

Access to Diabetes Self-Management Education in a Rural State: A GIS Analysis

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Abstract

Background: Diabetes is a major cause of mortality and morbidity in the state of Alabama. Research has demonstrated geographical disparities in diabetes outcomes and access to healthcare services. Supporting behavior changes through diabetes self-management education (DSME) has been shown to improve diabetes outcomes.

Purpose: The overall purpose of this study was to empirically measure and display spatial patterns of potential geographical accessibility of the Alabama populations to DSME services. Geographic information systems (GIS) technology was used to empirically and visually examine spatial

relationships between variables related to diabetes and access to DSME services. The specific aims were to: (1) Determine the percentage of the Alabama population with geographical access to DSME services within 30 and 60minutes of travel time; (2) Determine the percentage of the population with access by age, sex, race, rural status, and SES.

Method: A retrospective cohort, descriptive quantitative study DESIGN was used. GIS and U.S.Census Bureau data provided visual identification and empirical measures of distance and access.

Findings: GIS analysis provided percentages of Alabama’s total population with access to DSME at 30 and 60-minute travel time and maps allowed visualization of DSME service coverage areas. Analysis showed that 66.3% and 94.1% of the total Alabama population were within a 30 and 60-minute travel time to a DSME service location, respectively. While SES status had a minor effect on accessibility, the most noticeable disparity in equity of access was for those living in a rural setting. Only 44.1% of individuals in rural settings had 30-minute access to a facility, whereas 81.7% of individuals in an urban setting had 30-minute access. DISCUSSION: Timely access to the best practice of DSME is essential in reducing diabetes mortality and disparities. Social justice requires the reversal of healthcare disparities created by geographical and social inequalities through better distribution of resources. Healthcare policy can change DSME locations to increase access and decrease mortality.

Keywords: Diabetes, Diabetes self-management education, Healthcare access, Geographic information systems

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Background/Significance

Diabetes is a major cause of mortality and morbidity worldwide, in the United States (US), and the state of Alabama. Estimates indicate that 21 million Americans have been diagnosed with diabetes and an additional 8.1 million are living with undiagnosed diabetes. Currently diabetes is the 7th leading cause of death in the U.S. (Centers for Disease Control and Prevention [CDC], n.d.a) and prevalence is highest in the Southeast U.S. Southern states also have the highest prevalence of undiagnosed diabetes (Danaei, Friedman, Oza, Murray, & Ezzati, 2009). Alabama consistently ranks in the top five states with the highest diabetes rates (Robert Wood Johnson Foundation, n.d.). In 2014, 11.9% of the adult population in Alabama had been diagnosed with diabetes (CDC, n.d.b). These disparities are attributed to increased obesity rates, poverty, and larger African-American populations, a particularly at-risk group (Winerman, 2011). A higher prevalence of diabetes has also been associated with rural areas (O'Connor & Wellenius, 2012).

Studies have shown that socioeconomic status (SES) and ethnic inequalities exist in the provision of healthcare to individuals with diabetes (Ricci-Cabello, Ruiz-Perez, Olry de Labry-Lima, & Marquez-Calderon, 2010; Walker, Gebregziabher, Martin-Harris, & Egede, 2014; Walker, Gebregziabher, Martin-Harris, & Egede, 2015). Also, the literature demonstrates that racial/ethnic populations with lower SES are at risk for poor metabolic control and poor emotional functioning (Borschuk & Everhart, 2015; U.S. Department of Health and Human Services [USDHHS], n.d.) and that significant racial differences and barriers exist in diabetes self-monitoring and outcomes (Campbell, Walker, Smalls, & Egede, 2012).

Diabetes Self-Management Education

Diabetes Self-Management Education (DSME) has been shown to improve diabetes outcomes. National DSME standards (Brunisholz, 2014) call for an integrated approach that includes clinical content and skills, behavioral strategies (goal setting, problem solving), and engagement with psychosocial concerns (Funnell, et al, 2012). High quality DSME, including healthy eating, being active, adhering to medications, monitoring blood glucose, and stress management, can improve clinical outcomes and patient health status (American Diabetes Association [ADA], 2016; Powers, et al. 2015).

Clinical trials have well established the beneficial effects DSME can have on Hemoglobin A1c control and complication reduction (Brunisholz, 2014; Funnell, et al, 2012). In 2012, only 55.7% of adults diagnosed with diabetes in Alabama had ever attended a DSME class (CDC, n.d.b). Diabetes Self-Management Education programs function to promote informed decision-making, effective self-care behaviors, and active collaboration with healthcare teams to improve clinical outcomes, health status, and quality of life (Funnell, et al, 2012). But, DSME programs are not uniformly accessible, and lack of access can contribute to disparities in diabetes outcomes. While the amount of research about diabetes and associated risk factors is overwhelming, a greater understanding of specific regional geographical disparities is needed.

