Spatial Access to Substance Abuse Treatment for Low-Income and Minority Households: A Case Study in Dallas-Fort Worth Metroplex, Texas

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ABSTRACT
Recent health care overhauls increase demand on services and give a whole new group of individuals the possibility of seeking out care and treatment. One area that often gets overlooked is the substance abuse treatment. Spatial access to healthcare facilities influences health services usage as distance to facilities was recognized as a significant barrier to health access. In this study using an enhanced two-step floating catchment method, we measured spatial access to substance abuse treatment facilities at the Census block group level in the Dallas-Fort Worth metroplex, Texas. The results show the access disparities vary spatially within block groups in this area. In addition, we identified hotspots for low-income and racial/ethnic minority households in the area and then compared them with the spatial accessibility environment to better understand the service coverage among low-income and minority communities. The results show that low income and minority have disadvantages to access to substance abuse treatment facilities in the Dallas-Fort Worth metroplex area.

Categories and Subject Descriptors
D.3.3 [**Programming Languages**]: Computers and Society – computer-related health issue

General Terms
Measurement

Keywords
Substance Abuse Treatment, Spatial Access, Low-income, Minorities.

1. INTRODUCTION
Recent health care overhauls increases demand on services and give a whole new group of individuals the possibility of seeking out care and treatment. One area that often gets overlooked is the substance abuse treatment [1]. Adequate access to substance abuse service facilities is critical to improving population health and well-being. Access to healthcare facilities including substance abuse service facilities has multiple dimensions [2]. An important dimension is the spatial accessibility because distance to facilities was recognized as a significant barrier to health access.

The study of spatial access to healthcare facilities has received great interest in public health, geography and GIS areas in recent years [3]. Most studies focus on spatial access to primary healthcare facilities [4-6], hospitals and emergency care [7-9], and cancer care facilities [10-11]. To our knowledge, little work has been done to investigate spatial access to substance abuse service facilities with few exceptions such as [12].

Guerrero and Dennis [12] examined spatial access to facilities of mental health services among racial/ethnic minority and low-income communities in Los Angeles County, California. They found that these communities have limited access to facilities offering integrated mental health care in substance abuse treatment. In this study, spatial access to facilities was simply measured using geographic proximity to facilities that is represented by service areas for each facility, where the service area was constructed by surrounding area within a fixed buffer with 10-minute drive to each facility. As a hot topic of spatial access in GIS in recent years, several advanced methods for measuring spatial access to facilities have been developed. These methods can be used in order to improve our understanding of spatial accessibility to facilities that provide substance abuse treatment.

Among various measures of spatial accessibility to health care, two are the most comprehensive and widely used methods: the gravity model [13] and the two-step floating catchment area (2SFCA) method [14, 15]. The basic idea of the gravity-based model is to introduce the travel impedance (e.g., travel time) to all facilities within a reasonable distance into spatial accessibility measures. The 2SFCA method is a two-step process that first calculates a facility to population ratio within a catchment area, and then in the second step, a similar process is performed on the facility points from the population points to obtain spatial access for population points by summing up the computed ratios at corresponding facilities with the catchment. The 2SFCA method can be considered as a special case of the gravity-based method with only concerns with

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facilities and population within the catchment. The 2SFCA method and various variations [16] have been widely used in the study of spatial accessibility to facilities as it overcomes a difficulty in the gravity model, which might include far away points in the calculation that may be unnecessary and use valuable space in computer memory during computation.

The provision of substance abuse services has become critical in Texas, particularly in the Dallas-Fort area. Based on a report of adult survey of substance [17], lifetime use of alcohol among adults aged 18 to 25 in seven major counties including Dallas was 76.6 percent. Illicit drugs continue to enter from Mexico and then move northward to Dallas-Fort Worth. In addition, drugs move eastward from San Diego to Dallas-Fort Worth area [18].

