Baton Rouge Parish	19
Figure 4.2 : Travel Time from the Nearest Pharmacy in East Baton Rouge Parish	21
Figure 5.1: Spatial accessibility scores by 2SFCA method: (A) 5-minute catchment, (B) 20- minute catchment, (C) 35-minute catchment	28

ABSTRACT

Accessibility is a term used to define the relative ease by which activities or services, such as work, recreation, shopping, education or healthcare, can be accessed from a given location. It is an important locational amenity for residents. This study examines accessibility to over 100 pharmacies in Baton Rouge, Louisiana, in 2010. Accessibility to a pharmacy is critical for a community as it is the prime source to get medication and other health services. First, two Geographic Information Systems (GIS) based methods, namely the proximal area method and the two-step floating catchment area (2SFCA) method, are used to measure the spatial accessibility to pharmacies for residents at the census block group level. Second, the disparities of spatial accessibility across major racial-ethnic groups are examined in order to assess whether minorities disproportionately suffer from poorer access. Finally, a statistical test is developed to verify whether the racial-ethnic disparities in accessibility are statistically significant. The study indicates that higher percentages of African-Americans are located in areas with shorter travel time to their nearest pharmacies than Whites, but the pharmacies in these areas serve more people (i.e., fewer pharmacies per 10,000 residents). Seniors, particularly those of 75 years or older, tend to be disproportionately concentrated in areas with pharmacies that are closer and less crowded. The results have significant implications for public policy.

Key words: spatial accessibility, pharmacy, proximal area method, 2SFCA, racial disparity, Baton Rouge

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Accessibility is a term that describes the relative ease by which the locations of activities, such as work, recreation, shopping, education, or healthcare, can be reached from a given location. Accessibility can be measured as one's ability at a location to reach services available at various locations. As the distributions of services and population are not uniform across space, residents in some areas have greater accessibility than those in other areas. This is considered *disparity* (Rodrigue, 2013).

Accessibility can be related to spatial and nonspatial factors (Wang, 2006). *Spatial accessibility* emphasizes geographic barriers such as distance between services (supply) and residents (demand) and one's ability through transportation to overcome the barrier. Nonspatial factors include various demographic and socioeconomic variables that affect individuals' ability to obtain services. In short, spatial (geographic) accessibility is because of "where you are," and nonspatial accessibility is because of "who you are." This thesis focuses on spatial accessibility as it is of primary interest to geographers. However, it also examines how the spatial and nonspatial factors interact, such as the racial-ethnic disparities in spatial accessibility.

Pharmacies provide an important service for a community (Tucci, 2009). Pharmacists assess the suitability of medication for patients by taking into account their medical history, possible side effects and interactions with other drugs. In many areas, pharmacists also administer immunizations and deliver preventive services (Shah, 2010). Pharmacies are distributed across wide geographic areas, and operate during different hours in specific locations. Accessibility to pharmacies is critical for a community to ensure adequate delivery of the service for the entire population. An accurate and reliable measure of accessibility to pharmacies helps

health service planners and policymakers understand which areas and what demographic groups experience poorer access and what strategies may be adopted to mitigate the problem.

1.2 Objectives of the Study

In line with the notion that accessibility includes both spatial and nonspatial factors, this study has two major objectives.

The first objective of the study is to measure the spatial accessibility to over 100 pharmacy sites across census block groups in Baton Rouge, Louisiana. Two GIS-based methods are used. For health care services, proximity is the most influential component for a community (Law et al., 2011). The proximal area method assumes that residents choose the nearest pharmacy for pharmaceutical needs, and thus travel distance and time from the closest pharmacy store is used as a basic measure to capture the spatial accessibility at a residential location. The more advanced “two-step floating catchment area (2SFCA)” method accounts for both the spatial barrier between residents and pharmacies and the ratio between them. The latter is not considered in the proximal area method. The 2SFCA method is a comprehensive measure of spatial accessibility with wide adoptions in recent literature, and is chosen to represent a refined measure of pharmacy accessibility for this study. Spatial accessibility is location-specific and thus identical for all residents in the same community.

The second objective is to examine the interaction between the spatial accessibility and nonspatial factors. In a community with the same spatial accessibility, accessibility varies across racial-ethnic groups, age groups, socioeconomic classes, and others (Wang and Luo, 2005). This study focuses foremost on whether disproportionately high concentrations of certain racial-ethnic groups are in poorer accessibility areas of Baton Rouge. Specifically, differences in average

accessibility among demographic groups are examined first, and then further analysis is conducted to determine whether such a difference is statistically significant. The study uses U.S. Census data aggregated to an area unit (here census block groups), and does not include data on how individuals actually seek and obtain pharmaceutical care. This data limitation implies the ecological and exploratory nature of the study, which calls for the need of more in-depth analysis of individual behavior in the delivery and utilization of pharmaceutical care.

In short, the first objective identifies “pharmacy deserts”—areas with inadequate numbers of pharmacies, while the second objective helps identify any existing disparities in the service in terms of race, ethnicity, and other demographic attributes. The study assesses both geographic and racial disparities, a major issue in healthcare policy analysis.

1.3 Organization of the Thesis

Following this introductory chapter, Chapter 2 provides a literature review on the accessibility disparities including the sources and consequences. Chapter 3 describes the study area and data sources and processing. Chapters 4 and 5 discuss applications of the proximal area method and the 2SFCA method in measuring spatial accessibility to pharmacies in the study area, respectively. Chapter 6 presents statistical analysis in the form of a regression model with dummy variable to test whether the disparities in spatial accessibility are significant across racial-ethnic groups. The thesis concludes with a brief summary of major findings and limitations.

CHAPTER 2: LITERATURE REVIEW

2.1 Accessibility to Services

Universal access to services is the ability of all people to have an opportunity in receiving provided services regardless of their social class, ethnicity, or race. However, the reality is that access to various services is hardly uniform and lack of access is part of the definition of poverty. Sustained access to services such as education, parks and recreation, shopping, and health care is critical to long term improvements in productivity, reduction on inter-generational cycles of poverty, demographic transition, preventive health care, and reductions in inequality for a community. Among others, improvement in access to services and reduction of disparities of accessibility are major development goals.

Access may be classified according to two dichotomous dimensions (potential vs. revealed, and spatial vs. aspatial) into four categories, such as potential spatial access, potential aspatial access, revealed spatial access, and revealed aspatial access (Khan, 1992). Revealed accessibility is represented by actual use of a service, whereas potential accessibility reflects opportunities for people to use a service. The revealed accessibility may be reflected by frequency or satisfaction level of using a service, and thus often relies on some expensive data collections (e.g., surveys or interviews) to study. Most studies examine potential accessibility, which is evaluated based on the quality of the existing system of service delivery and likelihood for improved delivery if feasible strategies for improvement are implemented (Wang, 2006, pp.77). Spatial access emphasizes the importance of spatial separation between supply and demand as a barrier or a facilitator, whereas the aspatial access stresses non-geographic barriers or facilitators (Joseph and Phillips, 1984). Aspatial access is related to many demographic and socioeconomic variables. In a study of healthcare access, Wang and Luo (2005) included several

categories of aspatial variables: demographics such as age, sex, and ethnicity; socioeconomic status such as population under the poverty line, female-headed households, home ownership and income; environment such as residential crowdedness and number of housing units lacking basic amenities; linguistic barrier and service awareness such as population without a high-school diploma and households linguistically isolated; and transportation mobility such as households without vehicles. This thesis focuses on *potential spatial accessibility*.

There is a rich body of literature on various applications of accessibility. For example, a local community may be interested in examining the accessibility to children's playgrounds, identifying underserved areas and designing a plan of constructing new playgrounds or expanding existing ones (Talen and Anselin, 1998). Wang and Minor (2002) examined the intraurban variation of job accessibility in Cleveland and found a strong correlation between poorer job access and higher crime rates in neighborhoods. Zenk et al. (2004) evaluated the spatial accessibility of large chain supermarkets in Detroit, and observed that residential segregation disproportionately placed African-Americans in more impoverished neighborhoods and consequently had poorer access to supermarkets. Williams (2012) studied the accessibility of public high schools in metropolitan Baton Rouge, Louisiana, from 1990 to 2010. His research found that high schools with more Black students tended to have poorer accessibility levels, and schools with lower accessibility tended to be associated with poorer performance even after controlling for the effects of race and socioeconomic status-related factors. Sales et al. (2013) studied accessibility of urban public space. They found that barriers or difficulties in proper transportation to day-to-day activities of people can also have direct impacts on their health.

The applications of accessibility analysis are particularly rich in healthcare studies. For example, dental care is important for the overall health as there is strong evidence linking lack of

dental care with systemic diseases such as cardiovascular disease and low birth weight (Scannapieco, 2013). Susi and Mascarenhas (2002) used GIS to map the distribution of dentists in Ohio, and found that the poor, minorities, the uninsured, and people in poor health are most at risk as they suffered from poor access to dental services. Horner and Mascarenhas (2007) further advanced the study of dental care in Ohio by analyzing geographical accessibility and identifying regional inequities in access to dental services.

Early detection of cancer, facilitated by adequate access to primary care, enhances survival rates for cancer patients. Wang et al. (2007) found that convenience of visiting primary care physicians and short travel time from the nearest mammography facility reduce late-stage breast cancer risk and thus cancer mortality. Disadvantaged population groups including those with low income and racial and ethnic minorities tended to experience high rates of late-stage cancer diagnosis. More recently, Mennis et al. (2012) studied the geographic barriers to community-based psychiatric treatment for drug-dependent patients and found that longer travel time to treatment affected clients' treatment continuity and highlighted the need for more consideration of geographic access in psychiatric treatment planning.

In summary, accessibility is a major issue of great relevance to public policy, and accessibility of healthcare is particularly important to people's well-being. Spatial accessibility has received increasing attention in the research community and is a topic naturally suitable for geographers.

