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Patterns of Hearing Impairment in Rural and Urbanized Texas in 2018

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Abstract

This paper describes a study I completed in a graduated school course entitled Geographic Information System (GIS) and Spatial Epidemiology (Course Director: Thomas Stopka, Ph.D.) My project was designated as non-human subject research by the IRB at the Tufts University School of Medicine. It involved the analysis of geo-masked non-identifiable and publicly available data in conducting secondary analysis using ArcGIS.

My Ear, Nose, and Throat (ENT) treatment eligibility and access project, entitled "Patterns of Hearing Impairment in Rural and Urbanized Texas in 2018," aims to identify not eligible for funding allocation medically underserved areas.

Based on the findings, most rural populations in Texas are at higher risk for hearing loss, which agrees with the more extensive literature, suggesting that rural residents tend to receive less care than needed. However, rural and urban are multidimensional concepts, making clear-cut distinctions between the two difficult. Rurality is the crucial allocation factor, but there is no clear-cut distinction between rural and urban. By applying the Census Bureau criteria for urbanized and rural areas, the study population areas between 2,500 and 4,000 people will be considered urban. They will not be eligible to receive supplemental health care.

The use of GIS analytic tools, particularly the Weighted Overlay Analysis, allows the integration of complex data and map treatment access while analyzing its effect on hearing health among rural Texans. A GIS-enabled data visualization approach gives a more meaningful interpretation of an appropriate population size threshold between rural and urban places and provides objective methods to guide funding decisions.

Keywords: Geographic Information System (GIS), The Population at Risk for Hearing Loss, The Accessibility of Hearing Health Care, Treatment Eligibility, Rural-Urban Continuum

Introduction

- Hearing loss is a growing public health concern. Today around 20% of the population, about 48 million people, state that they experience hearing loss [1-3]. Hearing loss is the third most common chronic physical condition in the United States and is twice as prevalent as diabetes or cancer [2]. It is estimated that in 30 years, one in every ten people in the U.S. will have a hearing impairment.
- Poor hearing is associated with educational underachievement, stigma, social isolation, depression, and dementia. Hard-of-hearing adults are more likely to have a low income and be under- or unemployed than those with normal hearing [3]. Unaddressed hearing loss poses an annual global cost of 750 billion dollars, according to the World Health Organization [4].
- In 2011 the U.S. Preventive Services Task Force (USPSTF) examined the issue of screening for hearing loss as a population-wide measure during primary care visits for asymptomatic adults aged 50 years and older but did not recommend screening due to insufficient evidence of potential benefits of screening for this asymptomatic population [5]. Since hearing loss is not an immediately life-threatening condition, many patients may not seek medical care if they don't perceive themselves as having a problem with hearing loss. As a result, undiagnosed and unaddressed hearing loss is prevalent [2]. According to the health statistics, in 30 years, one in every ten people in the U.S. will have a hearing impairment. Once lost, hearing does not come back.
- In 2016 the National Academies of Sciences, Engineering, and Medicine advised establishing population-based data on hearing loss and exploring novel technology to increase the accessibility of hearing health care to populations at risk [6].
- There's agreement that rural patients have difficulty accessing care because of long travel times and a lack of providers. However, there is an ongoing debate over an appropriate population size threshold between rural and urban places [8]. The Census Bureau defines rural areas are sparsely populated areas with fewer than 2,500 people, and urban areas are areas

with more than 2,500 people. Since rurality is a starting point for determining the eligibility for needed medical programs offered through local governments, it is vital to understand the population density threshold corresponding to rurality to align resources with intended beneficiaries.

- • It is well known that the Geographic Information System (GIS) and spatial epidemiology have unique methodological expertise in evaluating geographic data. However, its application in assessing hearing census data has not been thoroughly investigated [7].

