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# Measuring Primary Health Care Accessibility in Mississippi State Using an Extended Kernel Density 2SFCA Method

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MEASURING PRIMARY HEALTH CARE ACCESSIBILITY IN MISSISSIPPI  
STATE USING AN EXTENDED KERNEL DENSITY 2SFCA METHOD

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  
Master of Science

in

The Department of Geography and Anthropology

by  
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## **Abstract**

The accessibility of primary health care is fundamentally important to people's life quality and wellbeing. Based on the block group level 2010 census data from the U.S. Census Bureau and primary health care data from Association of American Medical Colleges, this study focuses on measuring the primary health care accessibility using an extended kernel-density two Step Float Catchment Area method. The study area is the Mississippi State, which is ranked last state for health care. The objectives of this study are to calculate the accessibility and analyze the spatial and non-spatial disadvantages of communities in accessibility of primary health care of the Mississippi State. Results showed that the two-step floating catchment area integrated by a Gaussian function method is a viable method of calculating accessibility. Overall, urban and the fringe areas have higher spatial accessibility to primary health care, while lower accessibility areas are the suburban and rural areas. Relatively, Hinds County, Madison County, Rankin County, Lamer County, Forrest County, Jones County, Lauderdale County, and Lee County have higher accessibility, while some counties have lower accessibility, such as Marshall County, Winston County, Noxubee County, Wilkinson County, Smith County, and Greene County. From the factor analysis, those urban areas showed greater mobility disadvantages and higher health care needs. Besides, the attempts to integrate the health needs index and the mobility index with the spatial accessibility helps to balance accessibility with different non-spatial conditions. Additionally, this study provides implications for public policy about the health care distribution and the high health needs population.

## Chapter 1. Introduction

### 1.1 Background

The Institute of Medicine defines primary care as “the provision of integrated, accessible health care services by clinicians who are accountable for addressing a large majority of personal health care needs, developing a sustained partnership with patients, and practicing in the context of family”(Donaldson, Yordy, Lohr, & Vanselow, 1996). In the United States, primary care is recognized as the most important form of health care because it is cheaper and more accessible than specialty and inpatient care. Therefore, studying the geographic distribution of accessibility of primary care has become very important.

According to a report from the Commonwealth Fund in 2009, Mississippi State is ranked as the lowest one out of all 50 states for health care(McCarthy, How, Schoen, Cantor, & Belloff, 2009). According to the America’s Health Rankings from 1990 to 2014, the Mississippi State is ranked the lowest of all 50 states in most years. And for several years, it ranked 48 or 49 for the health condition. Besides, Mississippi has the highest rate of obesity, high blood pressure, and diabetes. The annual report of United Health Foundation also shows that Mississippi has lower birthweight and infant mortality than any other state (*Americas Health Rankings*, 2014). With limited resources to improve the health care condition of the whole state, the key is to find the communities that are in the greatest needs for primary health care and allocate the resources to these places. The goal of the study is to measure the accessibility of primary health care and to find out those areas with extremely low accessibility. Figure 1.1 is the location map of the study area. Accessibility is modeled from the distances between demands of primary care measured by population and supply of primary care measured by capability of the primary care facilities. To study what social economic factors are associated with primary care accessibility, a factor analysis



on selected social economic variables is used to extract these comprehensive variables as non-spatial accessibility indices.

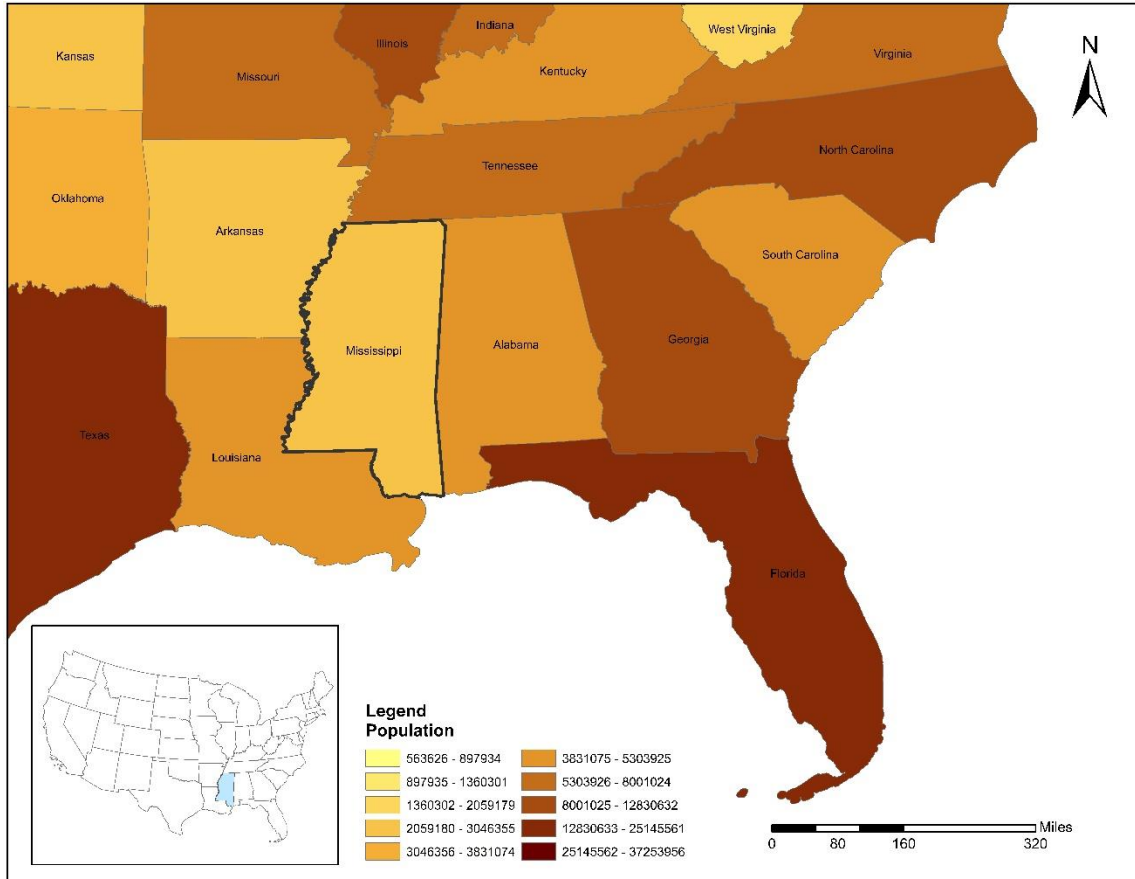


Figure 1.1 Study Area

## 1.2 Research Objectives

This research is designed with three objectives:

First, this study will measure the primary health care accessibility for Mississippi using an extended kernel density two-step float catchment area method, or so called 2SFCA (Wang and Luo 2005).

Second, this research attempts to integrate the spatial accessibility and non-spatial social economic factors into one index. This index can be used to map how accessibility is associated

with social economic disadvantages of the communities. Special cares should be paid to the areas with low accessibility and greater social economic disadvantages. This would help policy makers for resource allocation to improve the health care condition of the people in Mississippi.

Third, this study analyzes the distribution pattern of primary health care accessibility and the non-spatial factors. This study will help identify the association between primary care accessibility and the communities' social economic status. Scientific findings could be inferred from the spatial patterns of the association and add to our body of knowledge in public health studies.

## **Chapter 2: Literature Review**

### **2.1 Primary Care**

The Institute of Medicine defines primary care as “the provision of integrated, accessible health care services by clinicians who are accountable for addressing a large majority of personal health care needs, developing a sustained partnership with patients, and practicing in the context of family”(Donaldson, et al., 1996). Primary care physicians include family physicians, general practitioners, general internists, general pediatricians, and some obstetrician-gynecologists(Cooper, 1994).

Primary care is the first line of defense for a population(Dewulf, Neutens, De Weerd, & Van de Weghe, 2013). Primary care is recognized as the most important form of healthcare for maintaining population health for two reasons(Guagliardo, 2004). One is that primary care is more affordable than specialty and inpatient care, which makes it more easily to be delivered. The other reason is that if primary care is more properly distributed, it is the most effective in preventing disease progression on a large scale. Primary care services are significant to the quality of the health care system of the United States(Lee, 1995).

### **2.2 Health Care Accessibility**

Accessibility is the relative ease by which the locations of services, such as employment, retail, or health care, can be reached from a given location (Fenn, 1998). There are two dichotomous dimensions to classify the access to health care(Khan, 1992). One classification is potential access and revealed access. Potential accessibility describes the probability of the entry into the health care system, while revealed accessibility focuses on the actual use of health care services(Khan, 1992; W. Luo & Wang, 2003). On the other hand, accessibility may be classified into spatial accessibility and non-spatial accessibility. Spatial access focus on the spatial

distribution between supply and demand(Joseph & Phillips, 1984). Non-spatial accessibility considers some demographic and socioeconomic variables such as income, age, race, and so on(Meade & Earickson, 2000).

Distance from the health care provider has been recognized as an important barrier to access in the US since the 19<sup>th</sup> century (Hunter, Shannon, & Sambrook, 1986; Jarvis, 1852). The simplest method to measure accessibility is using the distance or travel time. As the capacity of supply is not scarce or unknown, the main concern of accessibility is the distance or the travel time between supply and demand(Brabyn & Gower, 2003). For example, minimum travel time to the nearest cancer care facility was used to measure accessibility(Onega et al., 2008). Scott and Honer(2008) measured job accessibility using the cumulative opportunities within a distance or travel time. The gravity-based potential model was used to measure the job accessibility(Hansen, 1959).

As demand is also a very important factor that affects accessibility, most case studies consider both supply and demand as the factors. The simplest index to calculate accessibility is the ratio of supply and demand for the selected area. The area is usually administration unit, such as state, parish, or tract and so on. Cervero(1989) and Giuliano and Small(1993) used the ratio of jobs and resident workers to calculate the job accessibility. In 2008, the Department Health and Human Services used the ratio between population and physician to define Health Professional Shortage Areas (HPSAs)(*Designation of medically underserved populations and Health Professional Shortage Areas: Proposed rule*, 2008). However, there are some disadvantages for this method. On one hand, the administration unit is too large and it can't reveal the detailed spatial variations with each unit. On the other hand, it assumes that units near the target unit will not affect the target

unit. However, people may also go to some primary care physicians far away from home due to many reasons.