2.2 Accessibility to Pharmacies

The pharmacy is an important component of healthcare delivery for a community. In many areas, pharmacists not only provide the pharmaceutical service to customers, but also

administer immunizations and deliver preventive services (Shah, 2010). Pharmacy accessibility to a certain location is influenced by many factors, including the number of pharmacies in the area (supply), the total population around the area (demand), their health condition, other social and economic characteristics of the population, their knowledge about health and the health-related facilities, and geographical barriers between population and health services (Aday and Andersen, 1974). For reasons stated previously, given the focus of this study on geographic issues, the review in this subsection emphasizes the existing work related to geographic access. A search of the literature reveals only a few publications closely related to this topic.

Swu-Jane (2004) analyzed the accessibility to the community pharmacy by the elderly population in Illinois, and the focus was on the geographic accessibility and the disparity between urban and rural areas. A major finding from the study was the adequate access to pharmacies for remote rural populations. On the other hand, Casey et al. (2008) found that lack of financial viability led to frequent closures of pharmacy stores in rural areas in Minnesota, North Dakota, and South Dakota. Law et al. (2011) studied the geographic accessibility of community pharmacies and modeled the impact of possible closures in Ontario, Canada. Their study found that the majority of Ontario residents could access community pharmacies within reasonable travel distances via walking or driving. Owing to concentrations of competing pharmacies in areas zoned for commercial activity, their simulation results showed that reductions in the number of pharmacies would have only modest effects on geographic access to pharmacies in Ontario, but the effect of closures would be more pronounced on people living in rural areas. All three papers suggested the rural-urban disparity in accessibility of pharmacies.

In summary, the existing studies on this topic have benefited from the use of GIS technologies, but none has taken advantages of the recent development of accessibility

methodology as outlined in Wang (2012). A major task of this thesis research is to apply one of the comprehensive GIS-based accessibility measures to assess pharmacy accessibility.

2.3 Spatial Accessibility Measures

The methodological development of measuring spatial accessibility has evolved from simple supply-oriented accessibility measures to the supply-demand ratio methods, and most recently to the family of floating catchment area (FCA) methods.

Simple *supply-oriented accessibility measures* emphasize the proximity to supply locations. For instance, Hansen (1959) used a gravity-based potential model to measure accessibility to jobs by summing up the jobs around a residential location, each which is discounted by a distance decay factor. Onega et al. (2008) used minimum travel time to the closest cancer care facility to measure accessibility to cancer care service. By doing so, the service area of a supply facility is composed of consumers always choosing the nearest service. Therefore, the method is also termed the *proximal area method*. Scott and Horner (2008) used the cumulative opportunities within a distance (travel time) range to measure job accessibility. One major criticism for these methods is the complete absence of effect by the amount of demand. In other words, given the same setting of supply capacities and locations, the number of people competing for the service is not factored into their accessibility.

The *supply-demand ratio* approach computes the ratio of supply versus demand in an area (usually an administrative unit such as township or county) to measure accessibility. A higher ratio corresponds to better accessibility. For instance, the U.S. Department of Health and Human Services (DHHS) uses a threshold physician-to-population ratio (e.g., 1:3500) within a “rational service area” (e.g., a county or sub-county) as a basic indicator for defining physician

shortage areas (Wang and Luo, 2005). The shortcoming of this approach is its inability to reveal the spatial variation within an area unit and the negligence of supply-demand interaction across the border of analysis areas.

A method developed by Luo and Wang (2003) overcomes the above fallacies by repeating the process of “floating catchment” twice (once on supply locations and once on demand locations), and is therefore referred to as the *two-step floating catchment area (2SFCA) method*. In essence, the 2SFCA method is basically the ratio of supply to demand, and the interaction of supply and demand is confined within a threshold distance (travel time) or “catchment area.” See more details of the method in Chapter 5.

Other spatial accessibility measures have been proposed in the literature such as the gravity-based accessibility index by Joseph and Bantock (1982), Gaussian-function-based index (Dai and Wang, 2011) and the expanded-2SFCA (E2SFCA) method by Luo and Qi (2009). Based on the review by Wang (2012), most of these advanced methods can be synthesized into a *generalized 2SFCA model* with various ways of conceptualizing the distance decay behavior. More advanced methods usually require more data collection and analysis as well as more complexity in implementing the methods while losing much intuitiveness, easy interpretation, and potential of wide adoption by public policy analysts.

This thesis will use the proximal area method as the first attempt to measure spatial accessibility because of its widest usage as a baseline model. The more modern 2SFCA method will then be used to obtain a more accurate and effective measure of accessibility.

CHAPTER 3: STUDY AREA AND DATA PROCESSING

3.1 Study Area

The parish in Louisiana is a unit equivalent to county in other states in the U.S. The study area, East Baton Rouge Parish (EBRP), is located in the south-central part of Louisiana (Figure 3.1). It is separated by the Mississippi River from West Baton Rouge Parish on the west and by the Amite River from Livingston Parish on the east. These two rivers are the natural borders of the study area on the west and on the east. To the north and the south, EBRP mostly borders with East Feliciana Parish and Ascension Parish with some continuous urbanized areas connecting them. One limitation of this study is the possible *edge effect*, referring to less reliable conclusions than can be drawn in areas near the edge of the study area where interactions with neighboring parishes are not considered in the research. In other words, residents in the study area may visit pharmacies in neighboring parishes and vice versa. Admittedly, the edge effect may be present, particularly in the northwest corner and in the south, and caution needs to be taken in interpreting the results in those areas. As shown in Figure 3.1, this effect is limited since the study area is mostly confined by rivers or rural areas (Wang et al., 2009).

For simplicity, the study area is hereafter referred to as Baton Rouge. The land area has 455.37 square miles (1179.14 km²) and the water area is 14.86 square miles (38.48 km²). According to the Census 2010, the total population in the study area is 440,171. Baton Rouge anchors the Baton Rouge Metropolitan Statistical Area (MSA), i.e., the 65th largest MSA in the country (<http://quickfacts.census.gov/qfd/states/22/22033.html>). It has several incorporated municipalities such as City of Baton Rouge, City of Baker, City of Zachary, etc.

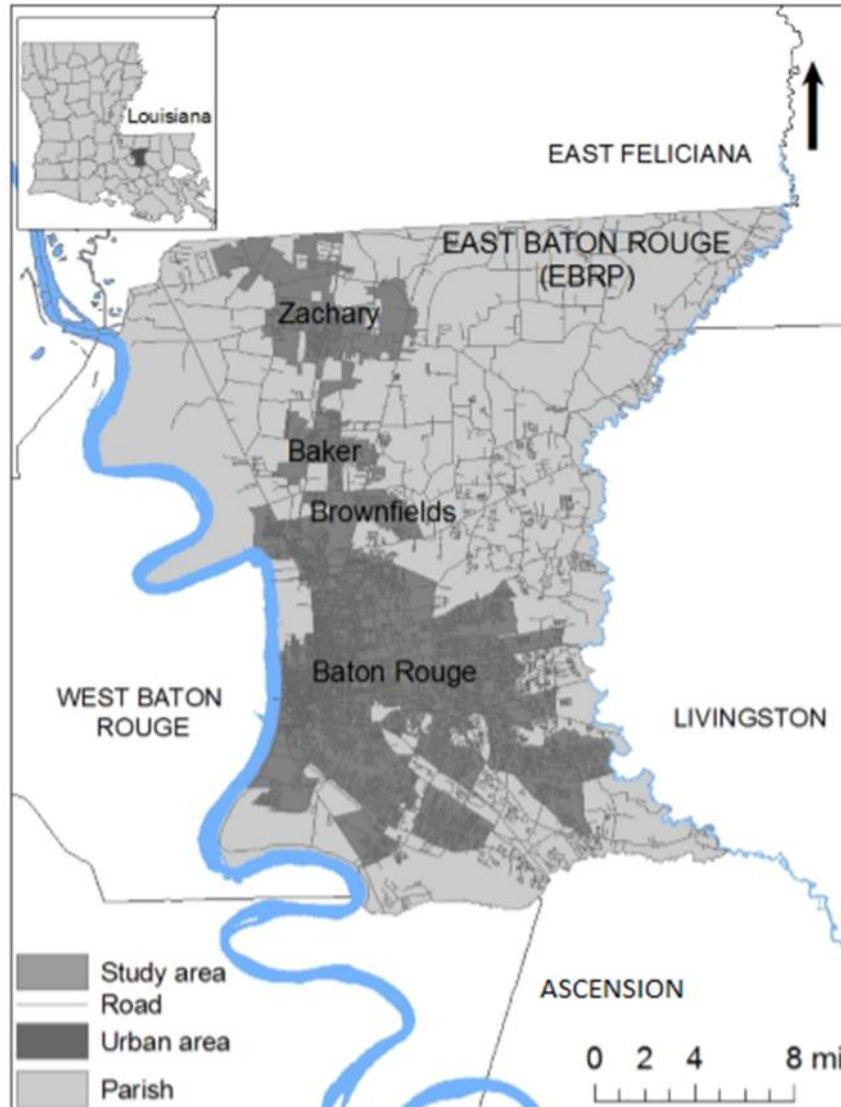


Figure 3.1 : Location and road network of East Baton Rouge Parish

According to the 2011 Greater Baton Rouge Community Health Needs Assessment report commissioned by the Baton Rouge Mayor-President (<http://healthybr.com/pdfs/NeedsAssessment.pdf>), Baton Rouge ranks 19th out of 64 parishes in Louisiana while the state ranks 49th in the nation. According to the same report, Baton Rouge also has double the national benchmarks in both low birth weight rate and uninsured population rate, and ranks 2nd in the nation for new HIV/AIDS cases and has six times the national average

rate of sexually transmitted diseases. These major challenges faced by the community further highlight the importance of research and understanding of health-related issues including pharmacy accessibility.

3.2 Road Network and Pharmacy Stores

Data preparation for analysis of spatial accessibility is usually composed of three parts: supply facilities, demand locations, and transportation linkage (e.g., road network) between them. In this case, the supply facilities are pharmacy stores, and demand locations are population in census block groups (in Section 3.3).