Materials and Methods

This study is an attempt to assess the GIS capabilities using publicly available data:

- to visualize hearing health statistics across study area rural-urban population continuum
- to capture spatially oriented patterns of hearing loss variability at the census level
- to analyze hearing health trends related to the study area population density and evaluate if it influences hearing loss
- to compare the identified population density cut-off point, beyond which the hearing outcome is impacted with the threshold for rurality recommended by the Census Bureau
- Study area: Texas. Selected for the following characteristics:
- Texas is the second-largest state in the U.S. by area
- Texas has the second-largest number of individuals with disabilities (12.9% of the population)
- The publicly available data sets used from:
- the U.S. Census Bureau Survey | Program: American Community Survey to represents the population with hearing difficulty in 3 141 counties and county-equivalents in the 50 states and District of Columbia at the county level (CSV & shapefile format) | Years: 2018-2019; 5-year averages to sample larger dataset |

URL: https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html

- Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities, Division of Human Development and Disability to represent the population with hearing difficulty in Texas at the census tracts level | Disability and Health Data System (DHDS) Data (shapefile) | Years: 2018 | URL: https://dhds.cdc.gov
- Centers for Medicare and Medicaid Services (CMS) and Health Resources Services Administration (HRSA) to represent hospital performance data for Medicare-certified hospitals at the county level across the U.S. using the National Hospital Comparison Measure summarizing a variety of metrics across seven areas of quality into a single star rating for each hospital (shapefile) | Years: 2019 | URL: https://data.cms.gov/provider-data/topics/hospitals
- Additional data sources include:
- ESRI | Years: 2018 | URL: https://www.esri.com/en-us/arcgis/products/arcgis-online
- USDA | Rural-Urban Continuum Codes | Informational | 2020 |

URL: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx#.U0VBhleG-Hs

- Projection: Albers | GIS_North_American_1983
- Geospatial association and analysis:
- Hotspot analysis was selected as a spatial analytic and mapping technique to identify statistically significant spatial clusters of high values (hot spots) and low values (cold spots) for the selected set of features, including population and hearing loss on the census level in Texas. Used Getis-Ord Gi* method to create census level hot spot clusters
- Kernel density analysis was selected to calculate a magnitude-hospital count-per-unit area of 100 km
- Weighted overlay analysis is employed to integrate data and optimize visualization of the highest population density, the highest medical capability, and best hearing indicators (or the lowest hearing impairment) (see Map 2)
- Urbanized and rural population descriptive statistics summarized (see Figure 1 & Figure 2)

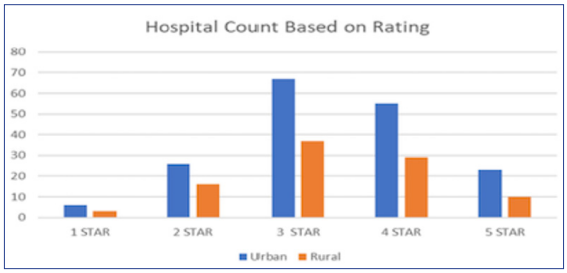


Figure 1: Frequency distribution bar chart of Medicare-certified hospitals across the rural and urban Texas representing their performance according to the U.S. National Hospital Comparison data from 2019

*the horizontal (x) axis corresponds to the total of five levels of the U.S. National Hospital Comparison Measures, positioned in ascending order according to its nominal ranking value ranging from `1 STAR` or underperformers to the best performing `5 STAR recipients

*the vertical (y) axis y depicts the frequency of rated hospitals based on their performance

*geolocation is color-labeled: blue corresponds to urban area & orange represents rural Texas

*the hospitals were rated according to the U.S. National Hospital Comparison Measure, summarizing a variety of metrics across seven areas of quality into a single star