In order to break the restriction of administrative boundaries, researchers used floating catchment area to replace the administration unit as calculating unit. There are some different ways to define floating catchment area. At the earlier stage, a catchment area is defined as a square around each demand location(Peng, 1997). In later research, the catchment area is also defined as a circle(Houston, 1998; Wang, 2000) or a fixed travel time range(Wang & Minor, 2002). However, this method also has some disadvantages. It assumes that services within the catchment area are available to residents and they just use the services in the catchment area. But actually each catchment area is affected by the nearby catchment areas significantly.

In order to improve this method, Luo and Wang(2003) developed the two-step floating catchment area (2SFCA) method. It repeats the process of floating catchment twice. The first step is to calculate the initial ratio between supply and demand that are with the catchment area for each supply location. The second step is to sum up the initial ratios in the overlapped service areas for a demand location. The disadvantage of the two-step floating catchment area method is that it doesn't consider the distance between demand and supply.

Besides, the previously mentioned methods – the gravity-based method can be used to measure accessibility. The gravity-based potential model considers the problem of distances between demand and supply, however, it accounts for all the supply locations when calculating the accessibility for each demand location. But actually, some supply locations will not be accessible from the demand location. Weibull(1976) developed an axiomatic approach by adding some quantitative indicators of accessibility to measure employment opportunities. Joseph and

Bantock(1982) applied the method to measure healthcare accessibility. Shen(1998) and Wang(2001) used the method for evaluating job accessibility.

In some cases, 2SFCA is a better method to measure accessibility than the gravity-based method. On one hand, the gravity-based method tends to inflate accessibility scores in poor-access areas than the 2SFCA method(W. Luo & Wang, 2003). On the other hand, the gravity-based method needs more computation. Besides, finding the value of the distance friction coefficient  $\beta$  requires additional data and work to define and may be region-specific(Huff, 2000).

As the increasing use of two-step floating catchment area method, many researchers attempted to improve the method. For example, a kernel density function(Dai & Wang, 2011; Guagliardo, 2004) or a Gaussian function(Dai, 2010) was used to model the distance decay effect. Luo and Qi(2009) assigned weights to different travel time zones, this method is expanded 2SFCA (E2SFCA). In order to minimize the healthcare-demand overestimation problem, a three-step floating catchment area (3SFCA) method was proposed(Wan, Zou, & Sternberg, 2012). A spatial impedance-based competition scheme was incorporated into the enhanced two-step floating catchment area (E2SFCA). McGrail and Humphreys(2009a) improved 2SFCA by an addition of a distance-decay function. This method used different floating catchment area weight for different regions. McGrail and Humphreys(2014) also developed a five-level dynamic catchment size incorporated with the 2SFCA method. A population's remoteness was used to delineate increasing catchment sizes. Paul L. Delamater(Delamater, 2013) developed a modified two-step floating catchment area (M2SFCA) method, which allows for the spatial accessibility to be discounted as a result of the suboptimal configuration of health care facilities within the system. Luo(J. Luo, 2014) integrated the Huff model and floating catchment area methods to calculate the spatial accessibility to health care.

These methods focus on the spatial accessibility of health care. However, non-spatial accessibility is also an important part for the measurement of accessibility. Non-spatial health care accessibility is affected by some demographic and socioeconomic factors. These factors include demographics (e.g. children, elder), socioeconomic status (poverty, median income, female-headed household), housing conditions (renter or owner, crowdedness, basic amenities)(Wang, 2012). Different people groups have different health care needs and different transportations(Morrill & Kelley, 1970). Walker and Hiller(2005) used the Index of Relative Socio-economic Disadvantage (IRSD) to measure disadvantage. The IRSD consists of three levels of disadvantage. The Agency for Healthcare Research and Quality(*National Healthcare Disparities Report, 2013, 2014*) specified seven priority populations for higher health care needs. They are racial and ethnic minority groups, low-income groups, women, children (under age 18), older adults (age 65 and over), residents of rural areas, and individuals with special health care needs including individuals with disparities and individuals who need chronic care or end-of-life care.

How to integrate these variables is a central issue to measure the non-spatial disadvantages and interact spatial accessibility. Some created an index of relative disadvantage to standardize and combine these variables(Field, 2000). However, the index of relative disadvantage may contain duplicate information since some of the variables are related. In order to reduce the effect of duplicate information, Wang and Luo(2005) used factor analysis methods to integrate these variables. The Department of Health and Human Services proposed to use factor analysis to design the weights to integrate the variables in the HPSA designations. Principal component analysis was also been used to integrate the non-spatial accessibility. McGrail and Humphreys(2009b) used this method to integrate the variables to summary scores of health needs and mobility. This method

provides one way to integrate spatial access and non-spatial factors into a unified measure. Pierre Polzin and Borges(2014) presented an extended kernel density two-step floating catchment area method integrated with the health needs index and mobility index.



## **Chapter 3. Data Sources and Processing**

This research uses the Geographic Information Systems (GIS) method to conduct spatial analysis. The original data contains both spatial and non-spatial data. The following sections will discuss the data source and processing method.

### **3.1 Spatial Data of Census Block Groups**

The spatial data of this study is acquired from the United States Census Bureau's TIGER/Line Shapefile products. The study area of this research is the State of Mississippi. Given that the population data and other demographic statistics are available at block group level, this study uses block group as the study unit. Another reason for choosing the block group is that each primary care location is geocoded to block group of residence. There are 2164 block groups in the study area.

### **3.2 Transportation Network Data**

In order to get a more accurate measurement for the accessibility of primary care, this study chose transportation network to compute travel distance instead of Euclidian distance. A transportation network has many elements such as link impedances, turn impedances, one-way streets, overpasses and underpasses(Chang, 2006). The network analyst module of ArcGIS includes all these network elements in the travel time analysis. The street network data is obtained from ESRI ArcGIS data package. The interstate, U.S. and state highways, and the local roads and some other roads with FCC codes A11- A48 are used to build the transportation network. In order to get the travel time of each section of roads, speeds are assigned to different roads according to the FCC codes and whether in urban/suburban/rural areas(W. Luo & Wang, 2003). Using the network analysis tool, a street network is conducted between the census block groups and primary care locations.

### **3.3 Demographic Data**

There are two demographic datasets used in this research. One dataset is the exact population data for each block group in 2010. It is selected from the 2010 census summary file 1.

The other dataset is the selected demographic and economic data from the American Community Survey 5-Year Estimates. This study chose 14 variables as follows: percentage of female population, percentage of population with aged under 17 years and above 65 years, percentage of non-white minorities, percentage of female-headed households, percentage of population without high school diploma, median income, percentage of population with disability, unemployment rate for the population 16 years and over, percentage of renter-occupied housing units, percentage of housing units with >1 person per room, the percentage of population with no insurance, percentage of population with linguistic isolation, percentage of households without vehicles, percentage of households below the poverty level.

### **3.4 Health Care Data**

The central issue of this study is the accessibility to primary care. Primary care contains family medicine, internal medicine, pediatrics, and general practice.

A data set of primary care physicians (n = 2977) was obtained from Association of American Medical Colleges. Each record represents a primary care physician and is geocoded to block group of residence. For each physician, the data includes the address, the specific name, the longitude, the latitude and the block group code that it belongs to. Figure 3.1 is a map showing the distribution of primary health care centers. This map shows that many health care centers are concentrated in the urban area, while rural areas have less primary health care centers.