The road network data set is downloaded from the U.S. Census Bureau web site for the topologically integrated geographic encoding and referencing (TIGER) files (<https://www.census.gov/geo/maps-data/data/tiger.html>), as shown in Figure 3.1. The current road network data do not contain the information of speed, which is critical for estimating travel time between block groups and pharmacies. This research adopts the strategy in Luo and Wang (2003) by assigning various speeds on roads according to their Census Feature Class Codes (CFCC), which identify the road classes and thus approximately corresponding speed limits.

An exhaustive search for the pharmacies in Baton Rouge resulted in a total of 110 pharmacies in business, and their addresses were collected from the Yellow Pages and Internet. The pharmacies include pharmacies of major brands (e.g., Walgreen's, CVS, and Rite Aid), pharmacies located inside grocery stores and supermarkets, and local pharmacies. All pharmacy addresses are geo-coded in ArcGIS (www.esri.com/software/arcgis) as a point layer shown in Figure 3.2. For quality control, the street addresses of all pharmacies have been verified by the Google Maps (www.google.com/maps).

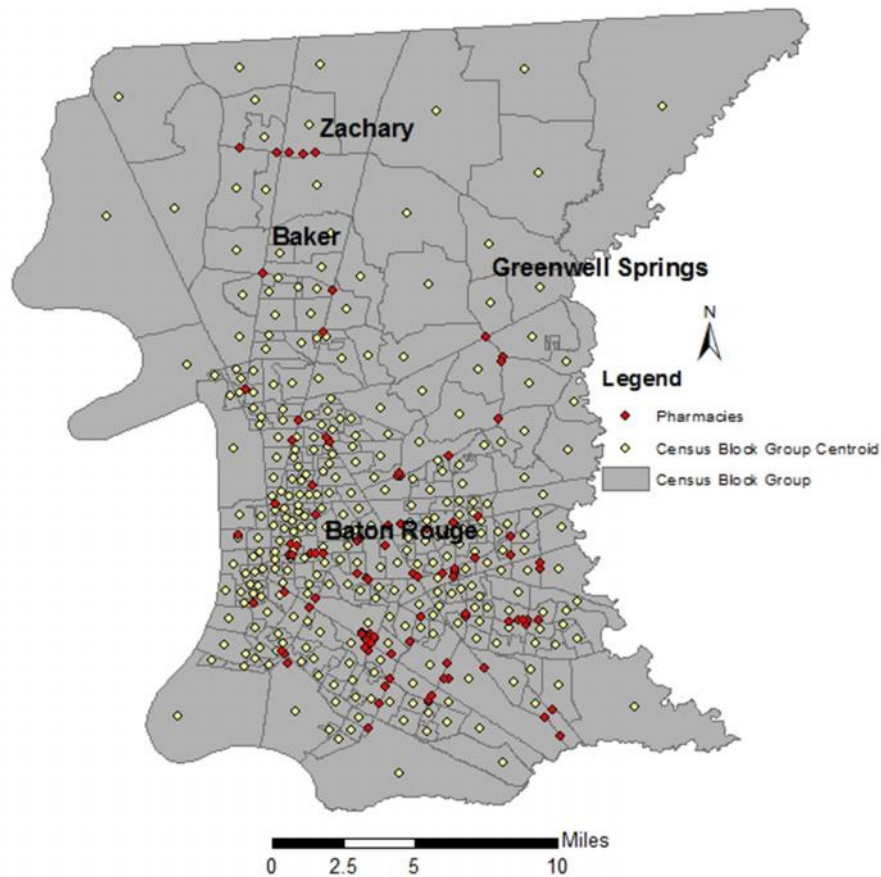


Figure 3.2 : Locations of Pharmacies and Census Block Groups in East Baton Rouge Parish

3.3 Demographic Data

The demographic data are extracted from the 2010 Census Data (<http://www.census.gov/2010census/data/>). Specifically, it is the Census Summary File 1 data at the block group level with variables such as total population, breakdowns by age, sex, race, and Hispanic or Latino origin etc. The corresponding GIS data in ArcGIS shapefiles for the block group level are also downloaded from the web site for the TIGER files, also managed by the Census Bureau (<https://www.census.gov/geo/maps-data/data/tiger.html>). The demographic data and the GIS data are integrated together for analysis in ArcGIS based on their common IDs. Other demographic variables such as income, poverty status, educational attainment, and other

detailed socioeconomic attributes at the corresponding small geographic units such as the block group level are no longer available in the decennial census products such as the 2010 Census. They are only available through the American Community Survey (ACS) 5-Year (e.g., 2006-2010) Estimates Data. Therefore, our analysis on demographic data is limited to total population, racial-ethnic groups, and age groups.

Census block group (BG) is the analysis unit chosen for this analysis. A BG is statistical division of census tract and consists of blocks within the same census tract. In other words, BG is a unit between census tract and block. The study area has 92 census tracts, 303 BGs, and 7,896 blocks. One might consider using census blocks, the smallest geographic area for which the Bureau of the Census gathers the decennial census data, in order to achieve better spatial accuracy and a sharper resolution. However, since the study area consists of a large number of blocks, some analyses such as deriving the travel time matrix and defining floating catchment areas at this scale can be computationally expansive and cumbersome. If census tracts are used, the spatial resolution would be too coarse for meaningful accessibility analysis. For example, since the number of supply (pharmacy) facilities is more than 100, the proximal area analysis would result in very few or even no tracts in a pharmacy store's service area. The BG data yield results with reasonable spatial variability and manageable computation complexity.

Total population in each BG is used to define the demand amount. In addition, population by major racial-ethnic groups and some age groups is also used in analysis of interaction between spatial accessibility and nonspatial factors. The study area is composed of 51% Whites, 44% African-Americans, 3% Hispanics, and 2% Asians. In subsequent analysis on racial disparities, three groups are selected White, African-American, and Hispanic. Other groups are not considered because of their lower percentages of population. Hispanic is included as an

experiment and results should be interpreted with caution. Table 3.1 shows the basic statistics for the three selected racial-ethnic groups at the block group level.

Table 3.1 Descriptive Statistics for Block Groups, by Ethnic Group and Age: East Baton Rouge Parish, 2010

	N (Block Groups)	Mean	Standard Deviation	Min	Max
All Population	303	1,452	694.87	0	4,859
<i>Ethnic/Racial Groups</i>					
White	303	709	687.84	0	3,376
African-American	303	658	516.91	0	2,809
Hispanic	303	53	79.29	0	723
<i>Age groups</i>					
< 5	303	97	67.68	0	457
65-74	303	87	53.20	0	312
75-84	303	50	34.22	0	264
85+	303	21	25.86	0	219

Figures 3.3A and 3.3B show the distinctive distribution patterns of White and African-American, respectively. The White population is concentrated mainly in south and also the northeast corner of the parish and the African-American population is the opposite and largely concentrated in the central city area. The Hispanic population is scattered in various neighborhoods with low percentages except for one BG north of downtown along the Plank Road, with more than 30% of the total population.

Although it is not the focus of the thesis, the age structure in the area is also of interest to our work, as children and seniors tend to have high demand for pharmaceutical services. See Table 3.1 for basic statistics for the four selected age groups at the block group level. Figures 3.4(A)-(D) show the distributions of age group under 5, 65-74, 75-84, and above 85,

respectively. No clear patterns may be identified for any of the four age groups except a cluster of seniors (all three age groups) at about 3-5 miles southeast of downtown.