In this study, using an enhanced 2SFCA methodwe measured the spatial accessibility to substance abuse treatment in the Dallas-Fort Worth metroplex, TX, the largest land-locked metropolitan area in the United States. In addition, we identified the hotspots for low-income and minority households, and further investigated the relationship between the derived spatial accessibility and the identified hot spots. The goal is to better understand spatial accessibility to the facilities among low-income and minority household communities in the area.

2. DATA AND METHODS

This study used block-group level data, the smallest available unit for the required data, for the majority 11 counties of the Dallas-Fort Worth metroplex area. The 11 counties include Collin, Dallas, Denton, Ellis, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise (Figure 1). Hispanic and African American are the two largest minority populations in this area. According to the 2010 United States census, 27.5% of the population is Hispanic and 15.4% of African American.

The population data, substance abuse treatment facilities, and street network are the three main data for spatial accessibility measurement. Population data were drawn from the 2008-2012 summary ACS (American Community Survey) data provided by the U.S. Census Bureau. The street data were obtained from ESRI StreetMap Premium Road Work.

We used two data sources to obtain substance abuse treatment facilities. The first source is the Behavioral Health Treatment Services Locator (findtreatment.samhsa.gov) under the Substance Abuse and Mental Health Services Administration (SAMHSA). This is an online source of information for public seeking treatment facilities in the United States for substance abuse/addiction and/or mental health problems. From this online source, we obtained all treatment facilities in the Dallas-Fort Worth Metroplex. However, the data available from this source only contain the location and services provided by facilities. Capacity such as number of physicians is also important to measure spatial accessibility to facilities. For that purpose, we used InfoUSA, a residential and business database. This database provides location, name, employee size, sales volume and other attributes for each business workplace.

To identify low-income and racial/ethnic minority hot spots, three types of data, namely poverty, African American population and Hispanic population at the block group level were also drawn from the 2008-2012 summary ACS data. To account for the edge effect, in addition to the data in the study area, data in the neighboring counties that share a border to these 11 counties were also obtained and included in the analysis. In total, there are 18 neighboring counties as shown in Figure 1.

We used the the 2SFCA method with two improvements to measure spatial accessibility to substance abuse treatment for each block group in the Dallas-Fort Worth metroplex area. First, for each substance abuse treatment facility *j*, we found out all block groups that are within the catchment, *D*, and computed the facility-to-population ratio, R_j, within the catchment area, as follows:

$$R_j = S_j / \sum_{k \in \{d_{kj} \le D_j\}} P_k$$

where, P_k: population at block group k
S_j: number of physicians
Dj: catchment for the facility *j*

Based on the data availability, the number of physicians is used to represent each facility's capacity. Next, for each block group *i*, we searched all facilities (*j*) that are within the catchment of each block group *i* and summed up R_j calculated for the corresponding facilities. The result (A_i) represents the spatial access value for the block group *i*.

$$A_i = \sum_{j \in \{d_{ij} \le D_i\}} R_j$$

where D_i is the catchment for block group *i*.

This first improvement on the 2SFCA is to add the variations to the catchment functions for both facilities and block groups. The catchment size of a facility is a threshold travel time in which a facility provides service. Based on services facilities provided, we classified substance abuse treatment facilities into two categories and they have different catchment sizes. One category is that offers hospitalization as well as outpatient services (hereafter we refer it as long term facilities). The other category is that only offers outpatient services (hereafter we refer this category as short-term facilities). Similarity, the second improvement is to add variations to the catchment functions for block groups, a threshold travel time that patients within a block group travel to obtain services. The catchment size varies depending on whether patients live in urban or rural area and which facility category (short term or long term) they go. Although most of areas in the study area are metropolitan areas, there are some small towns or rural areas. We determined metropolitan areas and small town/rural areas in the study area based on 2010 Rural Commuting Area (RUCAs) codes defined by Rural Health Research Center (http://depts.washington.edu/uwruca). The RUCAs identify all of the nation's Census tracts regarding their rural and urban status and relationships. Table 1 shows the catchment sizes for different types of facilities and of block groups. The sizes were chosen by examining existing literature in spatial access to health care facilities.