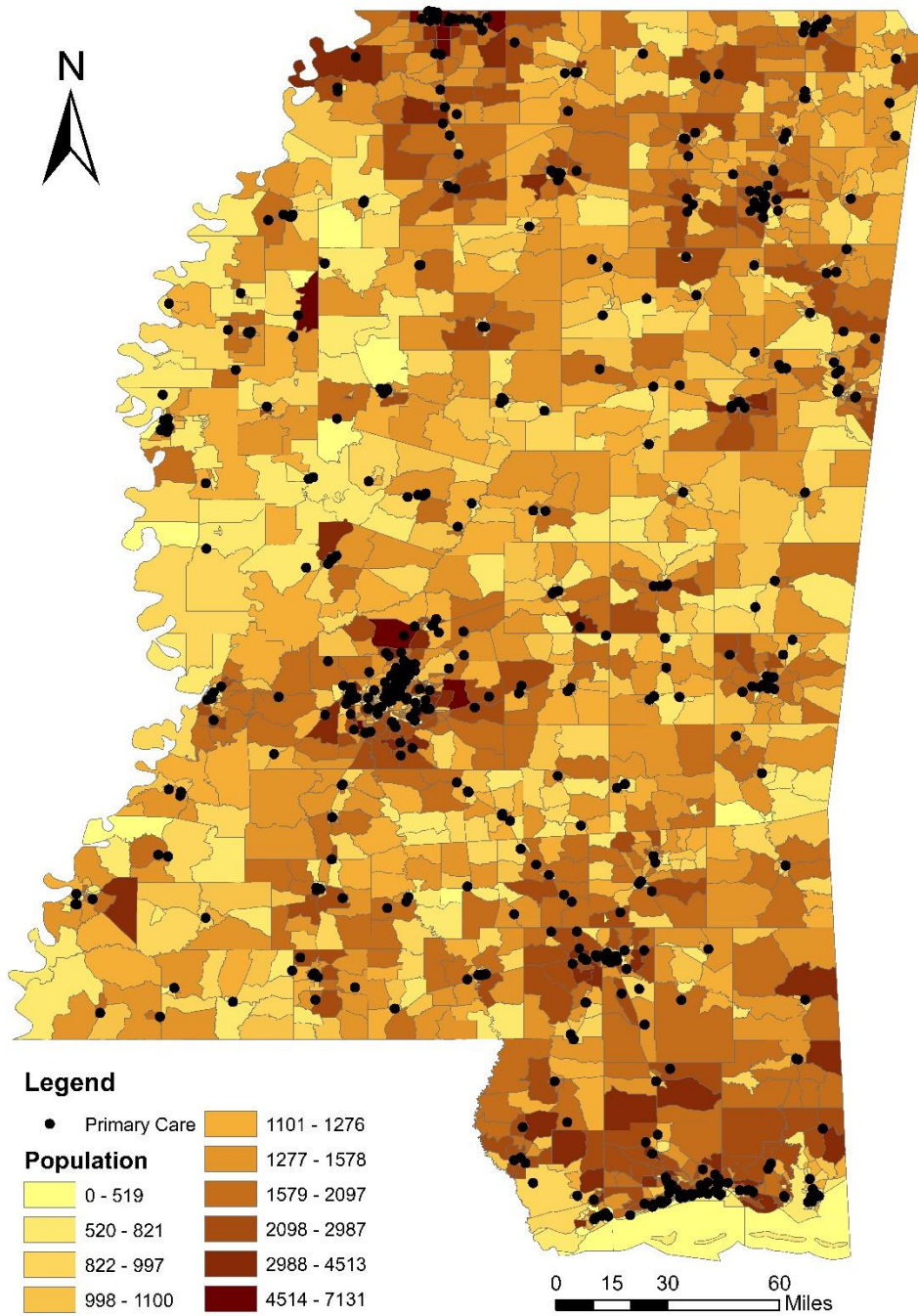


Figure 3.1 Primary Health Care Center Distribution in Mississippi State

## Chapter 4. Defining the Accessibility to Primary Care

### 4.1 Spatial Accessibility

In this research, spatial accessibility is measured by an extended kernel density two-step floating catchment area method (2SFCA) based on a Gaussian function (Dai, 2010). The extended kernel density 2SFCA is created as a new method to measure accessibility. On one hand, a Gaussian function is integrated with the 2SFCA method to show the continuous distance decay. On the other hand, both spatial and non-spatial factors are considered for the measurement of accessibility.

The 2SFCA (W. Luo & Wang, 2003) is a popular method to measure health care accessibility which processes the floating catchment twice. First, for each health care location  $j$ , the demand locations ( $k$ ) that are within a threshold travel distance or time ( $d_0$ ) from location  $j$  are selected and the supply-to-demand ratio  $R_j$  within the catchment area is computed, as shown in equation 4.1:

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k}, \quad (4.1)$$

where  $d_{kj}$  is the distance between supply location  $j$  and demand location  $k$ ,  $S_j$  is the numbers of physicians at location  $j$ , and  $D_k$  is the population at location  $k$  that falls within the catchment.

In the second step, for each demand location  $i$ , all the supply locations ( $j$ ) that are within the threshold distance ( $d_0$ ) from location  $i$  are selected and the supply to demand ratios  $R_j$  are summed up to get the accessibility  $A_i^F$  at the demand location  $i$ :

$$A_i^F = \sum_{j \in \{d_{ij} \leq d_0\}} R_j = \sum_{j \in \{d_{ij} \leq d_0\}} \left( \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k} \right), \quad (4.2)$$

where  $d_{ij}$  is the distance between demand location  $i$  and supply location  $j$ ,  $R_j$  is the ratio of supply-to-demand at supply location that falls within the catchment area at location  $i$ .

There are some limitations for the 2SFCA. On one hand, it uses only one catchment for all the population. On the other hand, it assumes that the proximity of each location within a catchment area is the same. In order to reduce the limitations for this method, this research used kernel density 2SFCA integrated with a Gaussian function (Dai, 2010), as shown in equation 4.3. Gaussian function is used to show the continuous distance decay of accessibility within a catchment area.

$$G(d_{ij}, d_0) = \begin{cases} \frac{e^{-1/2 * (d_{ij}/d_0)^2} - e^{-1/2}}{1 - e^{-1/2}} & \text{if } d_{ij} \leq d_0 \\ 0 & \text{if } d_{ij} > d_0 \end{cases} \quad (4.3)$$

For the kernel density 2SFCA method, the Gaussian function is integrated to the calculation of the accessibility. In the first step to get the supply-to-demand ratio, the demand is multiplied by the Gaussian function  $G(d_{kj}, d_0)$ .

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k * G(d_{kj}, d_0)}, \quad (4.4)$$

In the second step to get the accessibility, the supply-to-demand ratio is multiplied by the Gaussian function  $G(d_{ij}, d_0)$

$$A_i^F = \sum_{j \in \{d_{ij} \leq d_0\}} R_j * G(d_{ij}, d_0) = \sum_{j \in \{d_{ij} \leq d_0\}} \left( \frac{S_j * G(d_{ij}, d_0)}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k * G(d_{kj}, d_0)} \right), \quad (4.5)$$

This research used a 50-minute threshold in the analysis. Various bandwidths ranging from 30 – 60 minutes with 5-minute increments were used to investigate the results of the bandwidths. As a result, 50-minute is the best threshold to show the sensitivity and difference of the accessibility.

## 4.2 Non-Spatial Disadvantages

This study chose 12 variables for the non-spatial analysis: percentage of people in high health needs (female population with aged between 18 to 64 years old, population with aged under 17 years and above 65 years and population with disability), percentage of non-white minorities, percentage of female-headed households, percentage of population without high school diploma, median income, unemployment rate for the population 16 years and over, percentage of renter-occupied housing units, percentage of housing units with >1 person per room, the percentage of population with no insurance, percentage of population with linguistic isolation, percentage of households without vehicles, percentage of households below the poverty level. All the variables were standardized to 0~1 range.

In order to integrate these demographic and socioeconomic variables, this research creates two indices from the factor analysis to describe the non-spatial disadvantages (McGrail & Humphreys, 2009b; Polzin, et al., 2014). One index describes the health needs of the population, and the other index is the mobility index that measures the mobility of residents.

In order to integrating the spatial accessibility and health needs index, mobility index, the scale ranges for the indices are the central issues. Polzin (2014) converted the standardized PCA health needs index to the scale from 1 to 1.167. The definition of Health Professionals Shortage Areas (HPSA) from the US Department of Health and Human Services was used by Wang and Luo (2005) as part of an approach to defining health professional shortage areas. According to the definition, HPSA are the areas with physician-to-population ratios of less than 1:3500, but also with ratios less than 1:3000 if the residents have high needs. The two values are used to adjust the population size. That is to say, the populations with high health needs should reduce the corresponding physicians-to-population ratios by about 14.3%. When the physicians-to-population

ratios vary from 1:3000 to 1:3500, the population for a given number of physicians should increase by about 16.67%. According to this score, the health needs index between 0 to 1 can be scaled to 1 to 1.167.

According to the mobility index of McGrail and Humphreys(2009b), about 20% of the population in Australia are affected by the mobility barrier. They weighted the mobility index accordingly and the mobility index was scaled to 0.8~1.

As different study areas have different conditions, this research attempted to rescale the health needs index and mobility index to different ranges. It helps to identify the influence of the two indices. Referring the rescaled ranges above, the health needs index was rescaled to 1-1.167, 1-1.4, 1-1.6, 1-1.8 and mobility index was rescaled to 0.2-1, 0.4-1, 0.6-1 and 0.8-1. This research explores all possible combination of these rescaled indices to test the sensitivity of the rescaling method.

### 4.3 Integrating Spatial Accessibility and Non-Spatial Disadvantages

This research measures primary health care accessibility that integrates both spatial and non-spatial factors. In the first step to calculate the ratio between population and physicians, the health needs index is integrated for each block group.

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k * G(d_{kj}, d_0) * HN_k}, \quad (4.6)$$

where  $HN_k$  is the health needs index.

In the second step to get the accessibility, the supply-to-demand ratio is multiplied by the mobility index. As shown in the Formula 4.7,  $C_k$  is the mobility index.

$$A_i^F = \sum_{j \in \{d_{ij} \leq d_0\}} R_j * G(d_{ij}, d_0) = \sum_{j \in \{d_{ij} \leq d_0\}} \left( \frac{S_j * G(d_{ij}, d_0) * C_k}{\sum_{k \in \{d_{kj} \leq d_0\}} D_k * G(d_{kj}, d_0) * HN_k} \right), \quad (4.7)$$

As mentioned above, this research attempts to rescale the health needs index and mobility index to different ranges. The incorporation of accessibility will help analyze the distribution patterns of primary health care and identify the reasons for lower accessibility in the Mississippi State. On the other hand, this research integrated the variables into one single accessibility index, it is more convenient for the usage of governments, urban designers, as well as the health care practitioners to identify the lower accessibility areas.



## Chapter 5. Results and Discussion

### 5.1 Spatial Accessibility

This study used two-step floating catchment area integrated with a Gaussian function method to calculate the spatial accessibility. In order to compare the difference between the results of 2SFCA and 2SFCA integrated Gaussian function, distribution maps of accessibility are shown in this study. Figure 5.1 is the result of accessibility map by the 2SFCA method.

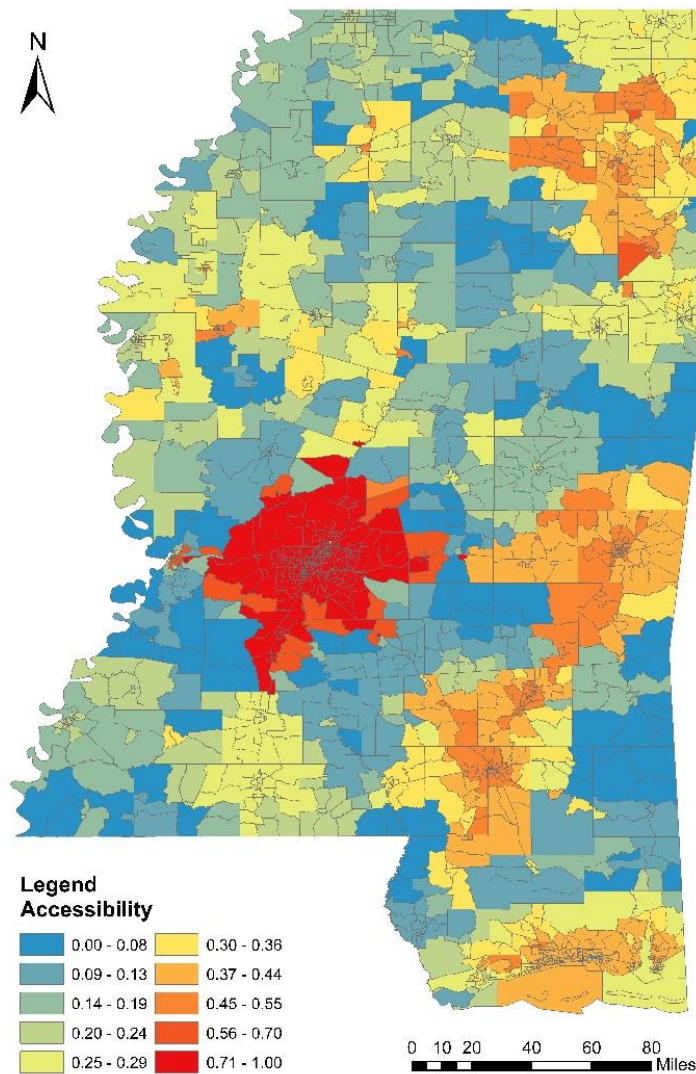


Figure 5.1 Spatial Accessibility with 2SFCA

High spatial accessibility usually appears urban and near urban regions, where hospitals are located. However, it overestimates the spatial accessibility for some areas. Besides, it is hard to tell the difference for the near areas, that is to say, the result of the 2SFCA method is not sensitive to show the real accessibility distribution.