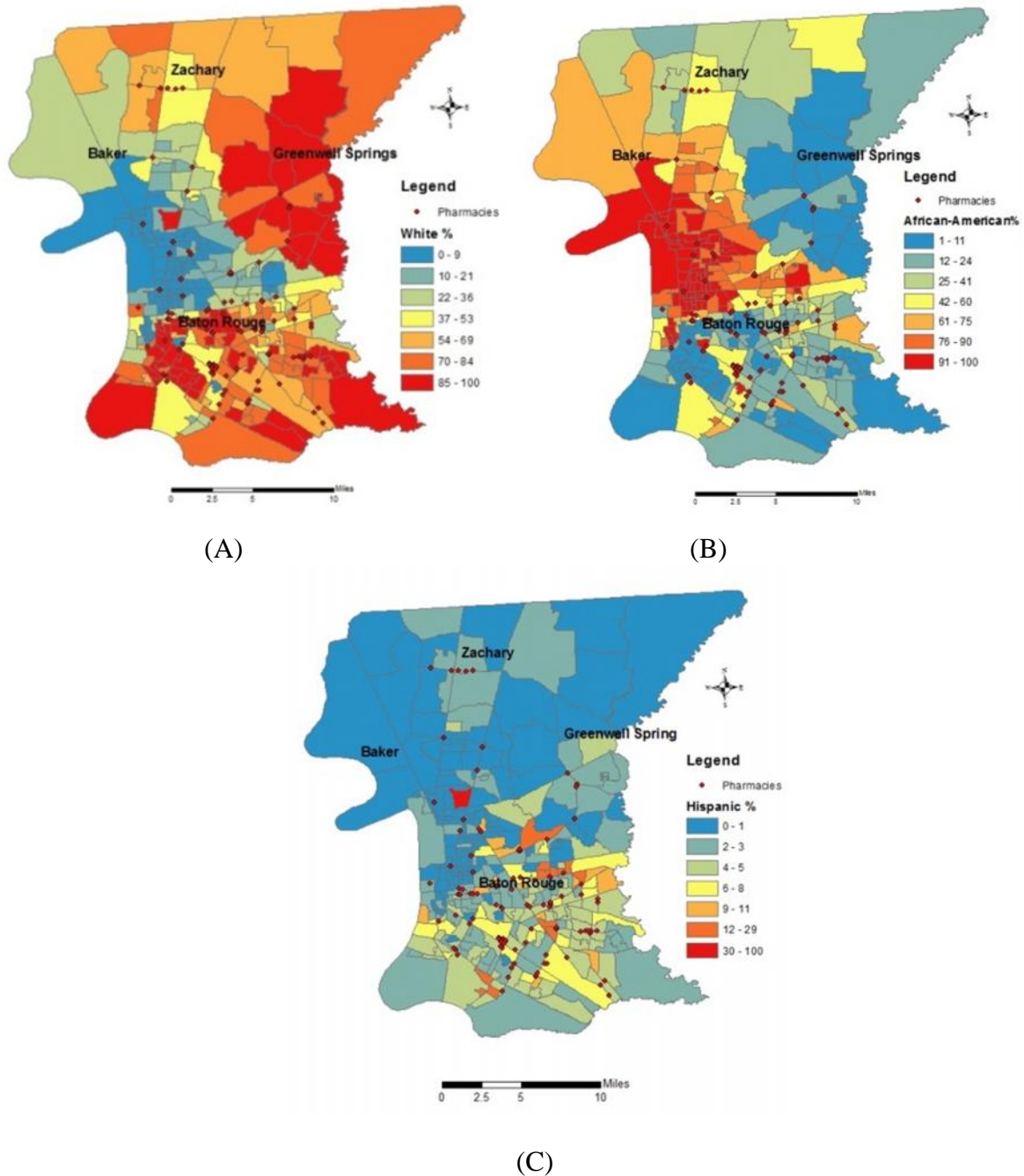
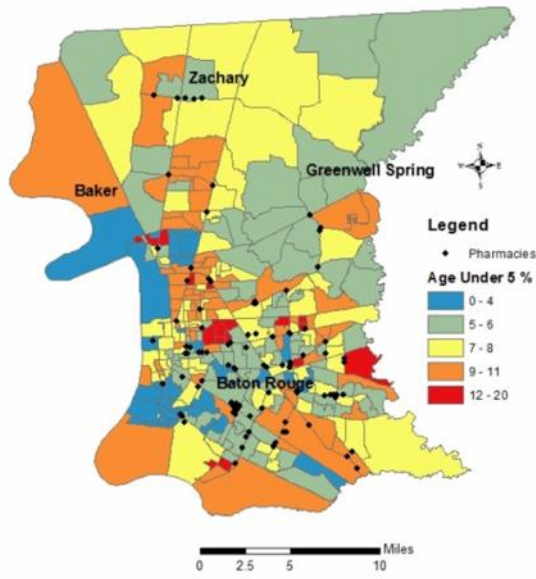
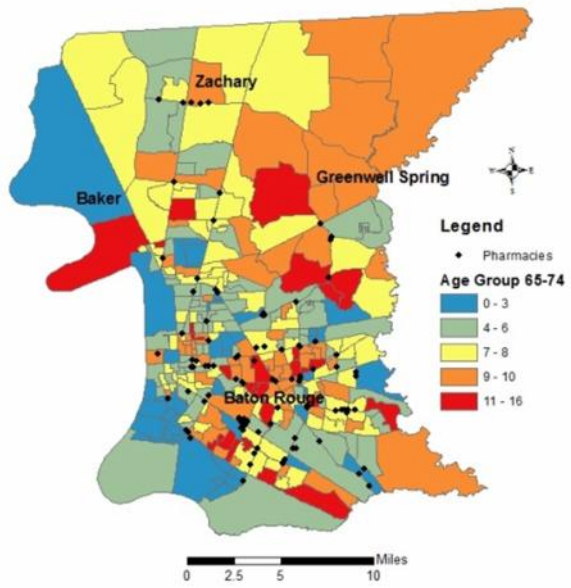


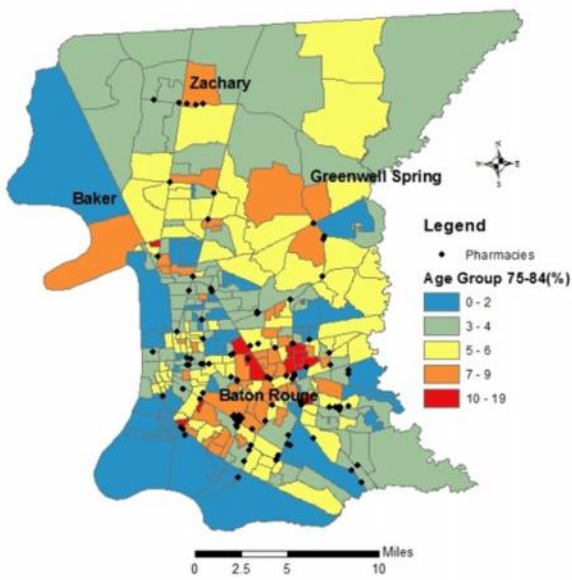
Figure 3.3 : Percentage of population by racial-ethnic group in East Baton Rouge Parish 2010: (A) White, (B) African-American, (C) Hispanic



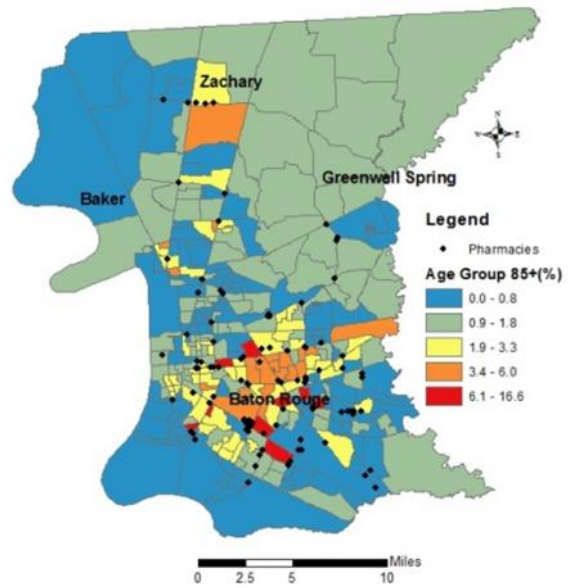
(A)



(B)



(C)



(D)

Figure 3.4 : Percentage of population by age group in East Baton Rouge Parish 2010: (A) < 5, (B) 65-74, (C) 75-84, (D) 85+

CHAPTER 4: THE PROXIMAL AREA ANALYSIS

The proximal area method is a simple geographic approach for defining service areas for a store by assuming that consumers choose the nearest store among similar outlets (Ghosh and McLafferty, 1987). The proximal area method implies that customers only consider distance (or travel time as an extension) in their shopping choice (Wang, 2006). The method is widely used in healthcare studies. For example, Brabyn and Gower (2003) measured geographical accessibility of general practitioners by the minimum distance to the closest facility. Wang et al. (2007) also used the travel time to the nearest mammography facility to capture accessibility of breast cancer screening service. Onega et al. (2008) used the travel time to the nearest cancer care facility to measure accessibility of cancer care. We begin the analysis by using this method to develop some basic understanding of spatial accessibility of pharmacies in the study area.

4.1 The Proximal Area Analysis by Euclidean Distance

In implementation, a census block group is represented by its centroid, and the Euclidean distance and travel time are calculated from the centroid to its closet pharmacy. While it is a common practice in GIS to represent an area by its centroid, the strategy is fairly reliable for areas of small area size but less accurate in large areas. In this case, block groups in high-density areas near the city center are small and compact whereas those in remote suburban are much larger in area.

Euclidean distance is simply a straight-line distance or “as the crow flies.” In ArcGIS, the “Near” tool is used to identify the closest pharmacy to each block group and also record the Euclidean distance between them. Figure 4.1 shows the Euclidean distances between block

groups and their nearest pharmacy. In general, the central area enjoys better accessibility with pharmacies less than 1 km away, and the distance increases outward. In parts of Zachary and Greenwell Springs in the north suburbs, some areas are more than 3 km from their nearest pharmacy stores. That is to say, residents in the central area in the City of Baton Rouge have better accessibility to pharmacies than those in the remote suburban, consistent with the finding from the literature reported in Chapter 2.

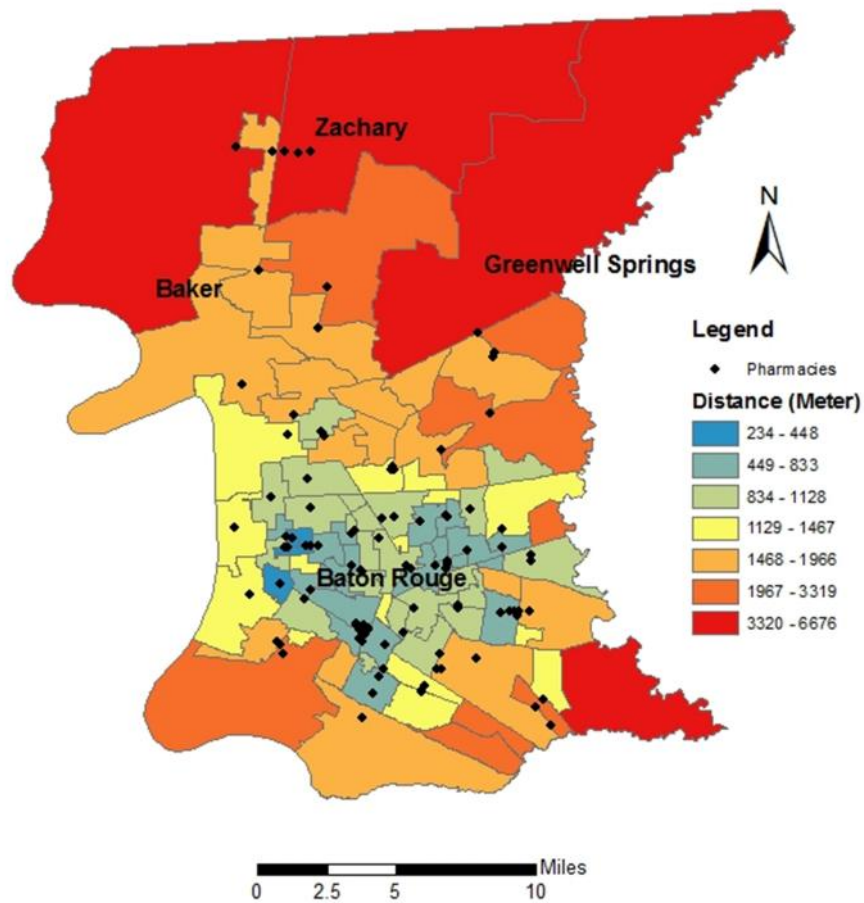


Figure 4.1: Euclidean Distance from the Nearest Pharmacy in East Baton Rouge Parish

Table 4.1 presents the breakdown of population by various distance ranges. 26.71% of population lives within 1 km of a pharmacy, while a majority of population (83.2%) lives within

2 km of a pharmacy location. Overall the population-weighted average distance from a nearest pharmacy location is 1.69 km in the study area (see Table 4.3). As urban neighborhoods do not extend more than a mile (Mark, 2004), the proximity analysis indicates that the majority of residents in Baton Rouge have access to a pharmacy in their neighborhoods.