The process of building catchment areas was completed by building service area polygons based on street data using the Network Analyst extension in ArcGIS 10.1. Processes were

run separately for each catchment variable listed in Table 1. The number of physicians was used to represent facilities' capacity. If the number of physicians is not available for a facility, an average of the number of physicians for the corresponding facility category (long term or short term) was used. The functions of the 2SFCA were carried out with python scripting, using the ArcPy library and were composed within the open source python module PyScripter. The result of the process was a decimal number representing the spatial accessibility to facilities for each block group. Lower values represent areas that have less spatial access to facilities while higher values represent areas with greater spatial accessibility.

To identify hotspots for low-income and for ethnic minority households in the area , we used the Getis-Ord Gi* statistic method, a common hotspot analysis, to identify significant clusters of block groups with large concentrations of low-income, African Americans and Hispanics households. Low-income is defined as below the federal poverty level. The Spatial Statistics/Hotspot Analysis tool provided in ArcGIS 10.1 was used to perform the Getis-Ord Gi* method. This tool identifies "hot" spots of polygons with high values near each other and "cold" spots of low values near each other. We also investigate spatial access to all facilities for low-income and racial/ethnic minority households through overlaying the identified hotspots with derived spatial accessibility measures.

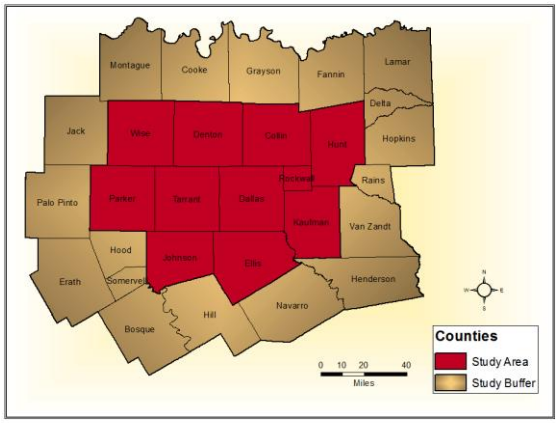

Figure 1. Study area of the Dallas/ Fort Worth metroplex.

Table 1. Catchment sizes for facilities and areas.

Facility Category	**Catchment Size (driving time)**	
Short term facilities (#65)	30 minutes	
Long term facilities (#27)	60 minutes	
Area Type for Block Groups	**Catchment size (driving time)**	
	To short term facilities	**To long term facilities**
Metropolitan Area (#4099)	30 minutes	60 minutes
Small town / Rural Area (#27)	60 minutes	90 minutes

3. RESULTS

Figure 2 shows the geographic distribution of substance abuse treatment facilities. There are a total of 92 facilities found that treat substance abuse in the Dallas-Fort Worth area, including 65 short-term facilities and 27 long-term facilities. Most of these facilities are located in the center of the area. Not surprisingly, among a total of 4126 block groups, majority are in metropolitan area. Only 27 block groups are small town/rural areas and they are located in Hunt County and Wise County.

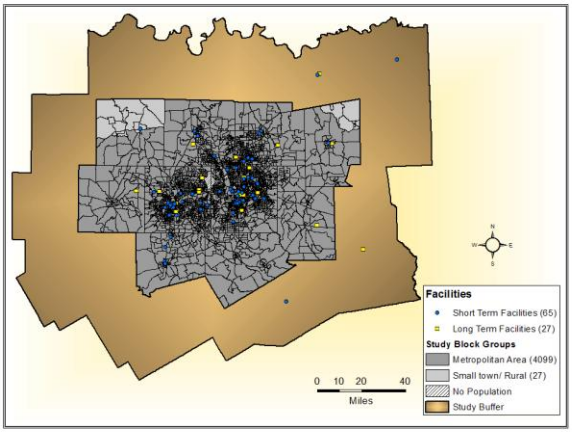

Figure 2. Geographic distribution of substance abuse treatment facilities in the Dallas/Fort Worth metroplex.