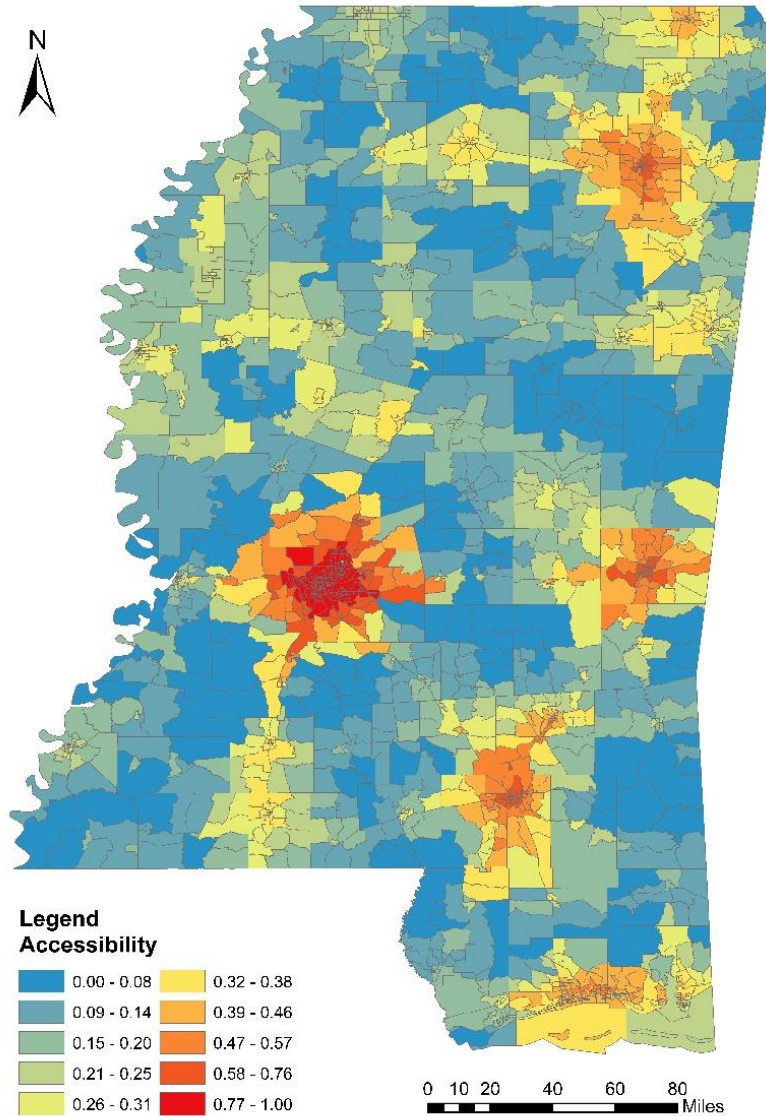


Figure 5.2 Spatial Accessibility with 2SFCA integrated Gaussian Function

In order to correct for disadvantages, this study used a 2SFCA integrated Gaussian function to calculate the spatial accessibility. Figure 5.2 is the result of spatial accessibility with 2SFCA integrated Gaussian Function. Overall, the cities and major towns have better spatial accessibility than the rural areas. However, it is more effective to show the difference of accessibility, especially for the near urban area.

The difference between the results of KD2SFCA and 2SFCA can also be revealed in the scatter plots, as shown in Figure 5.3. The accessibility with 2SFCA is higher than the accessibility with the KD2SFCA.

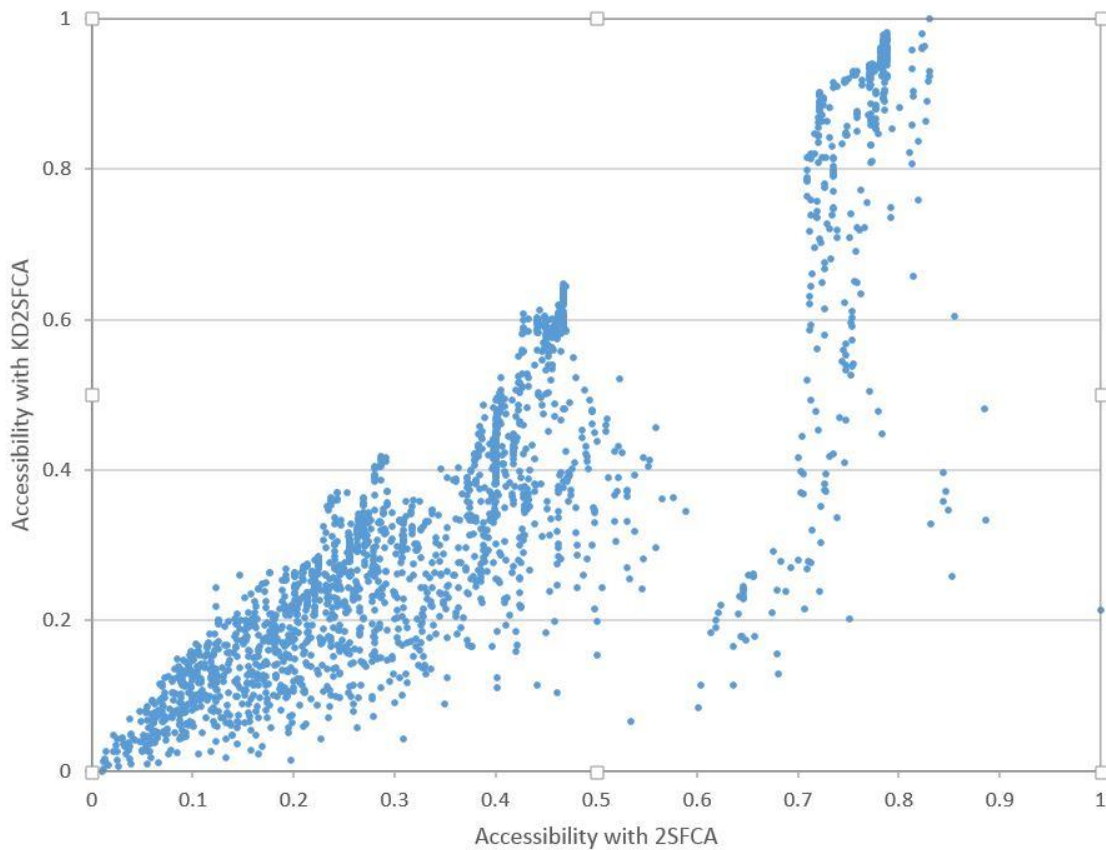


Figure 5.3 Dispersion of KD2SFCA Accessibility versus 2SFCA Accessibility

Consistent with expectations, in and near urban areas have higher spatial accessibility to primary health care, while lower spatial accessibility areas are the suburban and rural areas. As for the accessibility of each county, relatively, Hinds County, Madison County, Rankin County, Lamer County, Forrest County, Jones County, Lauderdale County, and Lee County have higher accessibility. These counties are areas with more hospitals located. Besides, some counties have lower accessibility, such as Marshall County, Winston County, Noxubee County, Wilkinson County, Smith County, and Greene County.

## 5.2 Non-spatial Disadvantages

The initial assessment is a bivariate correlation analysis between each of the twelve individual variables. The results, shown in Table 5.1, suggest that some of the variables have direct correlations, such as median income and poverty rate, percentage of non-white population and female-headed household, median income and population without a high school diploma, and so on.

Table 5.1 Correlation coefficients between the fourteen variables

	HighN	Minor	FHead	NoEdu	PoorH	MdInc	NoJob	HOwn	Over1	NoIns	LingH	NoCar
HighN	1											
Minor	0.181	1										
FHead	0.294	0.654	1									
NoEdu	0.282	0.390	0.335	1								
PoorH	0.305	0.589	0.568	0.522	1							
MdInc	-0.317	-0.514	-0.462	-0.572	-0.715	1						
NoJob	0.202	0.424	0.412	0.384	0.504	-0.423	1					
HOwn	-0.012	0.460	0.421	0.183	0.518	-0.451	0.268	1				
Over1	0.114	0.257	0.266	0.233	0.246	-0.207	0.208	0.207	1			
NoIns	-0.062	0.280	0.267	0.346	0.330	-0.410	0.347	0.326	0.224	1		
LingH	-0.210	-0.029	-0.070	0.054	-0.044	0.044	-0.069	0.196	0.187	0.252	1	
NoCar	0.267	-0.501	0.380	0.438	0.598	-0.491	0.386	0.450	0.132	0.215	-0.021	1

This research used the principle components factor analysis method to integrate the twelve variables. PCA was processed through IBM SPSS statistics. The eigenvalues reported in Table 5.2 shows variances captured by individual components. The eigenvalue indicates the importance of a component. Following a rule that the components with eigenvalues great than 1 are important(Griffith, 1997), two components were retained. The two factors explains 52.165% of the total variance. When the variables were extracted into two components, the result of Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0.852.