Disparities in Healthcare Access and Health Outcomes

Addressing disparities in access to healthcare services is a major public health priority. The U.S. Department of Health and Human Services has the goal of achieving health equity, eliminating disparities, and improving the health of all groups by 2020 (USDHHS, n.d.). Variations in access to healthcare are strongly associated with variables such as age, race, SES, and place of residence and have been linked to health outcome disparities (Andersen, 1995;

Graves, 2009; Shamshirgaran, et al., 2017; Spanakis & Golden, 2013). Geographical accessibility is reduced by distance because the additional time, cost, and effort of long distance travel decreases utilization of service facilities (Dal Bello-Haas, Cammer, Morgan, Stewart, & Kosteniuk, 2014). The relationship between the location of health care services and the locations of the populations in need can result in healthcare disparities.

Many studies have identified differences or gaps in healthcare access and health outcomes. Findings of these studies indicate that while most Americans have high quality healthcare available, disparities in healthcare access and health outcomes continue to exist. Disparities associated with age, race and ethnicity, sex, income and SES, and place of residence or location of healthcare services have been documented. Studies also show variation in healthcare access and adverse health outcomes associated with different geographical regions and urbanization levels (Gjesfjeld & Jung, 2011; Graves, 2009; Loop, et al., 2017; O'Connor & Wellenius, 2012). These differences create vulnerable, at-risk populations with excess diabetes related morbidity and mortality. *Where* DSME services are provided has economic, political, ethical, and geographic implications. There is a need for health policy to focus on geographical patterns of adverse disease outcomes and the effect on at-risk populations.

Access and Rural Populations

Merriam-Webster (n.d.) defines rural in general as *open land*. But there are many operational definitions of rural. The U.S. Department of Agriculture - Economic Research Service (USDA-ERS) uses rural-urban continuum codes (RUCCs) as a measure of rurality of U.S. counties as metropolitan (metro) versus non-metropolitan (non-metro) (USDA-ERS, n.d.).

The 2013 Rural-Urban Continuum Codes form a classification scheme that distinguishes metropolitan counties by the population size of their metro area, and nonmetropolitan

counties by degree of urbanization and adjacency to a metro area. Each county in the U.S. is assigned one of 9 codes. This scheme allows researchers to break county data into finer residential groups, beyond metro and nonmetro, particularly for the analysis of trends in nonmetro areas that are related to population density and metro influence (USDA-ERS, n.d., Para 1).

Many features of the rural environment create barriers to health service access. Dunkin (2000) provides a framework for considering financial, sociocultural (or personal), and structural factors as part of the complex web of causation in rural health. Financial factors include a lack of health insurance, adequate health insurance, or income or financial resources to personally pay for needed health services. Sociocultural factors include cultural and spiritual beliefs, language, education, self-reliance, and concern about confidentiality. Structural factors are those factors that relate to physical accessibility to health resources. They include availability of primary care providers, medical specialist (i.e. endocrinologist), or other healthcare professionals (i.e. certified diabetes educators) and health care facilities (i.e. certified ADA Diabetes Centers). These factors affect health-seeking behaviors, health service utilization, and ultimately, health outcomes in rural areas. Sociocultural and financial factors that influence health services have received extensive attention (Agency for Healthcare Research and Quality [AHRQ], 2017; Bushy, 2000; Folland, Goodman, & Stano, 2017; USDHHS, n.d.) while geographical factors of healthcare service access have received much less consideration.

Healthcare policy changes over the past decade have drastically decreased access to health services. The rural health environment has been impacted by these changes in many ways (AHRQ, 2012; Bushy, 2000; Folland et al., 2017). Significant decreases in health services to the already vulnerable, at-risk rural underserved populations compounds and increases existing health

disparities. Of noted importance are the drastic cuts in health services created by the chain of events from the Medicare Prospective Payment System of 1983, to the Balanced Budget Act of 1997, and through to the Patient Protection and Affordable Care Act of 2010. While the Patient Protection and Affordable Care Act increased the number of individuals covered by insurance overall access to many services was decreased.

Physicians within the US often prefer to practice in urban communities, rather than rural communities, due to volume. In 2010, only one out of ten physicians provided healthcare services in rural areas allowing for only 10% of the nation's physicians to provide healthcare to 20% of its population (AHRQ, 2012). Rural areas also have lower proportions of all healthcare professionals. Rural healthcare services often experience diseconomies of scale because long run average cost of operation increases as output increases (Folland et al., 2017). Providing care becomes too expensive, providers lose money, forcing them to close or merge with other services, thereby decreasing access. Rural populations then experience an increase in distance and travel time to access necessary healthcare services. This situation is the greatest in the costly provision of specialized healthcare services.

Access and Distance

When considering accessibility of healthcare services, physical proximity is an important enabling factor. Structural factors of access are measured in terms of availability and configuration of healthcare services, transportation to them, and distance and travel time to them (Cromley & McLafferty, 2011; Gatrell & Elliott, 2015; Hart, 1971; Meade & Emch, 2010). Research demonstrates that provision of healthcare services often does not match need and that the use of services declines as distance increases (Cullinan, Gillispie, Owen, & Dunne, 2011; Hart, 1971; Tompkins, Luginaah, Booth, Stewart, & Harris, 2010). Studies show patients may forgo free

healthcare if distance is greater than 20 miles. In response, many state health departments have proposed a standard in which rural residents should not have to travel more than 30 minutes to see a physician (Chan, Hart, & Goodman, 2006).