For each block group we calculated the spatial access values to all facilities, short term facilities and long term facilities, respectively using the enhanced 2SFCA method (Figures 3 – 5). The areas were divided into five categories based on the values of access to facilities: low, med-low, medium, med-high, and high. The natural breaks statistical method was used to perform classification, as suggested in [15].

As shown in Figure 3, about 28% of the areas have high or med-high access while about 58% of the areas are indicated as low or med-low access. Most areas in the counties of Denton, Collin, Rockwall, Kaufman and Ellis and Parker have low or med-low access to all facilities that provide substance abuse treatment. As for spatial access to long term facilities (Figure 4), about 45% areas are categorized as low or med-low access and they are mainly in the edge of the area. As shown in Figure 5, the pattern of spatial access to short term facilities presents a similar pattern as that to all facilities.

Figures 6-8 show hotspots and their associated spatial access values to all facilities for low-income, African American and Hispanic households, respectively. Most of the hotspots for these three types of households are in the center areas with the exception of some low-income hotspots in north, south and east north areas. There are about 23% of areas in low-income hotspots have low access to all facilities while about 7% in African American hotspots and only about 3% in Hispanic hotspots. For all of these groups of communities, the category of high access to facilities received the smallest areas compared with other four access categories, with 15% for low-

income, 1% for African American and 0.8% for Hispanic areas of hot spots. More specifically, as shown in Table 2, the areas of low-income hot spots are quite evenly allocated to the five access categories. In contrast, the majority (73%) African American hotspot areas are in either med-low access or medium access categories, and the majority (72%) Hispanic hotspot areas have either medium or med-high spatial accessibility to all facilities. For all of these groups of communities, the category of high access to facilities received the smallest areas compared with the other four access categories.

Table 3 shows the facilities in these three types of hotspots. 42 out of the 92 facilities, including 30 out of the 65 short term facilities and 12 out of the 27 long term facilities are in the low-income hotspots. In contrast, only 14 out of the 65 short term facilities and 6 out of the 27 long term facilities are in African American hotspots. Similarly, 19 out the 65 short term facilities and 5 out of the 27 long term facilities are in Hispanic hotspots.

Table 2. Percentages of square mileage for each category of spatial accessibility within the boundaries of hotspots.

	Low Access	Med-Low Access	Medium Access	Med-High Access	High Access
Poverty	22.97%	18.48%	25.62%	18.29%	14.65%
African American	7.23%	36.08%	36.74%	18.89%	1.05%
Hispanic	2.74%	24.58%	38.30%	33.62%	0.78%

Table 3. Number of facilities within low-income, African American and Hispanic hotspots.

	Total Facilities (# 92)	Long Term Facilities (# 27)	Short Term Facilities (# 65)
Poverty	42	12	30
African American	20	6	14
Hispanic	24	5	19

4. DISCUSSION

In this paper we first studied spatial access to substance abuse treatment facilities in the Dallas-Fort Worth metroplex, TX. The findings show that distribution of spatial access to the facilities varies over the space. Residents in the edge area face lack access to the facilities relative to those in the center areas. Over half of the areas present low or med-low access to facilities that provide short term facilities. In addition, we specifically examined the spatial accessibility to the facilities among low-income and minority households. The results show that spatial access to facilities that provide substance abuse treatment was limited in low-income and minority communities, supporting findings from the study in Los Angeles County, California [12].

Our findings suggest a clear relationship between treatment access and low-income and minority communities in a visualization way. Mainly this is one benefit of examining spatial access environment at a fine scale. Most of studies measure spatial accessibility at census tracts, zip codes or even coarser levels. In this study we measured the accessibility value for each census block group. The results at a finer scale provide the information in more detail and therefore help us better understand the spatial distribution and pattern of spatial accessibility to health care facilities.