Table 5.2 Eigenvalues from the principal components analysis

Component	Eigenvalue	Proportion	Cumulative
1	4.751	39.588	39.588
2	1.509	12.577	52.165
3	0.992	8.265	60.429
4	0.903	7.526	67.955
5	0.793	6.611	74.566
6	0.602	5.015	79.581
7	0.583	4.856	84.437
8	0.556	4.636	89.073
9	0.441	3.677	92.750
10	0.331	2.757	95.508
11	0.306	2.548	98.056
12	0.233	1.944	100.000

Referring to the results of component matrix, as shown in Table 5.3, variables are classified into two components.

Table 5.3 Component Matrix for Non-Spatial Variables

	Component	
	1	2
Households below poverty level (%)	0.857	-0.091
Median income (\$)	-0.804	0.069
Nonwhite minorities (%)	0.764	-0.025
Female-headed households (%)	0.723	-0.107
Households w/o vehicles (%)	0.703	-0.114
Population w/o high-school diploma (%)	0.662	-0.048
Unemployment population (%)	0.643	-0.067
Occupied house ownership (%)	0.618	0.351
Occupied house with >1 occupant per room (%)	0.382	0.302
Linguistically isolated population (%)	0.020	0.787
Population with high needs (%)	0.366	-0.607
Population with no Insurance (%)	0.505	0.511

Factor 1 is mainly from nine variables: percentage of non-white minorities, percentage of female-headed households, median income, unemployment rate for the population 16 years and over, percentage of renter-occupied housing units, percentage of housing units with >1 person per room, percentage of households below the poverty level, percentage of population without high school diploma, percentage of households without vehicles. Factor 1 indicates the mobility ability of residents.

Mobility index was constructed with PCA using the standardized variable values and the index was archived using the first component. It obtained an adequate value for the Kaiser-Meyer-Ilkin measure is 0.878. Table 5.4 is the component matrix for the variables. It shows how much each variable explains the mobility index. Percentage of households below the poverty level, percentage of non-white minorities, and percentage of female-headed households play an important role in the mobility index.

Table 5.4 Component Matrix for Mobility Index

	Component 1
Households below poverty level (%)	0.865
Nonwhite minorities (%)	0.782
Female-headed households (%)	0.730
Median Income (\$)	-0.796
Occupied house ownership (%)	0.634
Unemployment population (%)	0.638
Occupied house with >1 occupant per room (%)	0.376
Households w/o vehicles (%)	0.716
Population w/o high-school diploma (%)	0.650

Factor 2 contains 3 variables: percentage of population with linguistic isolation, the percentage of population with no insurance, population with high needs. Factor 2 shows the health needs of population. It obtained adequate value for the Kaiser-Meyer-Ilkin measure is 0.528. The same method is used to get the health needs index.

Table 5.5 is the component matrix for the variables that expresses the health needs of residences. It shows how much each variable explains the health need index. Percentage of population without high school diploma and percentage of households without vehicles play an important role in the health needs index.

Table 5.5 Component Matrix for Health Needs Variables

	Component 1
Linguistically isolated population (%)	0.783
Population with no Insurance (%)	0.648
Population with high needs (%)	0.572

Figure 5.4 shows the spatial distribution of the health needs index. The higher scores shows the areas with residents have higher needs for primary health care. Figure 5.5 is the mobility index distribution map. Higher scores for the mobility index mean the low mobility of residents. In contrast to the spatial accessibility to primary health care, health needs index and mobility index show different distribution patterns. Areas with higher scores (poor access) are concentrated in the urban areas, and lower scores (good access) are mostly in the suburban and rural areas.

### 5.3 Accessibility Integrated by Spatial Accessibility and Non-spatial Disadvantages

This research attempted to rescale the health needs index and mobility index to different ranges. As mentioned above, the health needs index was rescaled to 1-1.2, 1-1.4, 1-1.6, 1-1.8 and mobility index was rescaled to 0.2-1, 0.4-1, 0.6-1 and 0.8-1. The results of accessibility are as shown in the Table 5.6.

Comparing the results of different scales, the influence of the ranges can be found. The difference will be shown in details in the next part.