Geographical Information Systems

The use of Geographic Information Systems (GIS) in healthcare is growing. This growing technology and research methodology is simply an information system that can efficiently capture, organize, store, manipulate, and analyze spatial data. Its ability to link geographical features on a map with attribute data is efficient for analyzing health data, revealing trends and determining relationships that might be missed in a strictly tabular format (Evans et al., 2016; Gjesfjeld & Jung, 2011; Graves, 2009). GIS have demonstrated value in integration of statistical and geographic data and the visualization of the spatial relationship between location and resources (Andersen, 1995; Chan et al., 2006; Cromley & McLafferty, 2011; Cullinan et al., 2011; Gjesfjeld & Jung, 2011; Graves, 2009; 2011; Love & Lindquist, 1995) and therefore in health planning and the allocation of healthcare resources.

Theoretical Framework

The study used a framework of accessibility, the model for assessment of potential geographical accessibility (Graves, 2011), adapted from the behavioral model of health services use developed by R.M. Andersen (1995). Andersen's original model (Aday & Andersen, 1974) was initially developed in the late 1960s to help understand the use of health services, to define and measure equitable access to healthcare, and to assist in health policy development to promote equal access to healthcare. This seminal model has been used both to predict and explain the use of health services. In the revised behavioral model of health services use, Andersen posits that

health service use is a function of people's predisposition to use services, factors that enable or impede use, and their need for care.

Predisposing characteristics include demographic factors, social structure factors, and health beliefs. Biological imperatives, such as age and sex, are demographic factors that might explain the need for healthcare. Measures of social structure are education, occupation, ethnicity, as well as social networks, social interactions, and culture. In the assessment and measurement of *enabling resources*, Andersen challenges researchers to go beyond measures of *regular source of care*, *physician populations*, and *hospital bed counts*. Andersen believes that for utilization to happen, it is imperative that both *personal enabling resources* and *community resources* be socially and geographically available. The kinds and types of health services available where people live, as well as organizational structure and process, are important factors (Andersen, 1995).

The model used in this study can show *what* health services are provided *where* to *whom*, and by *whom* (organization) as well as where health service coverage is lacking. Application of concepts of geographical access and the use of GIS analysis can visually identify and empirically measure spatial relationships of geographical, environmental, and social influences of health, healthcare access, and healthcare outcomes (Andersen, 1995).

A more specific model for the assessment of access can help understand the health status of specific populations related to the provision of specific health services (Graves, 2011). Evaluation of specific small-area *need* and the relationship to that area's predisposing factors and enabling resources could lead to better understanding of disparities. The assessment of county-level mortality rates and the relationship to location or distance to health services may lead to improved mortality rates (See Figure 1). The Model for the Assessment of Potential Geographical

Accessibility is presented in this study and offers a replication model for the study of health outcomes by specific geographical areas (Graves, 2011).

More information about the relationship between social and geographical factors that enable people to obtain education for diabetes is needed. Specifically, are DSME services located across Alabama in a manner that allows equal access? Research linking diabetes health disparities of specific regions of the state to access to DSME services could provide information to assist in the reduction of the excess diabetes mortality. Ultimately, this analysis can serve to guide policy deliberations and health resource allocations as well as targeting of major healthcare priorities.

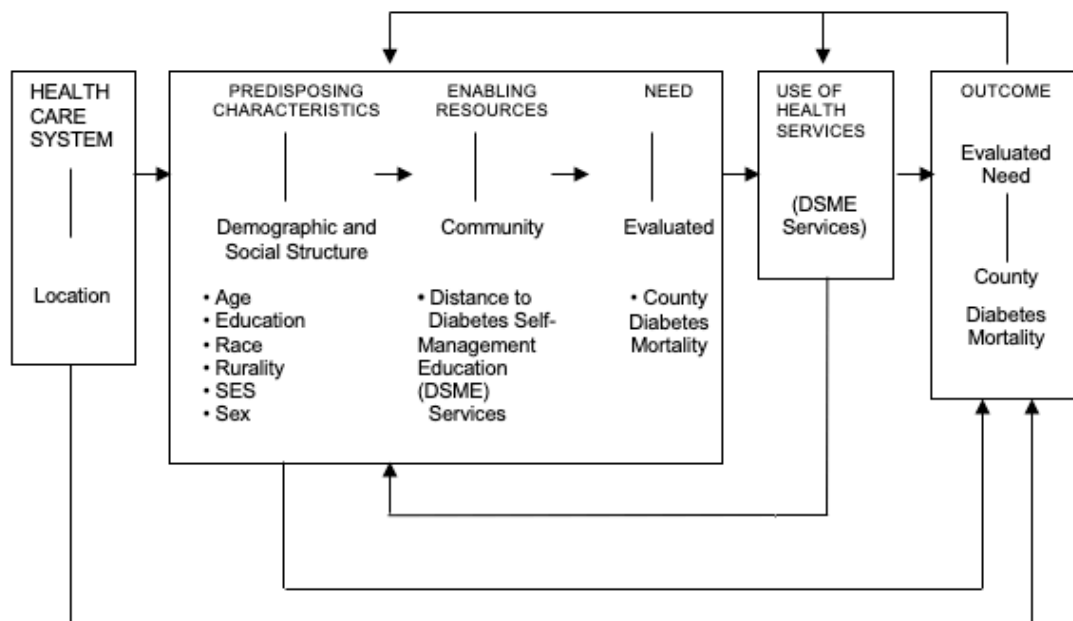


Figure 1. Diabetes education services: Model for Assessment of Potential Geographical Accessibility