Table 4.1: Population Served by Nearest Pharmacies Based on Euclidean Distance

Distance	Population Served	% of the Total Population
0-1 km	117591	26.71%
0-2 km	366541	83.2%
0-3 km	401985	91.3%
0-4 km	403366	91.6%
0-5 km	406534	92.3%
0-6 km	427310	97.0%
0-7 km	440171	100%

4.2 The Proximal Area Analysis by Travel Time

Euclidean distance is a simple but a rudimentary measure of spatial impedance. Travel time through a real-world road network is a better measure. This study uses the ArcGIS network analysis module to implement the proximal area analysis by travel time, assuming that people take the shortest route. Specifically, the “Closest Facility” tool in the Network Analyst module is used to implement the task. The network computation process first searches a node on the network that is closest to each block group centroid (origin node) and also another node closest to each pharmacy (destination node), and then identifies the nearest destination node from each origin node and the travel time between them.

Note that travel time reported in the result is only the time through the road network without accounting for the time spent by residents getting onto the road network at either end of the trip. In addition, it does not include the extra time used at the beginning of the journey to start the car and the time used at the end to park the car. Wang (2003) noted that the omitted time by

the software ArcGIS is significant (i.e., 13-17 minutes), and thus the travel time between a block group and a pharmacy estimated here is *much shorter* than what people normally experience. Based on another study by Wang and Xu (2011), travel time estimated by ArcGIS Network Analyst is consistently shorter than the time estimated by Google Maps API (which generally reflects our travel experience); however, the estimated travel times by the two methods correlates well. That is to say, if a researcher is mainly interested in the variability of travel time (as it is the case here), the estimated time by ArcGIS is fairly a good indicator of spatial accessibility when compared across block groups.

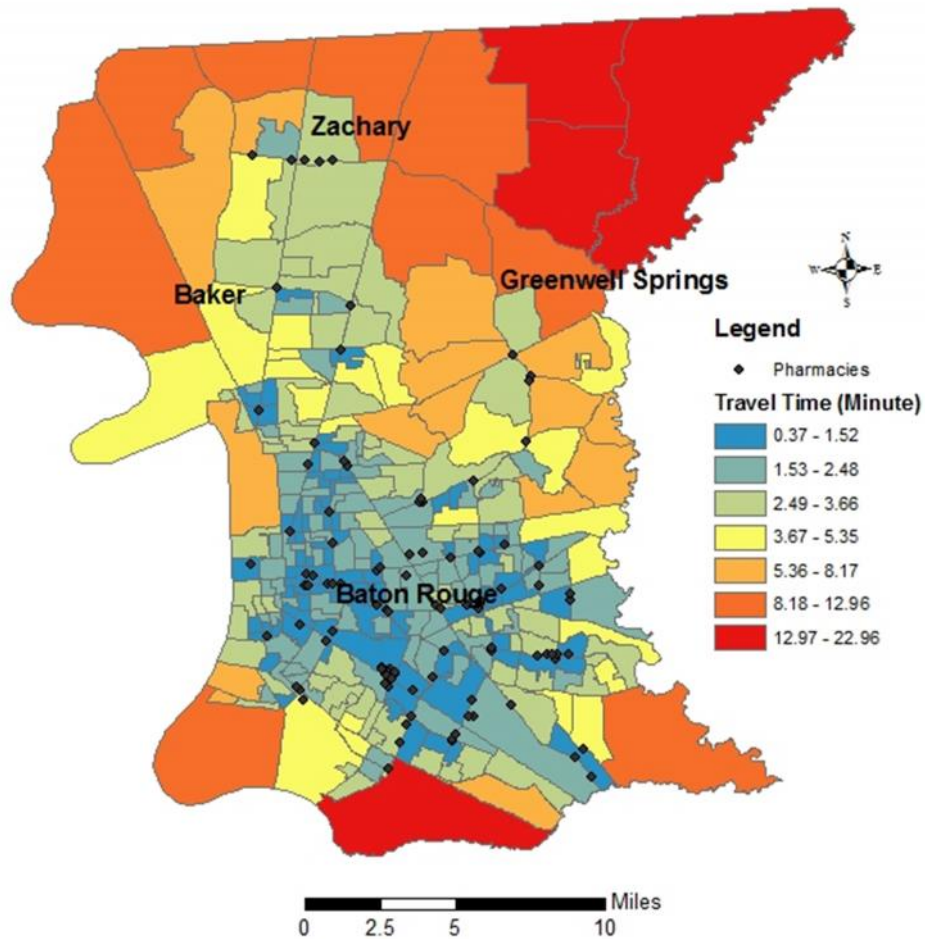


Figure 4.2 : Travel Time from the Nearest Pharmacy in East Baton Rouge Parish

Figure 4.2 shows the travel time to the nearest pharmacy across the block groups. With comparison to Figure 4.1, the general pattern is consistent, but the proximal areas by travel time do extend along major highways and arteries to take advantage of relatively faster speed on those roads. That is to say, the proximal area method by travel time indeed is a more realistic representation of spatial accessibility than that by Euclidean distance.

Table 4.2 presents the breakdowns of population served by the nearest pharmacy across various travel time ranges. Overall the population-weighted average travel time from a nearest pharmacy location is 3.19 minutes in the study area (see Table 4.3). Note that estimated travel time may be significantly lower than actual time for reasons explained previously.

Table 4.2: Population Served by Nearest Pharmacies Based on Travel Time

Estimated Travel Time	Population Served	% of Total Population
0-1 min	26836	6
0-2 min	184270	42
0-3 min	295077	67
0-4 min	360767	82
0-5 min	380807	86
0-10 min	420009	95
0-15 min	432043	98
0-20 min	437558	99
0-25 min	440171	100

4.3 Disparities among Demographic Groups by the Proximal Area Method

This section examines disparities of spatial accessibility between different demographic groups. The first task is on the differences among three major racial-ethnic groups: White, African-American, and Hispanic. While all three groups could be present in one block group with the same spatial accessibility, their relative concentrations (e.g., percentages) may vary. If the population of a racial-ethnic group is disproportionately higher in areas of poorer accessibility, it implies that overall this group may experience poorer access than others for various reasons

(e.g., discrimination in the housing market, lack of financial means, or immobility). We can evaluate this issue by simply comparing their average accessibility values (here distance or travel time) in this section, and then formally test a hypothesis by rigorous statistical analysis in Chapter 6.

Denoting p_i for population of a race/ethnicity in block group i and A_i for corresponding value of accessibility measure (i.e., Euclidean distance or travel time) in block group i , we have the weighted average accessibility \bar{A} :

$$\bar{A} = \sum_{i=1}^n (p_i A_i) / \sum_{i=1}^n p_i \quad (4.1)$$

Table 4.3: Weighted Average Distance and Travel Time to the Nearest Pharmacy for Various Population Groups

	Distance (km)	Travel Time (min)
<i>Racial-ethnic groups</i>		
White	1.91	3.69
African-American	1.48	2.67
Hispanic	1.39	2.71
<i>Age groups</i>		
< 5	1.66	3.19
65-74	1.77	3.28
75-84	1.59	2.98
85+	1.37	2.61
<i>All population</i>	<i>1.69</i>	<i>3.19</i>

Applying Equation (4.1) to each of the three racial-ethnic groups for all $n=303$ block groups, we obtain the weighted average distance (or travel time) for each group as reported in

Table 4.3. The weighted average distance and travel time are also computed for the overall population (i.e., 1.69 km and 3.19 minutes, respectively) as a baseline for comparison.

Table 4.3 shows that the weighted average distance for Whites (1.91 km) is longer than African-Americans (1.48 km) or Hispanics (1.39 km), and the weighted average travel time for Whites (3.69 minutes) is longer than African-Americans (2.67 minutes) or Hispanics (2.71 minutes). Note that a longer distance or travel time corresponds to worse spatial accessibility. That is to say, overall Hispanics and African-Americans actually enjoy better spatial accessibility to pharmacies (shorter distance or travel time from their closest pharmacy) than Whites in Baton Rouge. This is understandable since Hispanics and African-Americans tend to be more concentrated in the central city with a dense distribution of pharmacies; and White tend to locate more in the outskirts where pharmacies are sparse (as shown in Figures 3.3A-C).

Similarly, the weighted average distances and travel times for four age groups (one for children < 5 years, and three for seniors of 65 years or older) are computed and reported in Table 4.3. The results indicate that seniors of 65-74 is the only age group with longer distances or travel time from the nearest pharmacy than the general population, children are on par with the general population in either distance or travel time, and the two most senior groups (75-84 and 85+) enjoy shorter distance or time than the general population. The above findings are preliminary, and will be revisited by employing a rigorous statistical test. Furthermore, as stated previously, this study analyzes aggregated data in block groups and is thus of an ecological nature. In other words, this finding about the disparities is suggestive and not necessarily transferrable to individuals. This is commonly referred to as *ecological fallacy* when one attempts to infer individual behavior from data of aggregate areal units (Robinson, 1950).

CHAPTER 5: ACCESSIBILITY ANALYSIS BY THE 2SFCA METHOD

As outlined in Chapter 2, the proximal area method provides a preliminary assessment of spatial accessibility, but does not account for the competition for pharmaceutical service among residents, commonly referred to as the effect of crowdedness (Wang and Luo, 2005). A small number of pharmacists serving a large population implies possible long waiting time or delay in filling prescription drugs and delivering other service and thus reduces the accessibility. The popular two-step floating catchment area (2SFCA) method is used to overcome this limitation and considers the ratio between supply and demand of pharmacies while the interaction between them is confined within a reasonable distance (travel time) range.