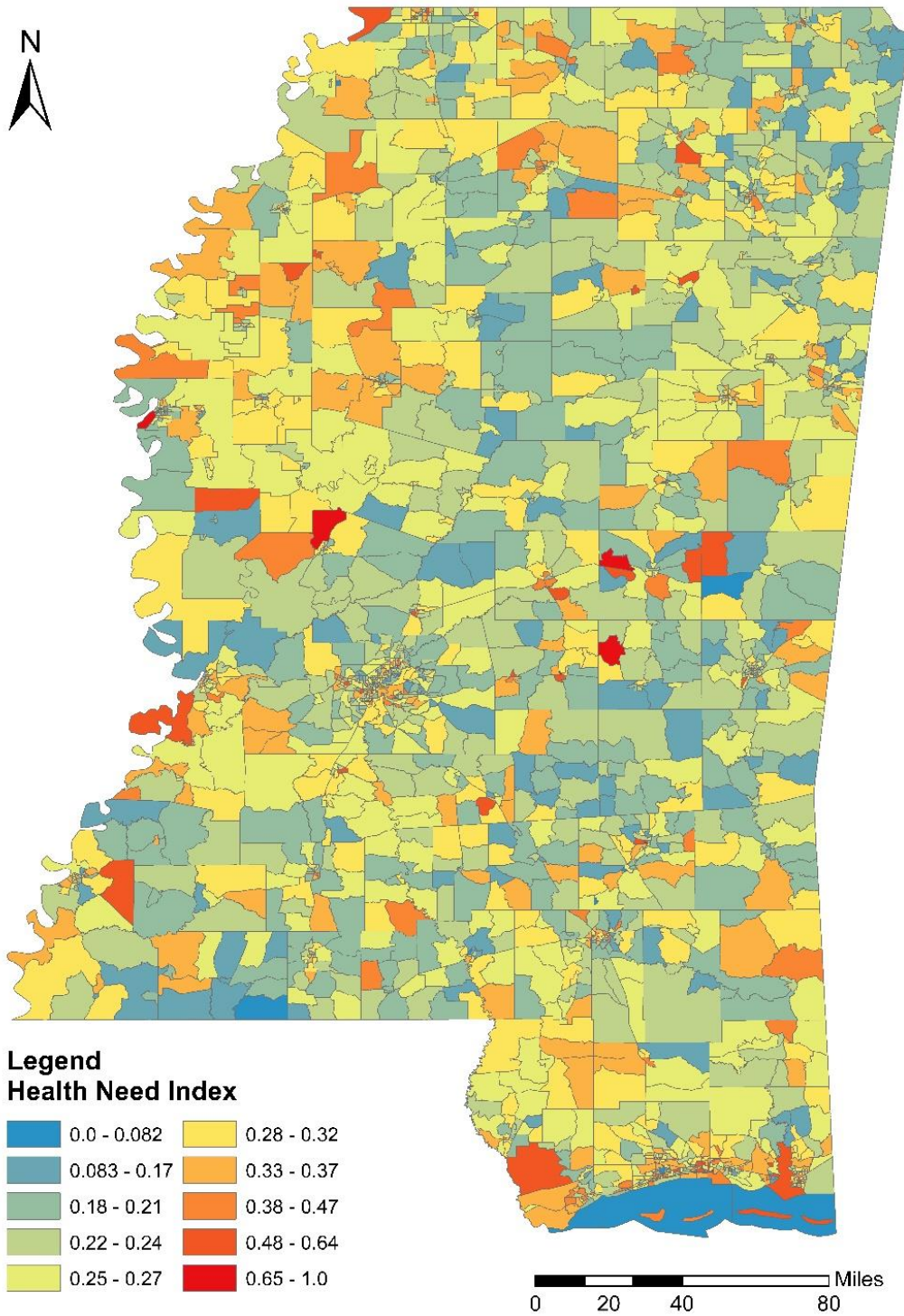


Figure 5.4 Health Needs Index Distribution



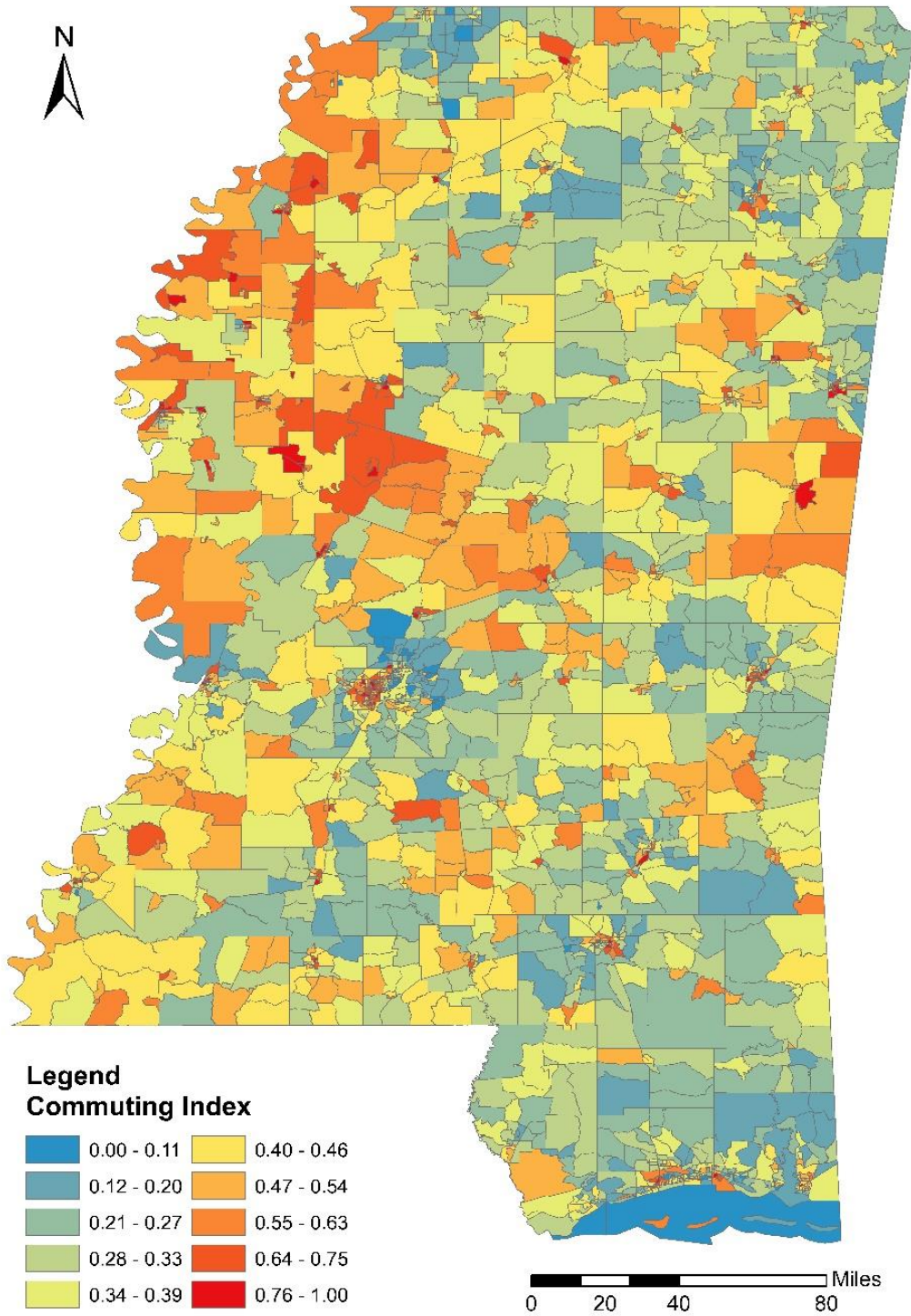
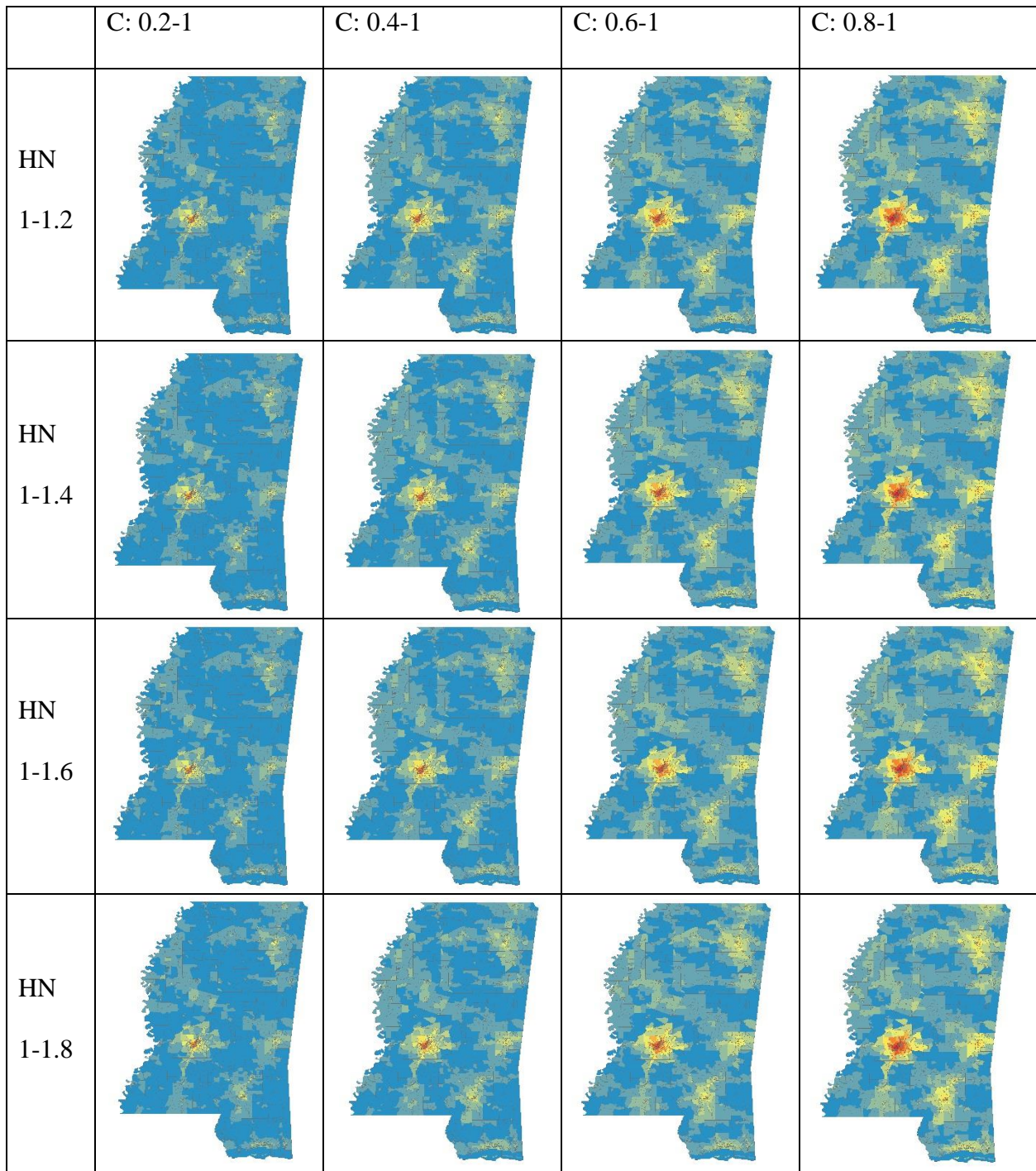
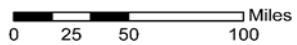
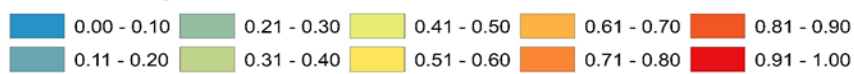


Figure 5.5 Mobility Index Distribution

Table 5.6 Accessibility in Mississippi State



**Legend  
Accessibility**



## 5.4 Accessibility in the Hints County

In order to compare the accessibility using different methods, this study selected Hints County where the largest city in Mississippi is located as an example.

Figure 5.6 and Figure 5.7 show the distribution maps using different methods. Comparing the spatial distribution with 2SFCA and 2SFCA integrated with Gaussian function. Obviously, the accessibility with 2SFCA overestimates the spatial accessibility in the some areas, such as the north and south block group near the urban area. In Hints County, the block group where the urban is located has the highest accessibility to primary health care. The block groups near the city have higher accessibility. The rural block groups have the lowest accessibility.

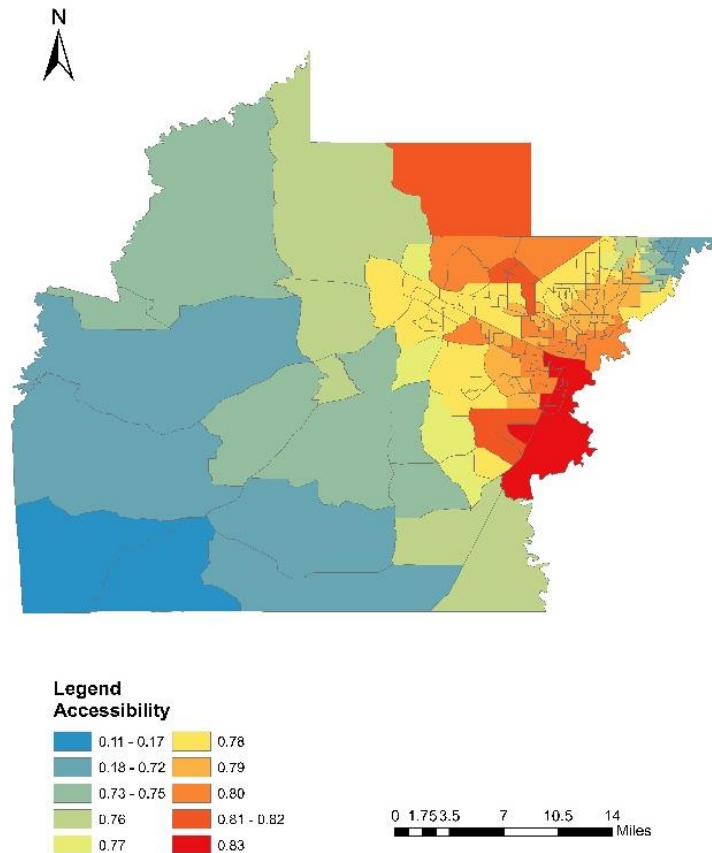


Figure 5.6 Spatial Accessibility Distribution with 2SFCA



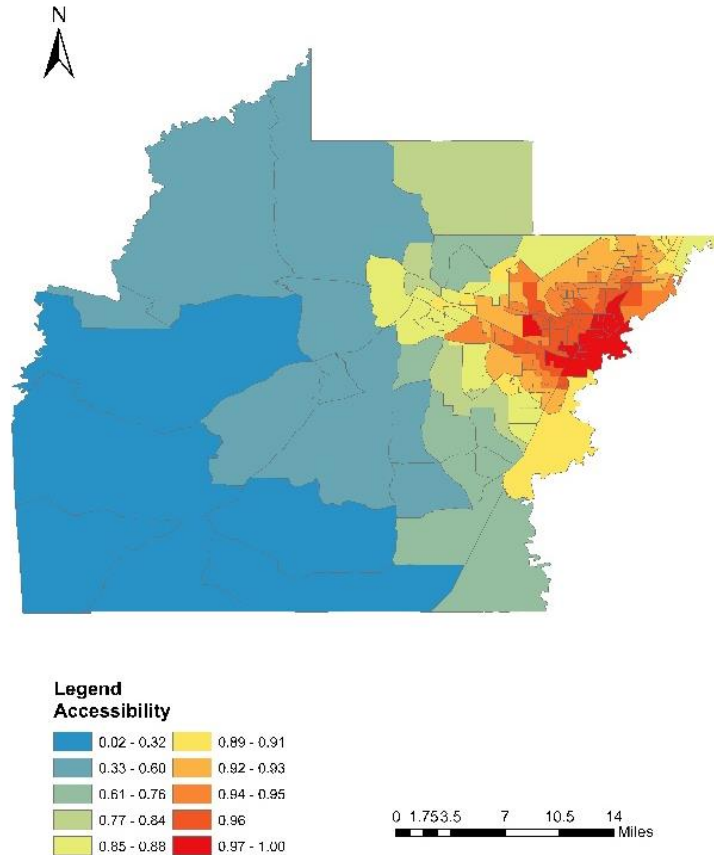


Figure 5.7 Spatial Accessibility Distribution with 2SFCA integrated Gaussian Function

Figure 5.8 is the scatter plot between the spatial accessibility and the distance to central business district. It verified that the urban areas have higher spatial accessibility.