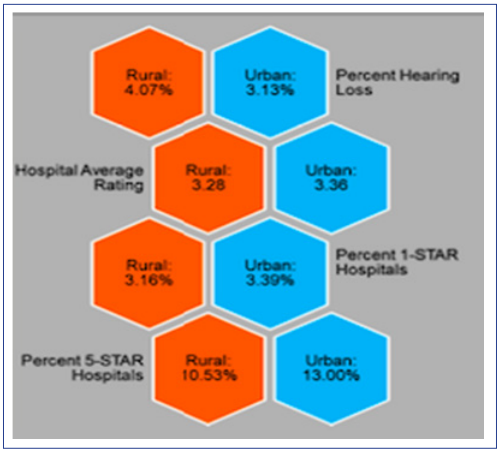


Figure 2: Comparison infographic of hearing statistics and medical capabilities in rural and urban Texas

*geolocation is color-labeled; color blue corresponds to urban area & orange represents rural Texas

*data categories are shown in vertically arranged row-by-row order, starting from top to bottom as following:

`Percent Hearing Loss` depicts the higher hearing impairment in rural areas (4.07% > 3.13%).

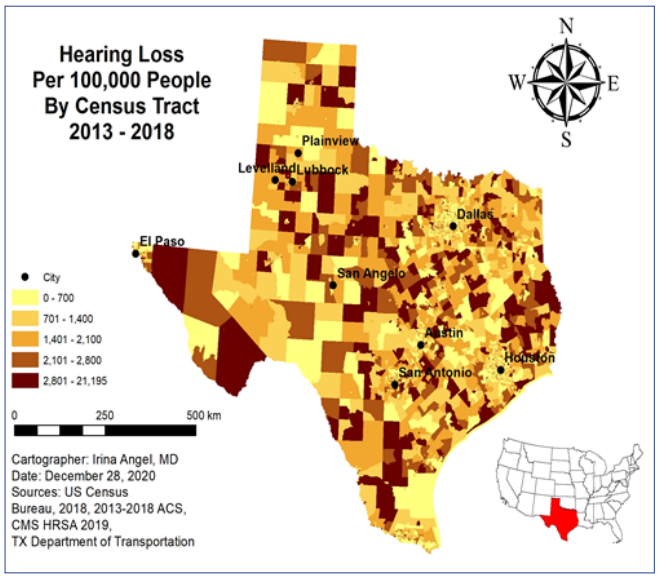
`Average Hospital Rating` depicts a slightly lower hospital average rating in rural areas (3.28% < 3.36%).

`Percent 1-STAR Hospitals` depicts lower 1-Star hospitals in rural

Texas (3.16% < 3.39%).
`Percent 5-STAR Hospitals` depicts lower 5-Star hospitals in rural Texas (10.53% < 13.00%)

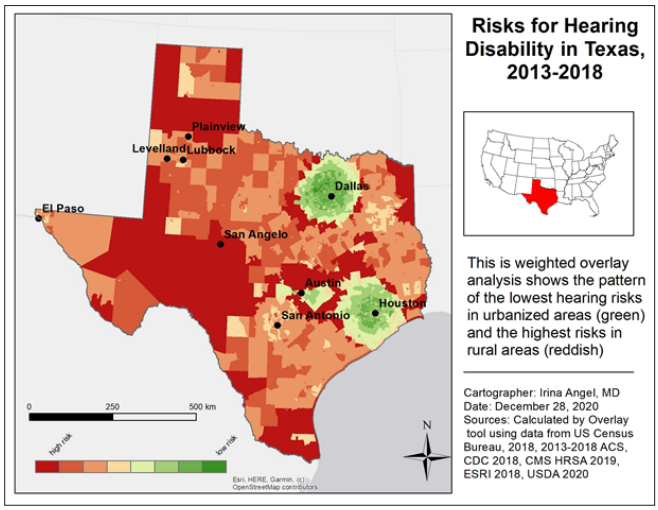
Maps

Map 1: Census Tract level Map of Texas depicts the differences among population affected by hearing loss, expressed as frequency per 100,000 people