5.1 The 2SFCA Method for Measuring Spatial Accessibility

As the name indicates, the 2SFCA method is composed of two steps. The first step measures the availability of each supply (pharmacy) site by the ratio of its capacity and surrounding demand (population). The second step sums up the initial ratios in the overlapped service areas to measure spatial accessibility at a demand location (block group), where residents have access to multiple pharmacy sites.

In mathematical terms, first, for each supply location j , search all demand locations (k) that are within a threshold distance (d_0) from location j (i.e., catchment area j), and compute the supply to demand ratio R_j within the catchment area:

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k} \quad (5.1)$$

where d_{kj} is the distance between k and j , D_k is the demand at location k that falls within the catchment (i.e., $d_{kj} \leq d_0$), and S_j is the capacity of supply at location j .

Next, for each demand location i , search all supply locations (j) that are within the threshold distance (d_0) from location i (i.e., catchment area i), and sum up the supply to demand ratios R_j at those locations defined in Equation 5.1 to obtain the accessibility A_i^F at demand location i :

$$A_i^F = \sum_{j \in \{d_{ij} \leq d_0\}} R_j = \sum_{j \in \{d_{ij} \leq d_0\}} \left(\frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k} \right) \quad (5.2)$$

where d_{ij} is the distance between i and j , and R_j is the supply to demand ratio at supply location j that falls within the catchment centered at i (i.e., $d_{ij} \leq d_0$).

Ideally, in Equation (5.2), the demand capacity S should be measured as the full-time equivalent pharmacists of each store. After repeated attempts to collect this information, it was deemed infeasible for all stores due to limited time and resources. This research assumes the same capacity for all pharmacies. The demand is defined as population in a block group. Equation (5.2) is basically the ratio of supply (number of pharmacies) and demand (population) filtered by a spatial window or catchment area. A larger value of A_i^F indicates more pharmacies per resident and thus a better accessibility at a location.

A major task in implementing the 2SFCA method is computation of the travel time matrix between block groups and pharmacy locations. A block group is once again represented by its centroid. The “OD Cost Matrix” tool in ArcGIS Network Analyst module is used to implement the task based on the road network. After the travel time table is prepared, a series of “Join” and “Summarize” tools in ArcGIS is used to compute the accessibility defined in Equation (5.2) (Wang, 2006). A property of the accessibility scores derived by the 2SFCA is that the weighted average score for the whole study area is the ratio of total number of pharmacies

and total population (i.e., $110/440171=0.00025$). In order to avoid small values, we inflate the 2SFCA scores uniformly by multiplying all values by 10,000, and the revised scores may be interpreted as pharmacies per 10,000 residents. In other words, the average accessibility score for the study area, an important benchmark, is 2.5 pharmacies per 10,000 residents in Baton Rouge.

One major parameter in the 2SFCA is the catchment size, and there is much debate in the literature on what is considered a reasonable travel range (Wang, 2012). In the absence of a field survey of actual travel behavior of people visiting pharmacies in Baton Rouge, the method is implemented by experimenting with three travel time thresholds—5, 20, and 35 minutes. The results are shown in Figure 5.1 (A), (B), and (C), respectively.

In Figure 5.1(A) where a 5-minute catchment is used, there are a significant number of block groups on the outskirts of the study area (particularly in the northeast corner) with no accessibility scores (shown as blank). That indicates that there are neither any pharmacies in the areas nor any within a 5-minute driving range. The areas around the intersection of Lee Drive and Highland Road in the south central part of Baton Rouge (and a couple of minor peaks in the north) have the best accessibility with a score range 6.5-10.7 pharmacies per 10,000 residents, and the scores decline outward in general. In Figure 5.1(B) based on a 20-minute catchment, the accessibility scores exhibit a clear concentric pattern, and the highest scores have a range 3.0-3.6 in the central area and decline outwards. The expanded catchment area size also reduces the areas with zero accessibility to only two block groups at the northeast corner (also shown as blank in Figure 5.1(B)). In Figure 5.1(C) based on a 35-minute catchment, much of the variability of accessibility is smoothed out, and the majority of the areas have accessibility scores around the area-wide average value 2.5-2.6, and even the areas at the northeast corner (previously with zero accessibility scores in Figure 5.1(A)-(B)) have a score above 0.3. Overall,

the central part of Baton Rouge is well served by a large number of pharmacy stores, and the outskirts are comparatively underserved with a paucity of pharmacies.

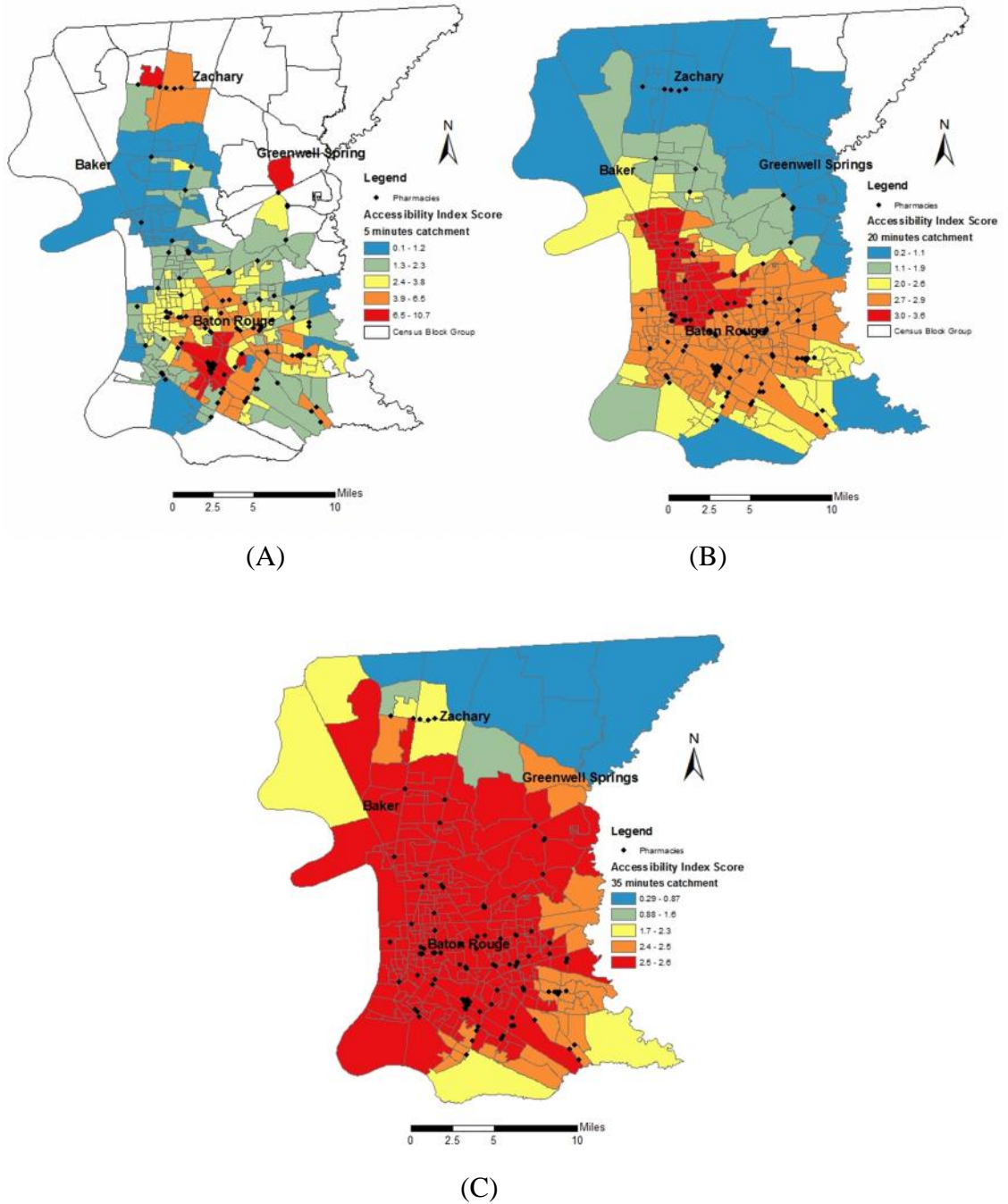


Figure 5.1: Spatial accessibility scores by 2SFCA method: (A) 5-minute catchment, (B) 20-minute catchment, (C) 35-minute catchment

From Figure 5.1(A) to 5.1(C), the spatial patterns of accessibility show a progression from a high to a low variability with an increased smoothing effect. The larger catchment areas such as 20 minutes and 35 minutes exert such a strong smoothing effect that very little spatial variability is preserved. Furthermore, based on Table 4.2, 86% of the population can reach their nearest pharmacies in 5 minutes (estimated travel time). Therefore, the 2SFCA result from a 5-minute catchment area is adopted for subsequent analysis in the following section and also in Chapter 6.

5.2 Disparities among Demographic Groups by the 2SFCA Method

Similar to Section 4.3, this section examines the disparities of spatial accessibility obtained by the 2SFCA method using the same racial-ethnic groups (White, African-American, and Hispanic) and age groups (children < 5 years, seniors 65-74, 75-85, and 85+). Using Equation (4.1), the weighted average 2SFCA accessibility scores for these population groups at the block group level are computed and presented in Table 5.1. As explained in the previous section, the population-weighted average of the 2SFCA method is equal to the number of pharmacies (supply) divided by the total population (demand). After inflating the small ratio by 10,000 time, it yields 2.50, indicating that 2.5 pharmacies serve 10,000 residents on average in Baton Rouge. Since the distributions of various demographic groups are not proportional to that of population in general, the weighted average of accessibility score for a particular demographic group is different and reflects the impact of its concentrations in some areas more than others.

Based on Table 5.1, the 2SFCA method actually reveals that minority groups such as African-Americans suffer from poorer accessibility than White. This is the opposite of the findings based on the proximal area method (distance and travel time from the nearest pharmacy)

as reported in Table 4.3. Note that a shorter distance or time indicates better accessibility whereas a smaller 2SFCA accessibility score reflects poorer accessibility. The results on disparities among age groups by 2SFCA are largely consistent from those by the proximal area method. Here, the weighted average accessibility score for children <5 years is below the population average, and all three senior groups have better accessibility above the population average.