Adapted from Model for the Assessment of Potential Geographical Accessibility with permission Graves (2009,) Online Journal of Rural Nursing and Health Care, <https://doi.org/10.14574/ojrnhc.v9i1.102>

Specific Aims and Objectives

The purpose of this study was to empirically measure and display spatial patterns of potential geographical accessibility of the Alabama populations to DSME services. GIS technology was

used to empirically and visually examine spatial relationships between variables related to diabetes and access to DSME services. The specific aims were to: (1) Determine the percentage of the Alabama population with geographical access to DSME services within 30 and 60-minutes of travel time; (2) Determine the percentage of the population with access by age, sex, race, rural status, and SES.

Research Design

A descriptive, ecological, explorative study design was used in a retrospective cohort. This design allowed description of the particular predisposing characteristics and the enabling resources of the Alabama populations. The study was ecological, seeking to analyze the interrelationship of population characteristics and the specific DSME services environment.

A GIS was used to provide distance data for a descriptive analysis of the potential access of Alabama populations to DSME services. A GIS-based analysis provided distance measure (estimated network travel time), geographical mapping, and linking of U.S. Census data for analyses of distance and other social determinants of health. Descriptive statistics and mapping were used to explore and describe geographical access to DSME services.

Sampling Method/Subjects/Protection of Human Subjects

This was a secondary analysis that used U.S. Census Bureau aggregate data within a GIS system; no individual data was used. Data for this study was restricted to analysis and statistical reporting as aggregate data only. Due to the nature of the data there are no human subjects, no at-risk populations, and the project was granted exempt status by The University of Alabama IRB Board (IRB#EX-17-CM-012-R1).

Methods/Data Collection Procedures

The following were the principle data sources used for this study:

- *American Diabetes Association data.* Street addresses of agencies that provide DSME services to Alabama populations were obtained from the American Diabetes Association Directory for each state (Alabama, Florida, Georgia, Mississippi, and Tennessee). These addresses were geocoded within ArcGIS and provided a geographical location for the identified services. Services in the surrounding four states were also included in the database due to potential to obtain services across state lines.
- *TIGER® data.* Zip code cartographic boundary files containing location in terms of latitude and longitude were downloaded from the United States Bureau of Census 2010 Census Data (U.S. Census Data, 2010). These files were used in ArcGIS to map and analyze characteristics of the Alabama population.
 - *Distance (Network travel time).* GIS used the street network database within the *TIGER* boundary files to calculate specified travel time from the identified locations of DSME services. From this data, network buffers of travel time were generated to define service areas of DSME services.
- *Rural status.* Rural status was determined using the USDA-ERS (n.d.) RUCCs as a measure of rurality of U.S. counties. Rurality was classification by a simple metropolitan (metro) versus non-metropolitan (non-metro) dichotomy. Codes 1 through 3 distinguish levels of metropolitan counties by degrees of urbanization, while codes 4 through 9 distinguish varying degrees of rurality and metropolitan proximity.
- 2010 U.S. Census Bureau zip code-level data (U.S. Census Bureau, 2010):
 - Age. GIS calculated proportion of the adult population with access to DSME services by age.

- Race. GIS calculated the proportions of the population located within each travel time service area to determine the proportion with access to DSME services by race groups (White, Black, American Eskimo/Indian, Asian, Hawaii/ Pacific Islander, Other, Multi-race, and Hispanic).
- Sex. GIS calculated the total proportions of the population located within each travel time service area to determine population with access to DSME services for biological males and females.
- SES. GIS calculated the proportions of the population located within each travel time service area to determine access to DSME services by poverty status measured by those at or below poverty level.

Table 1

Selected Outcomes Measures

Model Category	Construct	Specific Measures	Data source
PHASE 1: DESCRIPTIVE ANALYSIS			
Health System	Geographic location	GIS coordinates	GIS Addresses from American Diabetes Association directory
Predisposing characteristics	Demographic and Social Structure	GIS will calculate the total proportions of the population within travel time service areas to determine population with access to DES by:	GIS and U.S. Census Bureau
	Age	age categories (ages 22-29, 30-39, 40-49, 50-64, and 65 and greater).	GIS and U.S. Census Bureau
	Race	race groups (White, Black, American Eskimo/Indian, Asian, Hawaii/ Pacific Islander, Other, Multi-race, and Hispanic).	GIS and U.S. Census Bureau
	Sex	males and females.	GIS and U.S. Census Bureau
	SES	poverty status: SES proportions will be reported for those at or below poverty level.	GIS and U.S. Census Bureau