Urban areas have the highest immobility index value, which means the residents in the urban areas have the lowest mobility. As for the distribution of health needs index, higher values appear near the urban areas and the lower one are in the rural areas. Figure 5.9 are the maps of mobility index distribution and health needs index distribution.

The accessibility distribution maps for different index ranges are shown in the Figure table 5.7.

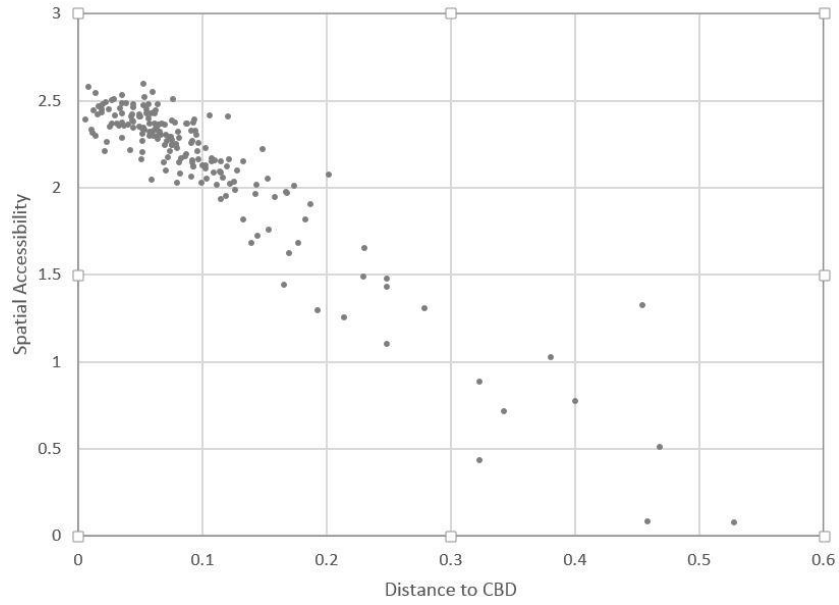


Figure 5.8 Relationship between Accessibility and Distance to CBD for Hints

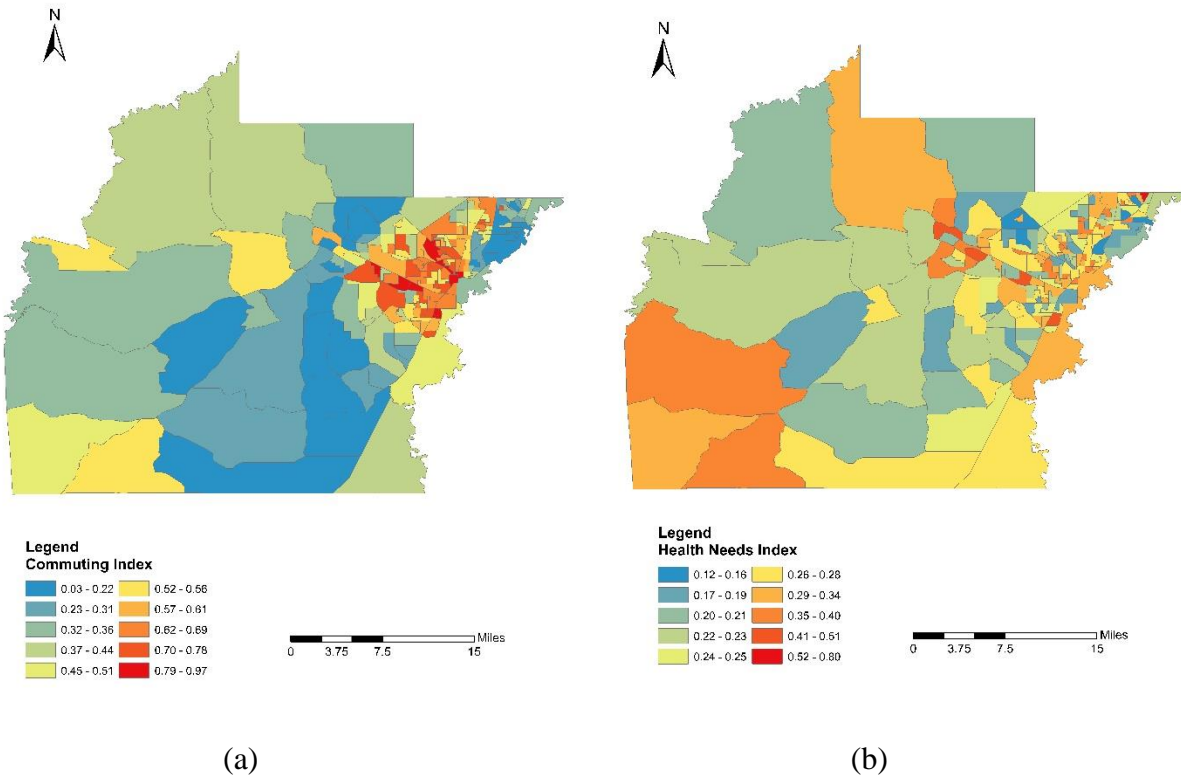
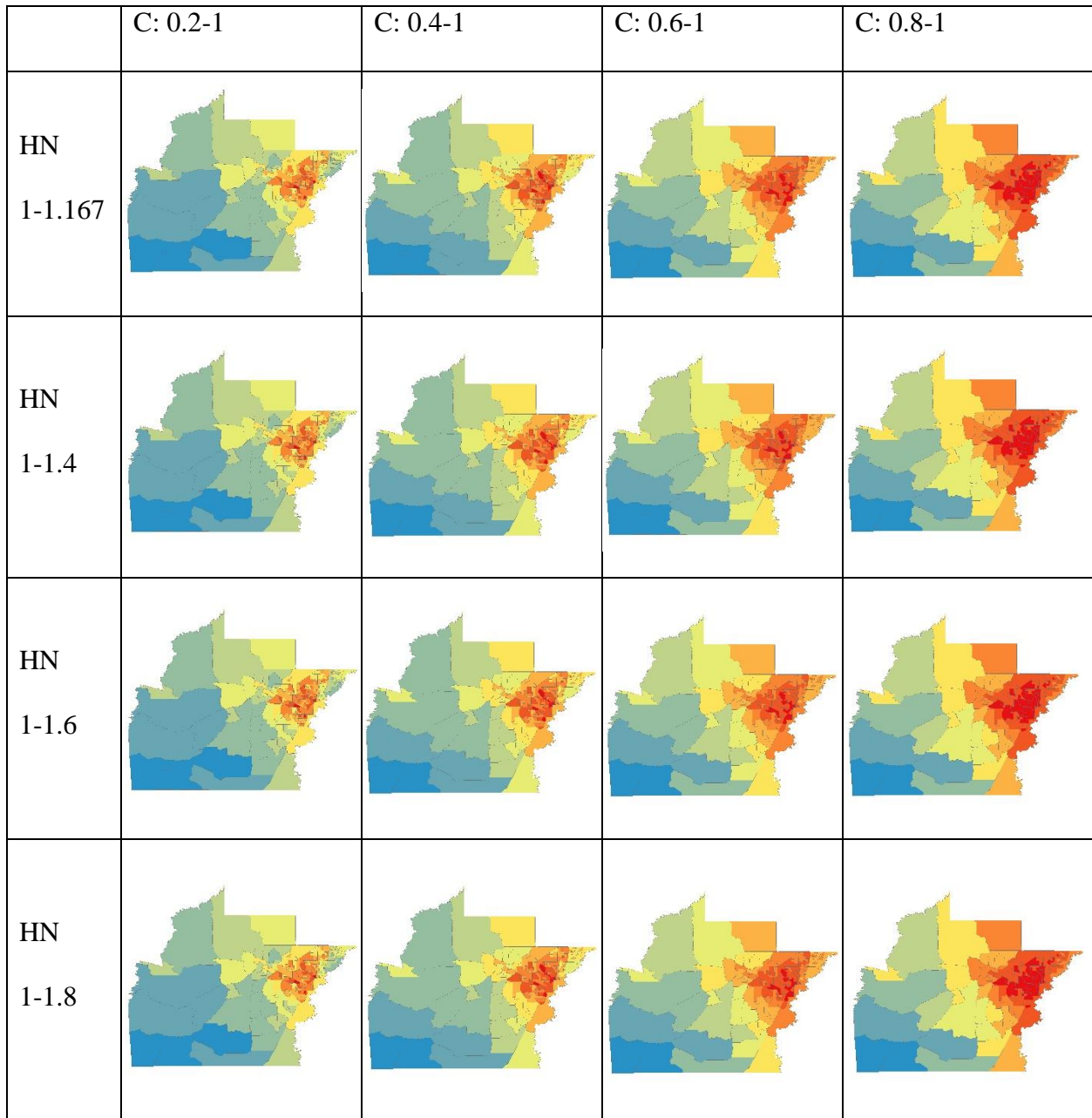
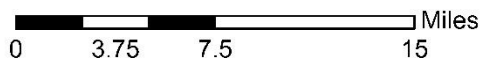
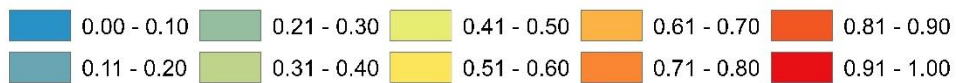


Figure 5.9 (a) Mobility Index Distribution; (b) Health Needs Index Distribution

Table 5.7 Accessibility maps in Hints County



**Legend  
Accessibility**



The scatter plots between the accessibility and distance to CBD are drawn as the indices changed in Figure 5.10 and Figure 5.11. Figure 5.10 is accessibility maps when the health needs index was rescaled from 1 to 1.2, and the mobility index was rescaled to 0.2-1, 0.4-1, 0.6-1 and 0.8-1 separately. Figure 5.11 shows the accessibility when the mobility index was rescales from 0.2 to 1, and the health needs index was rescaled to 1-1.2, 1-1.4, 1-1.6 and 1-1.8 separately.