This study is not without limitations. First, due to the data availability, we relied on SAMHSA data to collect substance abuse treatment facilities and depended on the InfoUSA data to obtain attributes such as the number of physicians for the facilities. Although these two datasets are highly correlated, some of the facilities in SAMHSA data are not contained in the InfoUSA data and therefore we have to use an average of the number of physicians in facilities that provide same services to represent the number of physicians for those facilities. Second, we relied on the existing literature to determine catchment sizes. This can be improved if travel information such as data on travel distances patients are willing to travel for services is available. Last, as stated in [15], patients are likely to go to a nearby facility to access services compared to the facility that is far away. Likewise, a facility is more likely to delivery services to population close by compared with those live far away. This kind of distance decay functions can be considered in the future work.

Despite some limitations, this study provides value evidence of a limited spatial access to facilities that provide substance abuse treatment in the Dallas-Fort Worth metroplex area, particularly for low-income and minority population. The findings can help community leaders, facility providers, policy makers and others to improve health and well-being in this area.

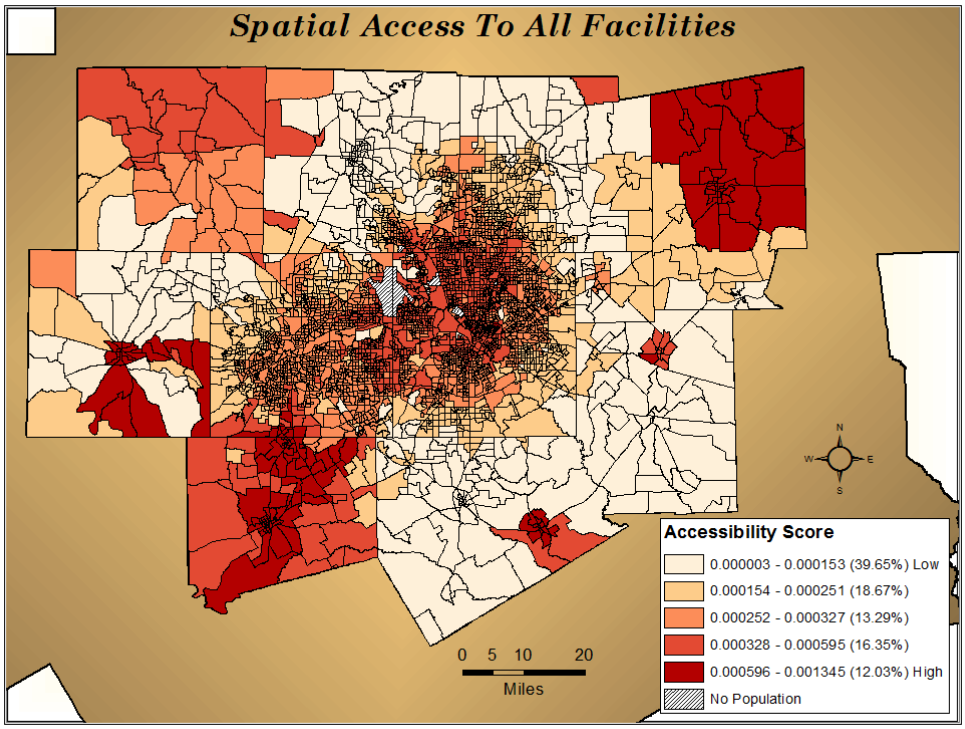

Figure 3. Spatial access to all facilities at the block group level. The percentages are of the total study area square mileage.

