Optimizing Access to Health Facilities for Under 5 Children: Assessing the Chiefdom with the Longest Average Distance

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Introduction:

The intersection of geospatial data and public health research has become increasingly pivotal in recent years. As researchers and policymakers seek to address complex healthcare challenges, understanding the geographical distribution of health facilities and demographic patterns emerges as a cornerstone for effective planning and resource allocation. Geospatial analysis allows for a nuanced exploration of spatial relationships, offering insights that extend beyond traditional demographic studies. This analysis, often conducted through the lens of geographic information systems (GIS), has the potential to inform evidence-based decision-making and enhance the overall efficiency of healthcare systems[1]. Whether authoratively created or volnteer generated and asserted GIS systems can offer useful insights to assist in systems level descion making[2].

Nations frequently encounter obstacles in the integration of Geographic Information Systems (GIS). African countries, in particular, confront some of these challenges, each with its unique set of issues[3]. GRID3 stands out as an organization actively tackling these challenges across multiple African nations. In addition to generating datasets, such as those utilized in this analysis, GRID3 collaborates with the Ministry of Health (MOH) to enhance capabilities and establish sustainable GIS data practices in Sierra Leone[4]. The data for health centers and population distribution used in this study was sourced from GRID3[5,6].

The objective of the analysis presented here is to embark on a comprehensive geographic exploration, amalgamating third-level administrative geodata[7], health center geodata[5], and population estimates[6]. This multifaceted approach seeks to uncover intricate patterns in health center distribution, population demographics, and accessibility within specific geographical regions. By combining diverse datasets and employing spatial analysis techniques, this study aims to contribute to the growing body of knowledge that leverages geospatial insights for public health enhancement.

Methods

Data Processing

The provided code encompasses a multifaceted data processing pipeline. In the initial phase, the code focuses on data acquisition and processing. Third-level administrative geodata, health center geodata, and georefrenced population estimate data were all obtained for futher analysis. The code leverages the GeoPandas library to manipulate the third-level administrative geodata and health center geodata. Spatial operations were performed to associate health centers with specific districts. The resulting GeoDataFrame captures the count of health centers within each district, contributing to a comprehensive understanding of their distribution.

The population data processing section involves reading data from GeoTIFF files.

This DataFrame encapsulates pixel coordinates as points and their corresponding population values. Age and gender-specific DataFrames are created, eventually merged into a unified GeoDataFrame containing the under-5 population at each georefrenced point. This population count was computed through grouping based on spatial geometry.

Straight line distance was then calculated to every health center for each pixel containing under-5 population count greater than one. The distance to the nearest health center was then stored along with the name of that health center. Geographic coordinates were utilized to determine the proximity.

Visualizaton

The ensuing analysis includes calculating and plotting weighted average distances to the nearest health center per chiefdom. A heat map was generated showing this average distance. A table was also generated displaying the five cheifdoms with the longest average distance. This table also displays relevent values for these calculations.

Spatial analysis and visualization further enhance the insights derived from the data. Population within the chiefdom of Neya wass visualized. Customized maps illustrating the spatial distribution of populatons and health centers within the chiefdom.

Results

Cheifdom Name	Health Center Count	Health Centers per 1000 U5	Avg Distance
Neya	7	1.61009	4.96328
Tambakha	5	0.849532	4.74312
Dodo	3	0.976144	4.40525
Banta Mokele	3	2.31568	4.17774
Mongo	11	2.19072	3.70462

Table 1: This showcases the five districts with the lengthiest average straight-line distance, measured in kilometers. Additionally, it provides relevant data points for calculating this distance, including the number of health centers and their respective counts per 1000 individuals under the age of 5.

The results of our study, as presented in Table 1, highlight the five chiefdoms in Sierra Leone with the most extensive average straight-line distances, measured in kilometers. Notably, Tambakha and Dodo chiefdoms emerge with fewer health centers per 1000 individuals under the age of 5 compared to other districts on the list. Despite Neya chiefdom having a relatively higher count of health centers per 1000 under-fives, it still manages to have the longest average distance among the