	Rural status	Rurality is based on the Office of Management and Budget (OMB) classification by a simple metropolitan (metro) versus non-metropolitan (non-metro) dichotomy. Codes 1 through 3 distinguish levels of metropolitan counties by degrees of urbanization, while codes 4 through 9 distinguish varying degrees of rurality and metropolitan proximity. For this study rural status will be defined as either metro or non-metro.	U.S. Department of Agriculture Economic Research Service (ERS) Rural-Urban Continuum Codes (RUCCs)
Enabling resources	Distance (Network travel time)	Network buffers of travel time generated to define service areas of diabetes education and provided a measure of access.	GIS and TIGER® data

Data Analysis

Data were analyzed using the ArcGIS® Desktop, a commercially available GIS software produced by Environmental Systems Research Institute, Inc (ESRI). A GIS-based analysis provided both geographical mapping and analyses of distance as well as social determinants of health.

Using U.S. Census data and GIS, maps of Alabama zip codes were generated as the first thematic layer. The locations of DSME services across Alabama and contiguous states were geocoded by latitude and longitude coordinates as point data on maps. The buffer tool in ArcView GIS Network Analysis was used to create network travel time buffer zones (service areas) of 30 and 60-minutes around point locations of DSME services. Thematic map layers of DSME point locations and travel time buffer zones were overlaid on a Alabama zip code map layer. Based on U.S. Census data for each zip code the total percentage of the Alabama population located within each travel time service area was calculated to describe access to DSME services. The linkage of

data sets and thematic map layers allowed GIS to estimate population characteristics by age, rural status, race, sex, and SES.