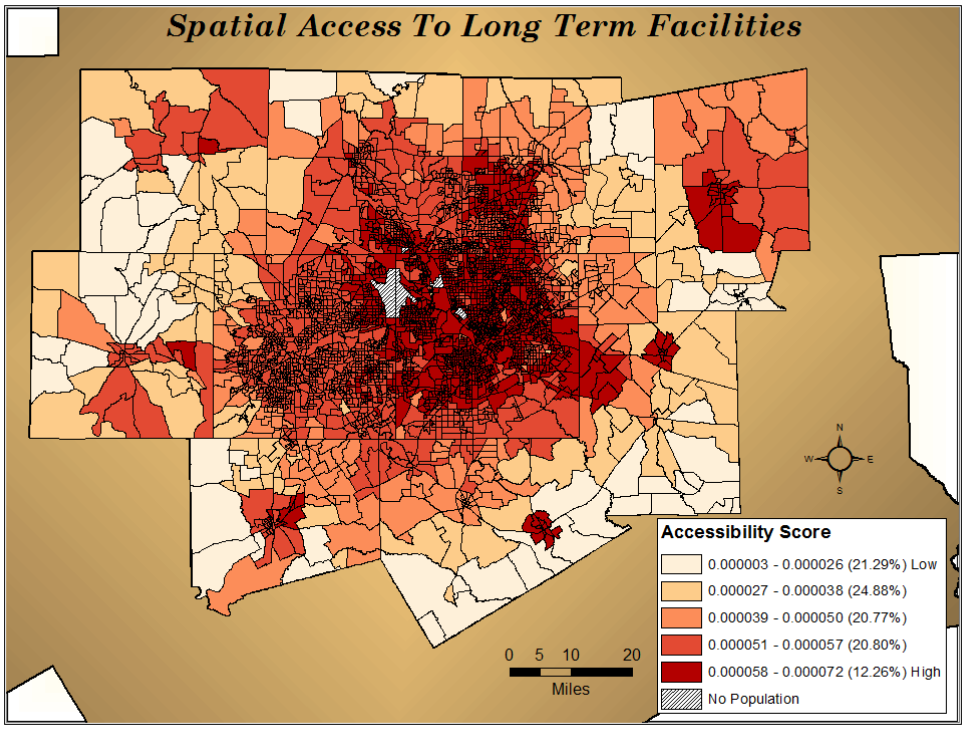

Figure 4. Spatial access to long term facilities at the block group level. The percentages are of the total study area square mileage.