* On the county level, there is a trend towards the most significant prevalence of hearing impairment seen in more rural areas; however, there is considerable variation of hearing impairment at the county level, and using census tract is preferred to clarify the pattern of hearing impairment throughout the state of Texas

Map 2: County-level map of Texas illustrates risks for hearing disability using a Weighted Overlay Analysis of multi-modal data



*the highest population density, the highest medical capability, and best hearing indicators (or the lowest hearing impairment) are depicted by color green and seen in urban Texas

*the lowest population density, lowest medical capability, and the worst hearing indicators (or the highest rate for hearing impairment) are depicted by the color red and seen in rural Texas

Results

- At the county level, there is a trend towards the most significant prevalence of hearing impairment in more rural areas
- There are fewer high-quality Medicare-certified hospitals across census tracts in rural Texas (see Figure 1)
- Hotspot spatial analysis of hearing loss data delineates elevated hearing health risks in rural Texas
- Descriptive statistics suggest higher hearing impairment in rural areas (4.07% > 3.13%) with slightly lower hospital average rating in rural areas (3.28% <3.36%) and lower 5-Star hospitals in rural Texas (10.53% < 13.00%) (see Figure 2)
- Overlay analysis shows the pattern of the lowest hearing impairment in urbanized Texas with the best medical capabilities and the highest hearing impairment in most rural Texas with the most deficient medical capabilities (see Map 2)

Discussion

- Using census tract is preferred to clarify the pattern of hearing impairment throughout the state of Texas due to a considerable variation at the county level (see Map 1)
- The Kernel density tool gives a more meaningful interpretation of the value that is attached to the hospital rating, which is easier to appreciate using visualization
- The use of a Weighted Overlay Analysis allowed to integrate multi-criteria data and to map treatment access while analyzing its effect on hearing health among rural Texans (see Map 2)
- Resetting parameters for urbanized versus rural census tract clearly showed the impact of the medical access and quality of care on hearing loss, which is represented by the number of census tracts with a higher share of affected individuals
- Based on study findings, the most rural populations in Texas are at higher risk for hearing loss, which is in agreement with the more extensive literature, suggesting that rural residents tend to receive less care than needed (see Map 2)
- However, rural and urban are multidimensional concepts, making clear-cut distinctions between the two difficult
- Rurality is the crucial allocation factor, but there is no clear-cut distinction between rural and urban. By applying the Census Bureau criteria for urbanized and rural areas, the study population areas between 2,500 and 4,000 will be considered as urban and therefore will not be eligible to receive supplemental health care
- GIS-enabled data visualization approach gives a more meaningful interpretation of an appropriate population size threshold between rural and urban places and providing objective methods to guide funding decisions
- Using data on maps can help state agencies understand the non-medical factors contributing to hearing health outcomes. It can help health advocates engage leadership in determining grant development by demonstrating the need for hearing aid services in medically underserved areas
- As the interface between geographic information, population health, and health care grows, the Geographic Information System becomes an emerging field of increasing importance to support clinical and government operations in healthcare

Conclusion

Despite available GIS and spatial epidemiology methodological expertise in evaluating general census data, its application in assessing hearing census data across rural and urban areas and its benefit in targeting locations in need of hearing health resources have not been thoroughly investigated.

This study assesses the GIS capabilities to capture hearing loss variability across rural-urban Texas and compare the identified population density cut-off point, beyond which the hearing outcome is impacted with the threshold for rurality recommended by the Census Bureau.

Based on findings from applied methods and analysis, the conclusion is that most rural populations in Texas are at higher risk for hearing loss, which is in agreement with the larger literature, suggesting that rural residents tend to receive less health care than needed. However, at present, the large section of the population in need is still not recognized as eligible to receive supplemental health care due to the current threshold between rural and urban places, identified by the Census Bureau.

GIS-enabled data visualization rediscovers an alternative rural-urban cut-off point by identifying missed locations in need of hearing health resources. GIS analytics provides objective methods to guide funding decisions to align health care resources with intended beneficiaries.

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