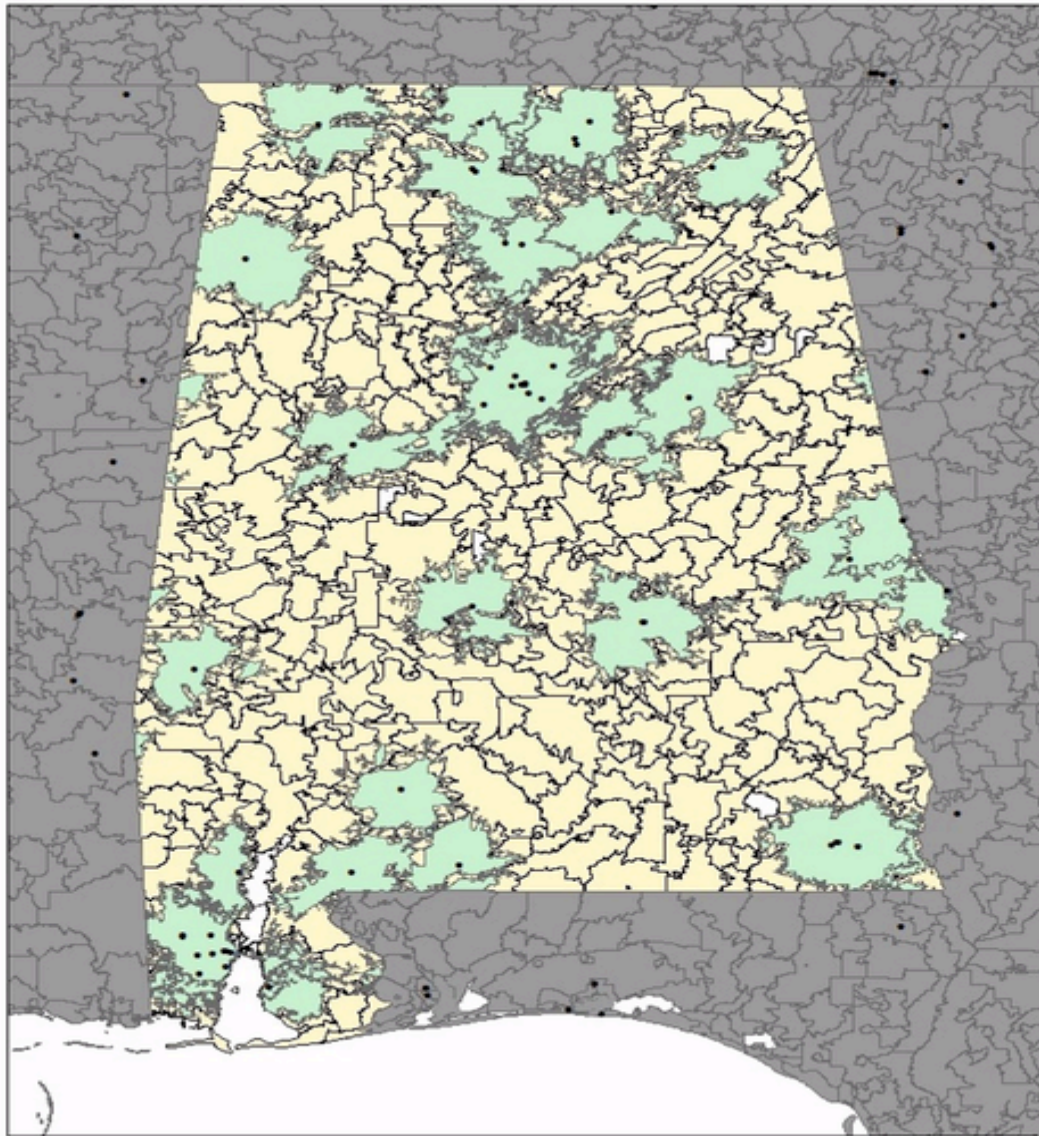
Limitations

While the quality and accuracy of the data in this study is believed to be high, it is important to note that the use of aggregated data sets and geospatial manipulations could have introduced bias and may provide limitations to this study. Data input, data manipulation, data output, and data interpretation are potential sources of errors or threats to validity and caution should be used when applying these findings to other geographical regions. Furthermore, diabetes is a multidimensional disease with a complex web of causation. This study was limited by the use of risk factors measured only at the aggregate ZIP code-level, creating the modifiable areal unit problem (MAUP). The MAUP is a common problem that is encountered with health geography research and occurs when the same data can yield different results when aggregated in different ways. By choosing to aggregate by ZIP code instead of a different areal unit, such as county or census tract, the distribution of individuals throughout each Zip Code Tabulation Area (ZCTA) is uncertain. This can skew results, as the exact number of individuals within each service area is unable to be calculated and must instead be estimated. By only using Alabama ZIP codes, the generalizability of the findings relating to access to DSME services is limited to geographical regions with similar population and demographic distributions.

Results

Access

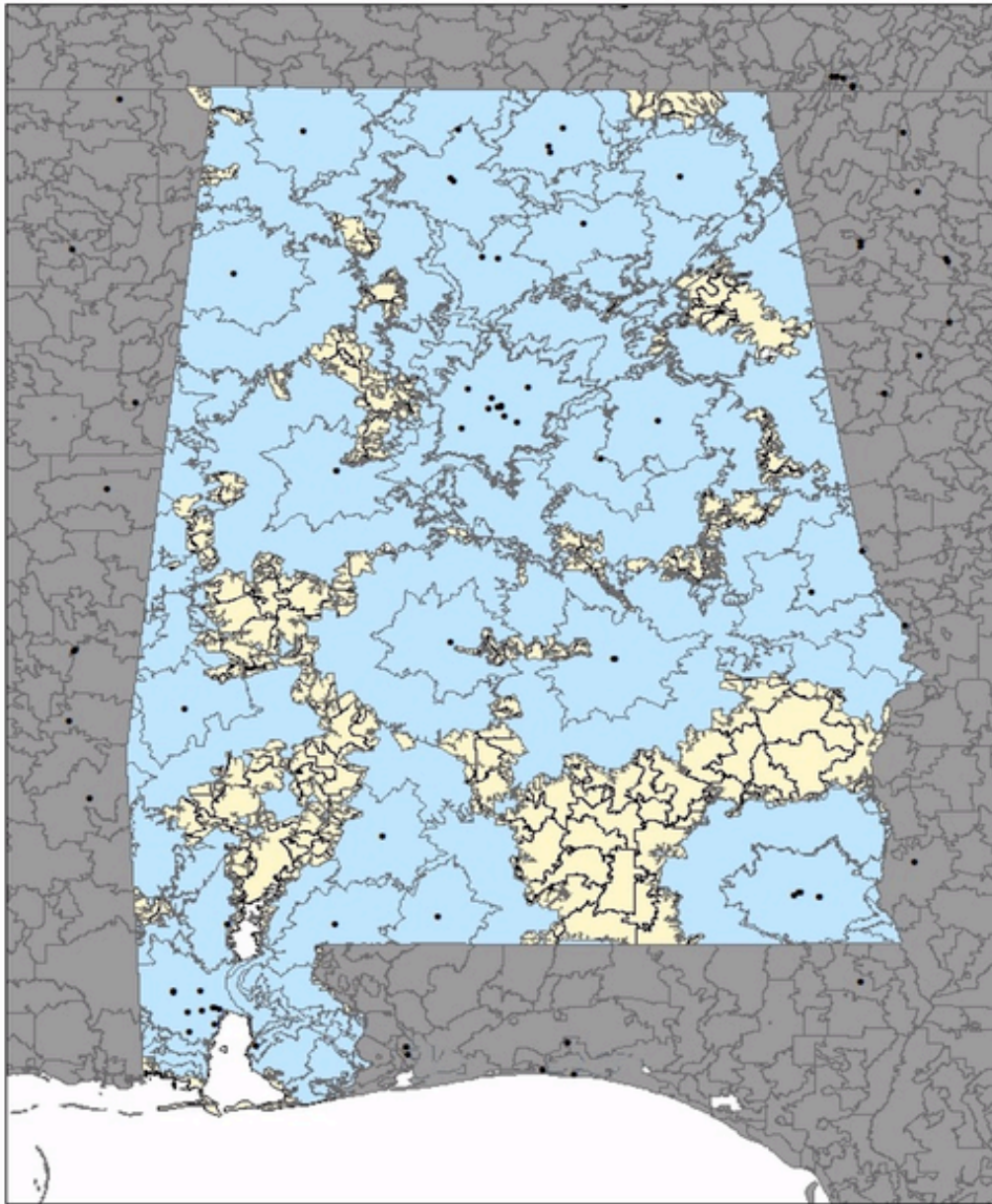
Figures 2 and 3 show the service areas surrounding each DSME service location to provide visualization of coverage within Alabama at 30 and 60-minutes of travel time.