Table 5.1: Weighted Average 2SFCA Accessibility Scores for Various Population Groups

	Accessibility score
<i>Racial-ethnic groups</i>	
White	2.62
African-American	2.21
Hispanic	2.59
<i>Age groups</i>	
< 5	2.32
65-74	2.63
75-84	2.82
85+	3.18
<i>All population</i>	2.50

The contrasting results from the proximal area method and the 2SFCA method on disparities among racial-ethnic groups are considered the most significant findings of this study. The proximal area method emphasizes the travel impedance from the nearest pharmacy, and the 2SFCA method captures the supply-demand ratio within a reasonable spatial range. As discussed in Chapter 4, the distance or time from the nearest store for most central city areas (with disproportionately high numbers of African-American) is short. However, this does not

necessarily transfer to more convenience or better accessibility for them since more population (including all demographic groups) competes for fewer pharmacy stores. Lower accessibility scores by 2SFCA imply more crowdedness and possible poorer quality of the service.

The shorter distance (time) for seniors (particularly for the 75-84 and 85+ age groups) as well as higher 2SFCA accessibility scores for them indicate that they not only tend to live closer to pharmacies (e.g., more in central city areas), but selectively in neighborhoods with more pharmacies per 10,000 residents. That is to say, seniors are likely to be aware of the importance of pharmaceutical services more than any other demographic groups and conceivably make the most conscious decision in their residential choice by living close to a store as well as avoiding overcrowded stores.

Once again, these findings are preliminary, and await the rigorous statistical analysis in the next chapter to validate.

CHAPTER 6: STATISTICAL ANALYSIS OF ACCESSIBILITY DIFFERENCES BETWEEN DEMOGRAPHIC GROUPS

Chapters 4 and 5 have discussed the accessibility disparities among three racial-ethnic groups and four age groups based on the proximal area method and the 2SFCA method, respectively. However, the findings are based on the weighted average values of accessibility, and it is not sufficient to conclude that the observed differences on average are statistically significant. This chapter uses a regression model to implement the conventional ANOVA (analysis of variance) and tests the statistical differences between demographic groups.

6.1 Regression Model for Analysis of Accessibility Differences between Demographic Groups

As stated previously, this study is based on aggregated data at block groups. A block group usually includes multiple racial-ethnic groups and various age groups, who share the same spatial accessibility. Our primary interest here is to examine whether a particular demographic group is disproportionately concentrated in areas of poorer accessibility and possible presence of racial or age disparities. Specifically, given the nature of aggregated data, the hypothesis for testing racial disparities is formulated as:

H₀ (null hypothesis): the ratios of a demographic group in areas with above-average accessibility measures are the same as those in areas with below-average accessibility.

When the above null hypothesis is rejected (one-tailed test), the notion that the particular population group is distributed disproportionately higher in areas of poorer accessibility is supported.

One may use a conventional pooled t -test to compare the sample mean of demographic group % in those block groups with accessibility above the area-wide average and the sample mean of those below the area-wide average. For easy implementation for a large number of repetitive tests, this study employs a regression model developed in a study of environmental justice in Illinois (Wang and Feliberty, 2010) to implement the statistical test. The two approaches are completely equivalent. For clarification, the regression model here is proposed to implement a statistical test, not for the purpose of explaining the variation of a dependent variable.

In implementation, the 303 block groups in the study area are first split into two parts: Part 1 with above-average accessibility measure are coded as “Flag = 0,” and Part 2 are below-average block groups coded as “Flag = 1”. Take “White” as an example. Denoting the White % in each block group as Y , the regression model is defined as

$$Y = a + b * Flag \quad (6.1)$$

In Equation (6.1), Y is the percentage of White out of total population in census blocks groups, $Flag$ is a binary variable = 0 or 1, and a and b are parameters to be calculated. The intercept value a is the average White % in Part 1 (when $Flag = 0$), and the slope b is the difference between Part 1 and 2 (a positive b implies a higher average White % in Part 2 than Part 1, and a negative b indicates otherwise). In addition, the corresponding t value for b reveals the statistical significance for the difference.

6.2 Results and Discussion

An example is used to further illustrate the regression model and its interpretation. For instance, when the distance from the nearest pharmacy is used to measure accessibility, first the

data set of block groups was split into two groups: those with distances above 1.69 km coded with $Flag = 1$, and those with distance below 1.69 km with $Flag = 0$. The benchmark distance 1.69 km is the population-weighted average distance for the study area (Table 4.3). In the case of assessing the distribution of Whites, the % of Whites was calculated in each block group, denoted by Y . A simple ordinary least squares (OLS) regression yields

$$Y = 50.0449 - 7.3477 \textit{Flag}$$

(13.21) (-1.65)

The corresponding t values for the intercept a and slope b are in parentheses beneath the equation. Based on the regression result, when $Flag = 0$, $Y = 50.0449$, which is the intercept, i.e., the sample mean of White % for block groups *above* the 1.60-km distance range (1.60 km) from the nearest sites. If $Flag = 1$, then $Y = 50.0449 - 7.3477 = 42.6972$, which is the sample mean of White % for block groups *below* the 1.60-km distance range. The slope $b = -7.3477$ indicates the difference between the two sample means, and its corresponding t value (-1.65) is the same as the t value in the pooled- t test (the negative sign indicating a lower sample mean for block groups below the threshold distance, identified by $Flag = 1$). That is to say, block groups within a distance 1.60 km from their nearest pharmacies tend to have a lower % of Whites (about 7.35% lower) than those block groups beyond this threshold distance, but such a difference is not statistically significant (note that the critical t value is 1.96 at the 0.05 significance level).

The model is run on all seven demographic groups and the results are reported in Table 6.1. The average % of a demographic group above the threshold distance (2nd column) is the value a , its average % below the threshold distance (3rd column) is calculated as $a+b$, the difference between them (4th column) is the value b , and the corresponding t value for b is reported in the 5th column.

Similarly, Table 6.2 reports the results based on the proximal area method using travel time measure. Table 6.3 reports the results based on the 2SFCA method.

Table 6.1: Demographic Groups in Areas beyond and within the Average Distance

	% beyond 1.69 km (84 BGs)	% within 1.69 km (219 BGs)	Difference in %	<i>t</i> value
<i>Racial-ethnic groups</i>				
White	50.04	42.70	-7.34	-1.65
African-American	45.49	51.78	6.29	1.36
Hispanic	3.06	3.39	0.33	0.64
<i>Age groups</i>				
< 5	6.63	6.59	-0.03	-0.11
65-74	6.28	6.34	0.05	0.89
75-84	3.18	4.04	0.86	2.72**
85+	1.09	1.82	0.73	3.02**

Note: ** indicates statistically significant at 0.01.

Table 6.2: Demographic Groups in Areas beyond and within the Average Time

	% beyond 3.19 minutes (77 BGs)	% within 3.19 minutes (226 BGs)	Difference in %	<i>t</i> value
<i>Racial-ethnic groups</i>				
White	56.29	41.02	-15.27	-3.39***
African-American	40.55	53.50	12.95	2.75**
Hispanic	4.33	3.38	-0.95	-1.04
<i>Age groups</i>				
< 5	6.40	6.64	0.23	0.70
65-74	6.49	6.24	-0.25	-0.64
75-84	3.12	4.02	0.90	2.78**
85+	0.99	1.83	0.84	3.40***

Note: ** indicates statistically significant at 0.01, and *** indicates statistically significant at 0.001.

Results from Tables 6.1 and 6.2 are largely consistent with each other. Revisiting the findings discussed in Section 4.3, the observations on the differences for two major racial groups (Whites and African-Americans) versus general population is not statistically significant when

using Euclidean distance as the measure, but statistically significant when using travel time. That is to say, based on travel time, African-Americans are disproportionately concentrated in areas within the area-wide average travel time from their nearest pharmacy, and Whites are the opposite. The difference for Hispanics versus general population in terms of proximity to pharmacies is not statistically significant in either measure, and the observation needs to be interpreted with caution given the small percentage overall. For the four age groups, children younger than 5 years or senior of 65-74 years are no different from the general population in their geographic distributions in either measure, but seniors of 75-85 years or seniors older than 85 years tend to be disproportionately concentrated in areas closer to their nearest pharmacy.

Table 6.3: Demographic Groups in Areas above or below the average 2SFCA Accessibility Score

	% with accessibility score > 2.50 km (125 BGs)	% with accessibility score < 2.50 km (178 BGs)	Difference in %	t value
<i>Racial-ethnic groups</i>				
White	53.88	38.34	-15.54	-3.93 ^{***}
African-American	40.64	56.60	15.97	3.88 ^{***}
Hispanic	3.49	3.17	-0.32	-0.66
<i>Age groups</i>				
< 5	6.20	6.88	0.68	2.31 [*]
65-74	7.02	5.84	-1.18	-3.55 ^{***}
75-84	4.45	3.35	-1.10	-3.91 ^{***}
85+	2.09	1.29	-0.80	-3.67 ^{***}

Note: * indicates statistically significant at 0.05, and *** indicates statistically significant at 0.001.

Based on Table 6.3, Whites are disproportionately concentrated in areas with above-average accessibility scores, and African-Americans are disproportionately concentrated in areas with below-average accessibility scores. The statistical significance in both cases clearly indicates the racial disparity in accessibility between them when using the 2SFCA measure. Once again, the difference between Hispanic percentages in areas with below-average

accessibility and those with above-average accessibility is not statistically significant. On the age groups, children younger than 5 years are disproportionately concentrated in areas with below-average accessibility, but all three senior groups are disproportionately concentrated in areas with higher accessibility scores.

In summary, the statistical test examines whether percentages of a demographic group differ between areas of better and poorer accessibility. This is an indirect approach to assessing the disparities between demographic groups given the nature of aggregated data. The statistical test is built upon the analysis of weighted average measures of accessibility of various groups in the previous two chapters, and advances the study by employing a rigorous statistical test. The major findings confirm most of the preliminary ones observed in Chapters 4 and 5.