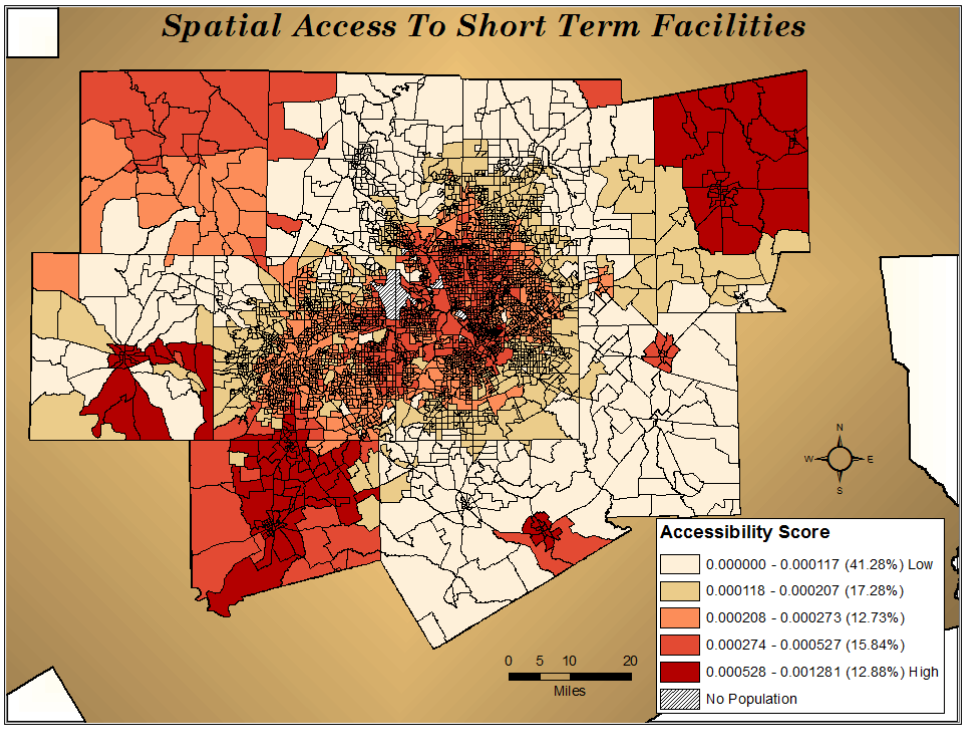

Figure 5. Spatial access to short term facilities at the block group level. The percentages are of the total study area square mileage.

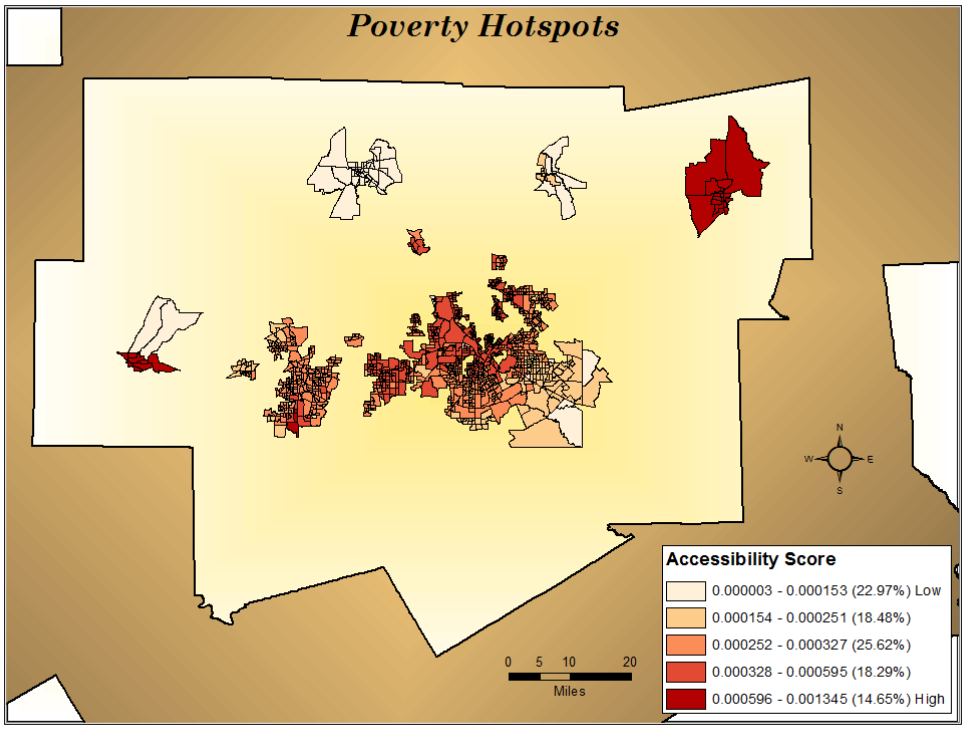

Figure 6. Poverty hotspots and spatial access to all facilities.