Legend

- DSME Services
- 30 Minute Service Areas
- No Data
- Zip Codes

Figure 2. DSME service locations with 30-minute travel service areas



Legend

- DSME Services
- 60 Minute Service Areas
- Zip Codes
- No Data

Figure 3. DSME service locations with 60-minute travel service areas

Detailed results of the GIS analysis by total population, sex, rural status, race, age, and SES are reported in Table 2 by 30 and 60-minute travel networks. Analysis showed that 66.3% and 94.1% of the total Alabama population were within a 30 and 60-minute travel time to a DSME service location, respectively.

Table 2

Results - Summary of Population Percentages with Access to DSME Centers in Alabama

Census Category	30 min		60 min		Total
	n	%	n	%	n
Total Population	3,214,395	66.3	4,561,424	94.1	4,845,056
Sex					
Male	1,555,319	66.1	2,215,730	94.1	2,354,198
Female	1,659,076	66.6	2,345,694	94.2	2,490,858
Rural Status					
Rural	872,849	44.1	1,790,682	90.6	1,977,476
Urban	2,341,546	81.7	2,770,742	96.6	2,867,580
Race					
White	2,112,080	63.5	3,131,917	94.2	3,324,389
Black/African American	920,599	73.1	1,178,407	93.6	1,258,954
American Indian/ Alaska Native	18,308	64.1	27,225	95.3	28,578
Asian	46,282	84.4	52,928	96.6	54,812
Hawaiian/Pacific Islander	2,071	63.5	3,006	92.1	3,263
Other	66,192	65.1	98,359	96.7	101,731
Multiracial	48,863	66.6	69,582	94.9	73,329
Hispanic/Latino	129,780	66.6	188,073	96.6	194,720
Age					
20-29	460,712	69.9	622,333	94.5	658,646
30-39	412,853	67.1	582,375	94.6	615,301
40-49	440,106	66.2	626,931	94.3	664,760
50-59	436,320	65.5	625,203	93.9	665,754
60-64	176,963	63.5	260,248	93.3	278,848
65+	418,627	62.9	620,515	93.3	665,364
SES status					
Below poverty level	826375	62.0	1186738	92.4	

Equity of Access

Demographic and SES data from the 2010 U.S. Census were joined to ZCTA data in order to analyze how DSME service access varies between different demographics. Results from the GIS analysis are shown in Table 2. Access did not differ depending on sex (Males 66.1% and 94.1%, Females 66.6% and 94.2%). Increasing age appeared to have a negative correlation with accessibility for ages 30 to 65+ (67.1% to 62.9% in 30-minute access and 94.6% to 93.3% in 60-minute access) demonstrating a gradient effect. These results were also comparable to access of the total population of Alabama (66.3% for 30-minute networks and 94.1% for 60-minute networks).

Table 2 compares access to DSME services across eight categories of race, which affected accessibility most noticeably in the 30-minute networks. The Asian population had 18% more access (84.4%) compared to the total access of Alabama, and the Black/African American population access was 6.8% greater than the total access of Alabama. The other races had accessibility similar to the total population of Alabama. For 60-minute networks, inequality of access between races was less pronounced, with all of the results around Alabama's total access of 94.1%

SES had a minor effect on accessibility. Sixty-two percent of households living under the poverty line in Alabama lived within a 30-minute travel network of a DSME service location, and 92% lived within a 60-minute travel network. These are comparable to the overall accessibility of the total population of Alabama.

The most noticeable disparity in equity of access was for those living in a rural setting. Only 44.1% of individuals in rural settings had 30-minute access to a facility, whereas 81.7% of

individuals in an urban setting had 30-minute access. The disparity decreases at 60-minute access (90.6% for rural and 96.6% for urban).

Discussion

The purpose of this study was to empirically measure and display the geographical accessibility of the Alabama population to DSME services. Detailed results of the GIS analysis by total population, sex, rural status, race, age, and SES are reported in Table 2 by 30-minute and 60-minute travel times. Past literature indicates unequal access to healthcare services due to the previously mentioned demographic attributes and geographic location (USDHHS, n.d.; Andersen, 1995; Gjesfjeld & Jung, 2011; Graves, 2009; O'Connor & Wellenius, 2012). While this study demonstrates some variation in access, there are few of significant magnitude and most measured variables have comparable levels of access with the total Alabama population.