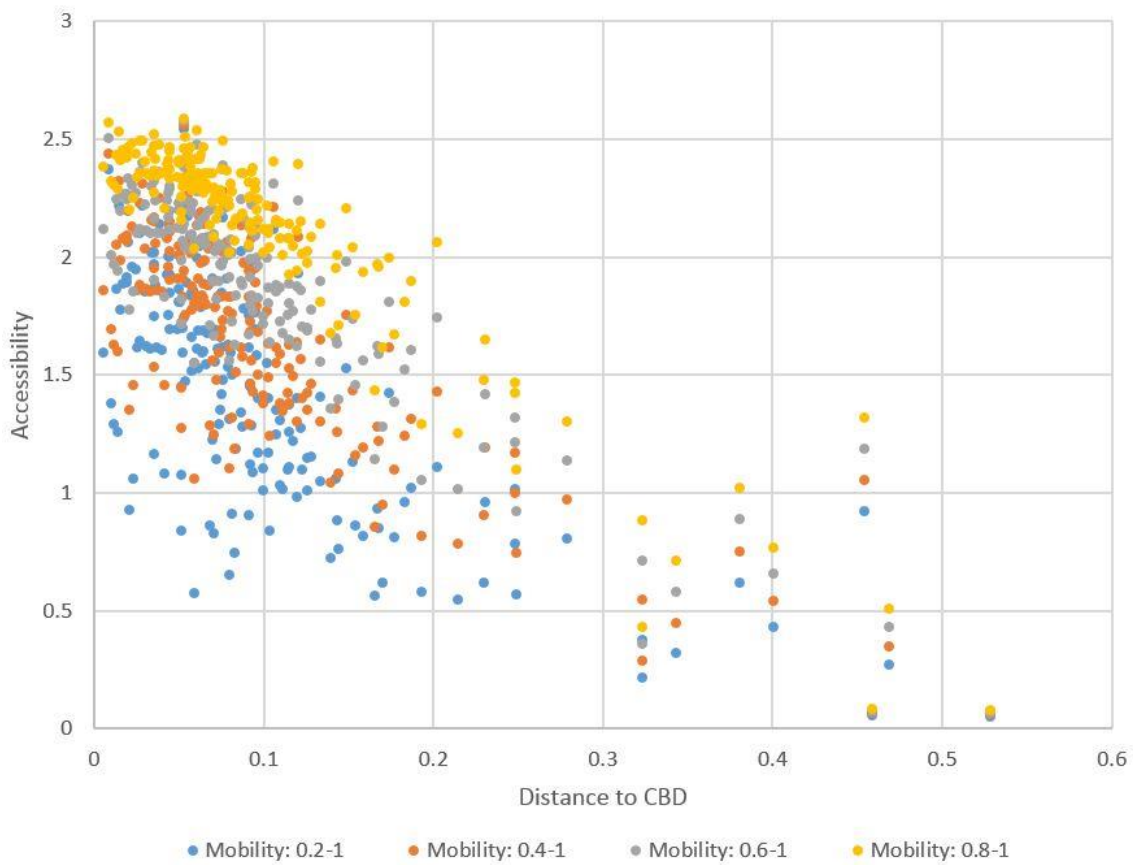


Figure 5.10 Relationship between Accessibility and Distance to CBD Using Different Scale of Mobility Index

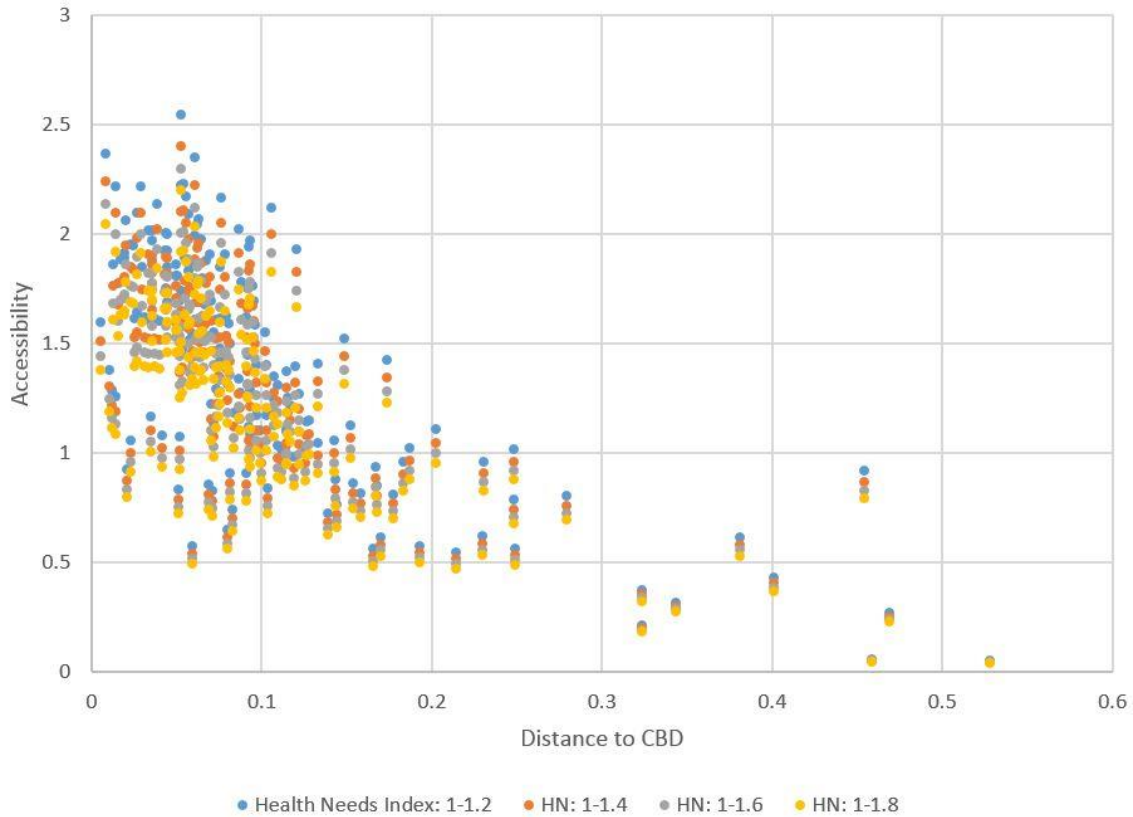


Figure 5.11 Relationship between Accessibility and Distance to CBD Using Different Scale of Health Needs Index

Based on the maps and scatter plots, the scale ranges affect the results of accessibility significantly. As the scale range of mobility index increases, most of the block groups got a lower accessibility value, and the changes are more obvious in urban and near urban areas. This can also be shown in the scatter plots (Figure 5.10). As for the effects of the scale range of health needs index, it is not very obvious in the maps. Larger scale range can bring more obvious change in accessibility. Combining with the scatter plots, the effects of scale range of health needs index can be achieved. On one hand, as the scale range increases, the accessibility decreases. On the other hand, the most obvious changes appear in the urban areas; while less changes appear in the rural areas. As a result, the incorporation of health needs index and mobility index can affect the results



of accessibility significantly, especially for the urban areas where more disadvantaged population groups reside.

Although a lot of effort is being spent on improving the methods for calculating accessibility, the efficient and effective verification method has not yet to be developed. That is to say, it is hard to identify the best scale ranges of health needs index and mobility index. With regard to this question, there are probably two ways to verify the accuracy of accessibility. The first method is to use field data, such as questionnaire and interviews of accessibility. The second way is to use proxies, such as the late-stage breast cancer diagnosis rates. In the research of relationship between the late-stage breast cancer diagnosis and health care access, Wang, McLafferty, Escamilla, and Luo (2008) got the conclusion that poor geographical access to primary health care significantly increases the risk of late diagnosis, and the disadvantaged population groups tend to experience high rates of late diagnosis. That is to say, the relationship between late-stage cancer diagnosis and primary health care accessibility can help verify the accessibility and calibrate the choice of scale ranges of health needs and mobility indices.

## Chapter 6. Conclusion

Based on the results of accessibility, the extended kernel density 2SFCA method was proven to be effect for calculating spatial accessibility to primary health care for the Mississippi State. Overall, urban and near urban areas have higher spatial accessibility to primary health care, while lower spatial accessibility areas are the suburban and rural areas. Relatively, Hinds County, Madison County, Rankin County, Lamer County, Forrest County, Jones County, Lauderdale County, and Lee County have higher accessibility, while some counties have lower accessibility, such as Marshall County, Winston County, Noxubee County, Wilkinson County, Smith County, and Greene County. However, the non-spatial disadvantages show the opposite distribution pattern, as more disadvantages population groups are concentrated in the urban areas.

Additionally, this study provides implications for public policy about the health care distribution and the high health needs population. In order to increase the accessibility to primary care accessibility, primary health care centers are more needed in the suburban and rural areas. For urban and near urban areas, higher health needs and low mobility are the main barrier to the better accessibility. Therefore, to provide better public transit system to low income people, especially for the routes that connect to primary care centers would be the most efficient way of improving the medical conditions of the state. It is hoped the results from this research could help the government of Mississippi State provide better public health service.

Also, I have to acknowledge that there are several limitations in this study. First, this research used speed limit to calculate the travel time for each street. In reality, people do not always obey the speed limit. And there are traffic jams that alter the pattern of how people select their route. All these would cause some variations from the actual travel time. Besides, multiple transportation modes should be considered, such as public transit and, walking, beyond private

cars. Second, primary health care records from the neighboring locations should be selected to reduce the edge effect and make sure the accurate calculation of accessibility. Third, although a lot of effort is being spent on improving the methods to calculate accessibility, the verification method has not been developed. As a result, it is hard to test the reliability of accessibility. Lastly, this study has intended to do some work on the racial disparity and inequality in the primary health care. However, the non-spatial data from United States Census Bureau is too scarce to be support the idea. I would suggest if possible in the future research, racial disparity of accessibility to primary health care should be included in the mode.

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## **Vita**

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