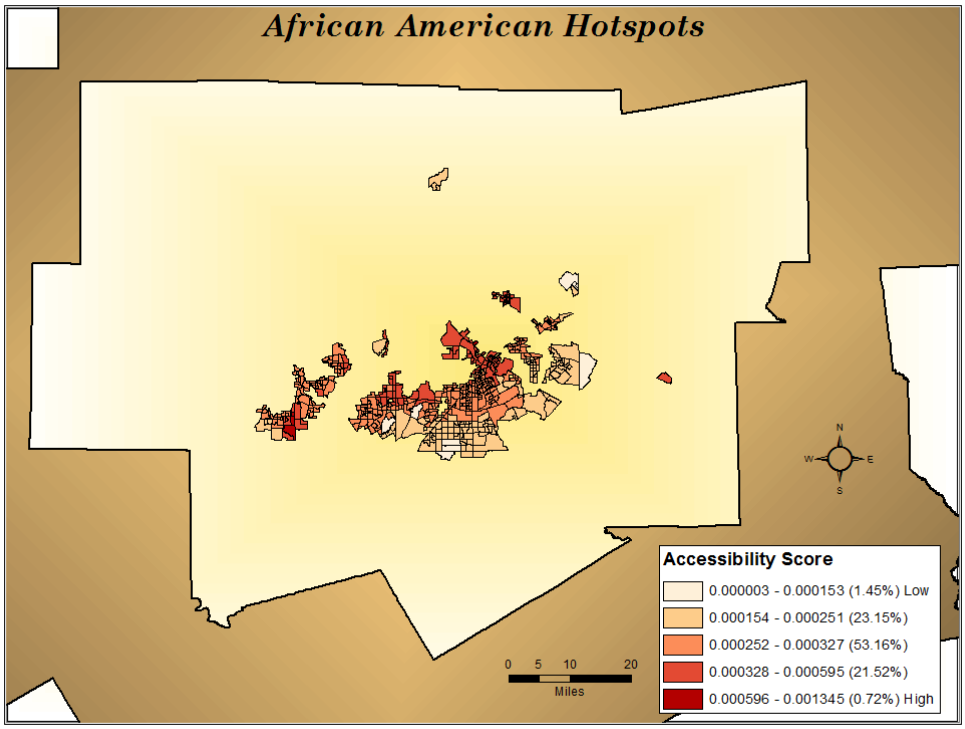

Figure 7. African American hotspots and spatial access to all facilities.

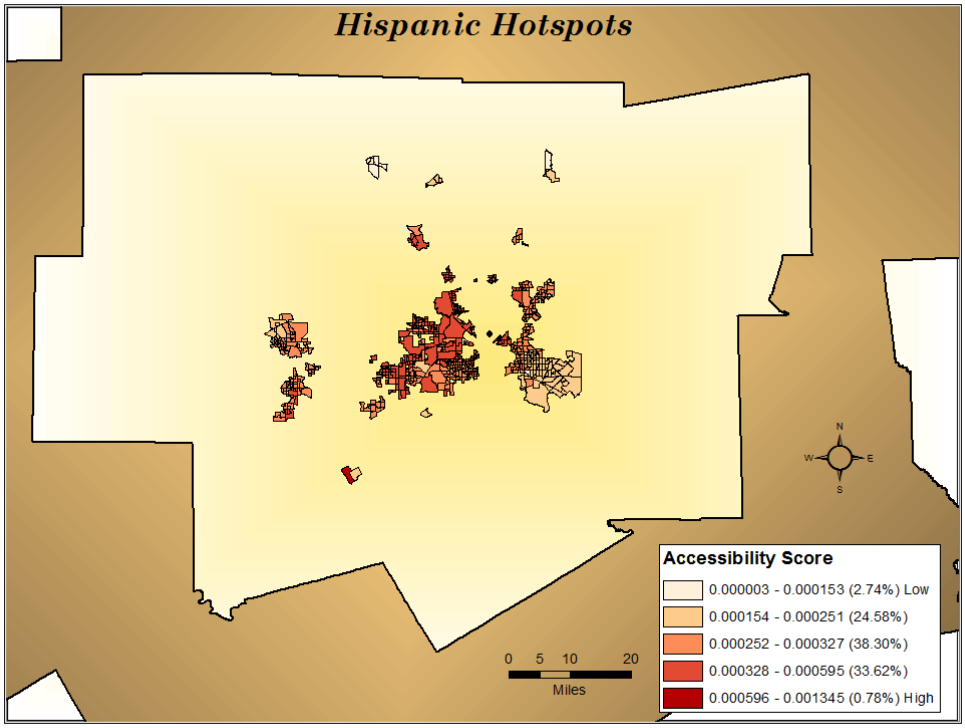

Figure 8. Hispanic hotspots and spatial access to all facilities.

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