CHAPTER 7: CONCLUSION

Accessibility is a term used to define the relative ease by which activities or services, such as work, recreation, shopping, education, or healthcare, can be accessed from a given location. It is an important locational amenity for residents. This study examines accessibility to pharmacies in Baton Rouge, Louisiana, in 2010. Accessibility to a pharmacy is critical for a community as it is the prime source to get medication and other health services. Two geographic information systems- (GIS-) based methods are used to measure the spatial accessibility to pharmacies for residents at the census block group level. Spatial accessibility emphasizes the geographic barriers one has to overcome for access to pharmaceutical services. The proximal area method assumes that residents use their nearest pharmacy, measured in both Euclidean distance and travel time. The two-step floating catchment area (2SFCA) method accounts for the ratio between the amounts of supply (i.e., number of pharmacies) and demand (i.e., population) that interact within a reasonable range (i.e., a threshold travel time). Based on results from both methods, the geographic patterns of spatial accessibility are examined, along with disparities across major racial-ethnic groups and selected age groups such as children and seniors. Finally, a statistical test is developed to verify whether the racial-ethnic disparities in accessibility are statistically significant.

There are several interesting findings from the study. Compared to the other groups, African-Americans are disproportionately concentrated in areas closer to their nearest pharmacy in terms of travel time, and White ratios tend to be higher in areas more distant from a pharmacy. However, this advantage for African-Americans is not apparent when the 2SFCA method is used. That result indicates that Whites are disproportionately located in areas with above-average accessibility scores, and African-Americans are more concentrated in areas with below-average

accessibility scores. In other words, more African-Americans are located closer to pharmacies but these pharmacies are more crowded in terms of average number of population served per store. Based on the results from the proximal area method, children younger than 5 years or seniors of 65-74 years are no different from the general population in their geographic distributions in terms of distance or travel time from their nearest pharmacy, but more seniors of 75 years or older reside in areas closer to their nearest pharmacy. Based on the results from the 2SFCA, there are higher percentages of children younger than 5 years in areas with below-average accessibility, but more seniors of 65 years or older are in areas with higher accessibility scores.

That is to say, one may consider it an advantage for African-Americans, who are mostly in central city areas that are close to pharmacies, but this advantage can be spurious because of the crowdedness of these stores; the stores serve more population per store. The racial disparity remains a social problem in access to pharmaceutical services. To mitigate the problem, public policy still needs to promote adding more pharmacies stores or expanding the capacities of existing stores in inner cities with higher minority populations. Seniors tend to live in areas that are not only closer to pharmacies but also have less crowded pharmacies. This indicates that access to pharmacies is indeed a major factor in residential location choice for seniors because of their high demand for such a service.

There are several limitations of the study. Foremost, our analysis of accessibility is based on aggregated demographic data from the Census and thus likely to suffer from the ecological fallacy. Future work needs to conduct surveys of individuals on their experiences of utilizing pharmacies and personal assessment of convenience. Secondly, as discussed in Chapter 3, the study is subject to the edge effect. People on the borders may use pharmacies in adjacent

parishes, and people in neighboring parishes may visit pharmacies in the study area. Neither is considered in this study. Future research can expand the study area by including significant buffer areas around the parish. Finally, census block groups provide a reasonable spatial scale for this study after balancing the computational complexity and accuracy, but future work can consider using a smaller unit such as census blocks, which will certainly improve the accuracy in estimation of distance and travel time between residential locations and pharmacies.

REFERENCES

- Aday, A., and Andersen, R. (1974). A framework for the study of access to medical care. *Health services research* 9(3): 208-220
- Brabyn, L., and Gower, P. (2003). Mapping accessibility to general practitioners. In *Geographic Information System and Health Applications*, Khan, O. and Skinner, R., Eds. Hershey, PA: Idea Group Publishing, pp. 289-307.
- Casey, M., Kligner, J., and Moscovice, I. (2008). Pharmacy services in rural areas: Is the problem geographic access or financial access? *The Journal of Rural Health* 18(3): 467-477.
- Dai, D., and Wang, F. (2011). Geographic disparities in accessibility to food stores in southwest Mississippi. *Environment and Planning B: Planning and Design* 38:659-677.
- Ghosh, A. and S. McLafferty. (1987). *Location Strategies for Retail and Service Firms*. Lexington, MA: D.C. Heath.
- Hansen, W. G. (1959). How accessibility shapes land use, *Journal of the American Institute of Planners* 25, 73-76.
- Horner, M. and Mascarenhas, A. (2007). Analyzing location-based accessibility to dental services: An Ohio case study. *Public Health Dentistry* 67(2): 113-118.
- Joseph, A. E. and P. R. Bantock. (1982). Measuring potential physical accessibility to general practitioners in rural areas: a method and case study. *Social Science and Medicine* 16, 85-90.
- Joseph, A., Phillips, D. (1984). Accessibility and utilization: geographical perspectives on healthcare delivery. *SAGE publications*.
- Khan, A. (1992). An Integrated approach to measuring potential spatial access to health care services. *Socio-economic Planning Science* 26(4):275-287.
- Law, M., Dijkstra, A., Douillard, J., and Morgan, S. (2011) Geographic accessibility of community pharmacies in Ontario. *Healthcare Policy* 6(3): 36-46.
- Luo, W. and Wang, F. (2003). Measures of spatial accessibility to health care in a GIS environment: Synthesis and a case study in the Chicago Region. *Environment and Planning B: Planning and Design* 30: 865-844.
- Luo, W. and Qi, Y. (2009). An Enhanced Two-Step Floating Catchment Area (E2SFCA) method for measuring spatial accessibility to primary care physicians. *Health & Place* 15 (4):1100-1107.

- Mennis, J., Stahler, G.J., and Baron, D.A. (2012). Geographic barriers to community-based psychiatric treatment for drug dependent patients. *Annals of the Association of American Geographers* 102 (5): 1093-1103.
- Mark, G. (2004). "Spatial accessibility of primary care: concepts, methods and challenges." *International Journal of Health Geographics* 3:3.
- Onega, T., E. J. Duell, X. Shi, D. Wang, E. Demidenko, and D. Goodman. (2008). Geographic access to cancer care in the U. S. *Cancer* 112: 909–18.
- Rodrigue, J-P. 2013. *The Geography of Transport Systems* (3rd ed.). New York: Routledge.
- Robinson, W. S. (1950). Ecological correlations and the behavior of individuals. *American Sociological Review* 15, 351-357.
- Sales M., Tobias G., Fernando É., and Ferreira B. (2013). Perception of health and accessibility: An approach to support projects for urban public spaces.
- Scannapieco, F. (2013). Periodontal disease as a potential risk factor for systemic diseases. *J Periodontol.* 1998: 69:841-50.
- Scott, D. and M. Horner. (2008). Examining the role of urban form in shaping people's accessibility to opportunities: an exploratory spatial data analysis. *Journal of Transport and Land Use* 1, 89–119
- Shah, A. (2010); Pharmacy intervention in the medication–use process: the role of pharmacies in improving patient safety. *University of Manitoba, Winnipeg, Canada.* 1-50.
- Susi, L. & Mascarenhas, A. (2002). Using a geographical information system to map the distribution of dentists in Ohio. *JADA* 133(5):636-42.
- Swu-Jane, L. (2004). Access to community pharmacies by the elderly in Illinois: a geographic information systems analysis. *Journal of Medical System*, 28(3): 301-309.
- Talen, E. and L. Anselin. (1998). Assessing spatial equity: an evaluation of measures of accessibility to public playgrounds. *Environment and Planning A* 30, 595-613.
- Tucci J. (2009). Why pharmacy's importance is growing. *LA Trobe University*.
- Wang, F. (2003). Job proximity and accessibility for workers of various wage groups. *Urban Geography* 24, 253-271.
- Wang F. (2006). *Quantitative Methods and Applications in GIS*. Boca Raton, London, and New York: CRC Press Francis and Taylor Group.

- Wang, F. (2012). Measurement, optimization, and impact of health care accessibility: A methodological review. *Annals of the Association of American Geographers* 102 (5): 1104-1112.
- Wang, F., Antipova, A., and Porta, S. (2009). Street centrality and land use intensity in Baton Rouge, Louisiana. *Journal of Transport Geography*.
- Wang, F. and Y. Feliberty. (2010). Spatial distribution of toxic release inventory sites in Chicago area: is there environmental inequity? *Geospatial Techniques in Urban Hazard and Disaster Analysis* (ed. Pamela S. Showalter and Yongmei Lu), Springer, 157-177
- Wang, F. and Luo, W. (2005). Assessing spatial and nonspatial factors for healthcare access: towards an integrated approach to defining health professional shortage areas. *Health and Place*, 11 (2): 131-146.
- Wang F., McLafferty S., Escamilla V., and Luo L. (2007). Late-stage breast cancer diagnosis and health care access in Illinois. *The Professional Geographer* 60:1, 54–69.
- Wang, F. and W. W. Minor. (2002). Where the jobs are: employment access and crime patterns in Cleveland. *Annals of the Association of American Geographers* 92: 435-450.
- Wang, F. and Y. Xu. (2011). Estimating O-D matrix of travel time by Google Maps API: implementation, advantages and implications. *Annals of GIS* 17: 199-209.
- Williams S. (2012). Accessibility to public high schools and school performance in Metropolitan Baton Rouge, Louisiana 1990-2010. MS Thesis, *Louisiana State University* 1-106.
- Zenk S, Schulz A., Israel B., James S., Bao S., and Wilson M. (2004). Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *American Journal of Public Health* 95(4): 660-667.

VITA

Samina Ikram was born in Bangladesh. She earned her undergraduate degree in Urban and Rural Planning in 1998. She came to USA in 2001 and completed her bachelors in Business Administration from Peace College, Raleigh, NC in 2004. She and her family moved to Baton Rouge, LA in 2007 and she made the decision to enter graduate school in the Department of Geography and Anthropology at Louisiana State University in 2012. She will receive her master's degree in May 2014 and plans to begin work in professional field.