Timely access to DSME services is essential in reducing diabetes mortality and disparities, but as previous studies indicate, a patient may forgo free health care if it is greater than 20 miles away. In response, many state health departments have proposed a standard in which rural residents should not have to travel more than 30-minutes to see a physician (Chan et al., 2006). However, detailed results of this study indicate that less than half of the rural population (44.1%) in Alabama is within a 30-minute service area of a DSME location compared to 81.7% of the urban population. Even within a 60-minute service area, a single large geographical area noted in the southern parts of Alabama did not have access to DSME services, as shown in Figure 3. This region is part of a large crescent-shaped geographic region known commonly as the Black Belt region, named for its fertile land and, more recently, for higher levels of rural poverty, declining population, and insufficient health resources, including lack of DSME services.

Previous studies have shown limited levels of healthcare access for Black, Hispanic, and Asian populations when compared to the White population, with Hispanics facing the greatest barriers (USDHHS, n.d.). However, these findings were not seen in this study for DSME services in Alabama. Instead, the Black and Asian category demonstrated a pattern of significantly higher access at a 30-minute travel time (73.1% and 84.4% respectively) when compared to the White category, which displayed the lowest level of access along with the Hawaiian/Pacific Islander category, both at 63.5%. The Hispanic/Latino population had a similar level of access to the total population at 66.6%. These findings at a 30-minute travel network were unexpected given previous research related to race and healthcare access, but become less prominent at a 60-minute travel network. The prevalence of diabetes is highest among Native Americans, Blacks, and Hispanics (Spanakis & Golden, 2013), and this study provides reassuring data that these racial groups have higher level of access to DSME services for diabetes treatment in Alabama. However, it is important to note that geographical location and travel time are not the only indicators of healthcare access, but many other social determinates such as transportation methods, finances, health insurance access, and education should be considered.

The inverse relationship between age and percentage of the population with 30-minute access supports the previously identified relationship by Love and Lindquist (1995) with 20-29 year olds having the highest level of access and 65 years and older with the lowest at 62.9%. This finding raises concerns since older age has been found to be associated with a higher prevalence of health complications associated with diabetes despite better glycemic control (Shamshirgaran, et al., 2017). However, the percentage differences between age groups were still comparable to that of the total population.

Social justice requires the reversal of healthcare disparities created by geographical and social inequalities through better distribution of resources. This study demonstrates visually the spatial relationships between the DSME services, which are not geographically equally distributed, throughout Alabama. As mentioned, there is notable lack of DSME services in the region known as the Black Belt while there are two noticeably denser areas of DSME services in the Birmingham and Mobile areas. This is most likely due to their urban statuses and provides higher levels of access for urban populations. However, the occurrence of diabetes is higher among rural residents (O'Connor, & Wellenius, 2012), which makes up over 40% of the Alabama population.

Contrary to previous studies that indicated that people who live in poverty experience lower access to health services and poorer health status than people above the poverty line (Shamshirgaran, et al., 2017), SES had a minor effect on geographic accessibility in Alabama. This could be due to the fact that rural status is based on low population density and thus contain a lower number of people, whereas there can be a dense group of people living below the poverty line that live within a 30-minute service network. There was also not a difference in geographical access between sex within Alabama, because sex within each ZCTA is about equally distributed.

It is important to note that the use of aggregated data sets and geospatial manipulations could have introduced bias and may provide limitations to this study. Data input, manipulation, output, and interpretation are potential sources of error, and caution should be used when applying these findings to other geographical regions. By only using Alabama ZIP codes, the generalizability of the findings relating to access to DSME services is limited to geographical regions with similar population and demographic distributions.

Because diabetes is a multidimensional disease with a complex web of causation, there are potential confounding variables that pose a threat to the validity of this study. While this study

investigates multiple demographic attributes, these are not the only factors that influence diabetes. Other factors, such as education, diet, social influences, and environment play a major role in diagnosis and complications relating to diabetes and provide possible confounding conditions. Also, while urban populations may be closer to DSME services it does not mean there are enough certified educators to meet the needs of increasing population sizes.

As identified by models of access (Andersen, 1995; Graves, 2011) accessibility to DSME services does not equate to acceptability of these services. More research is needed to aid understanding of acceptability of DSME education for rural populations, particularly from a cultural perspective. Describing the accessibility without including measures of acceptability is an additional limitation of the study.

Despite the limitations, outcomes of this study can guide policy deliberations and health resource allocations that target major healthcare disparities. Healthcare policy can change DSME service locations to increase access and decrease mortality.

Highlights

1. Previous studies have shown a generalized standard of acceptable travel distance to healthcare services of 20 miles or 30-minutes. However, this study indicated that less than half of the rural population in Alabama is within a 30-minute travel time to DSME services compared to 81.7% of the urban population.
2. This study showed an inverse relationship and apparent gradient between age and percentage of the population with 30-minute access to DSME services with the oldest adults having the least access.
3. Findings provided reassurance that racial groups with known disparities in access to healthcare had higher level of access to DSME services for diabetes treatment in Alabama.

4. While geographical location and travel time are not the only indicators of healthcare access, place and distance do matter. Social justice requires the reversal of healthcare disparities through better distribution of healthcare services. Future research should focus on rural and rural age disparities. Transportation methods, finances, and health insurance access also need to be considered.

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