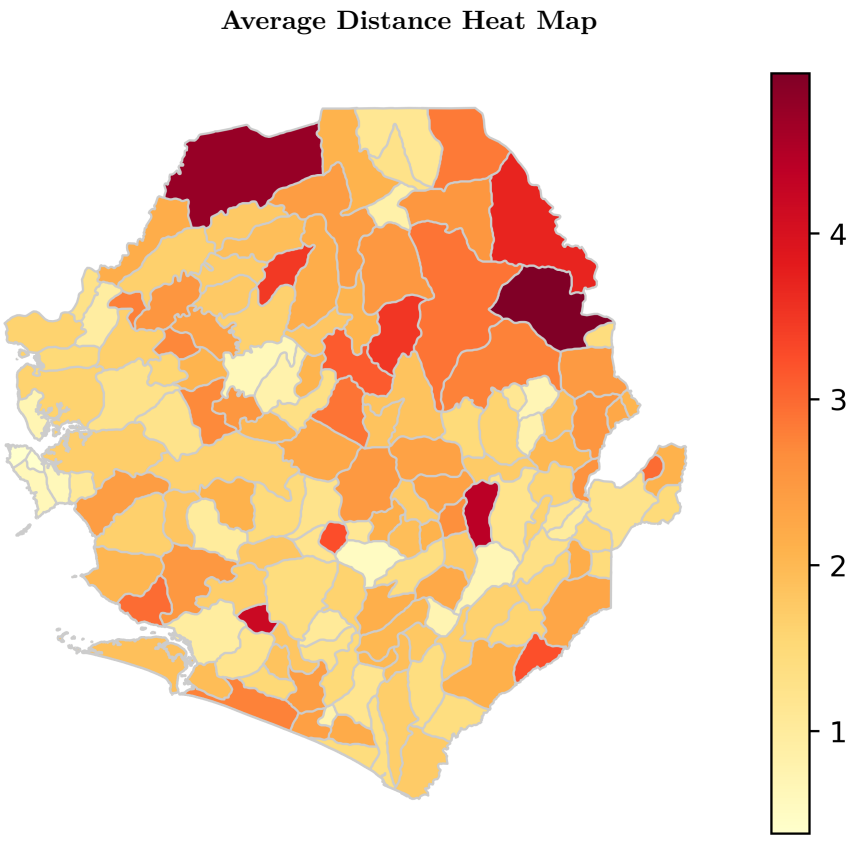

Figure 1: This figure illustrates a heat map displaying the weighted average straight-line distances, measured in kilometers, from various under-5 population centers to the nearest health center in each chiefdom in Sierra Leone.

Health Center and Under 5 Population Distribution in Neya District

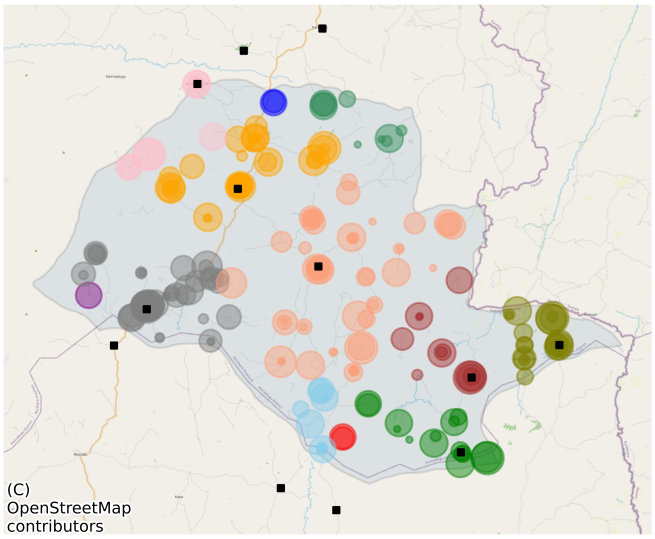

Figure 2: This figure provides a geospatial representation of the distribution of the under-5 population within the Neya district, which has the longest average distance among the districts. It also depicts the distribution of health centers serving the under-5 population within the Neya district.

districts, indicating a interplay between healthcare accessibility and geographical factors.

Figure 1 provides a comprehensive visualization of the weighted average straight-line distances from various under-5 population centers to the nearest health center in each chiefdom across Sierra Leone. The northern regions, particularly Neya chiefdom in the northeast, exhibit a concentration of longer distances, underscoring the geographical disparities in healthcare accessibility.

Zooming in on Neya chiefdom in Figure 2, our geospatial representation reveals a qualitative distribution of the under-5 population, emphasizing the east-central region as having the longest average distances. Additionally, the presence of a main road in the west portion of the chiefdom is notable. While not directly addressed in the quantitative data, this road likely plays a significant role in reducing the actual distances traveled, suggesting that the straight-line distances presented may underestimate the true challenges faced by the population in accessing healthcare.

Conclusion

The amalgamation of table insights and geospatial visualizations provides a nuanced understanding of healthcare accessibility, population distribution, and health center placement within the Neya district. These findings carry implications for strategic public health planning and resource allocation. The key takeaways from the analysis are summarized below.

Healthcare Accessibility: The identification of Neya as having the longest average distance to health centers, reaching approximately 4.96 kilometers, underscores significant challenges in healthcare accessibility for residents in this chiefdom. The subsequent ranking of chiefdoms with longer average distances, including Tambakha, Dodo, Banta Mokele, and Mongo, emphasizes the need for targeted interventions to address geographical disparities in healthcare access[8].

Geospatial Disparities: The heat map in Figure 1 vividly illustrates the spatial distribution of average distances to health centers. The higher density of chiefdoms experiencing longer distances in the northern region signifies a geographical pattern of healthcare disparities. This insight aligns with existing research highlighting the role of geospatial analysis in identifying areas with reduced healthcare accessibility[9]

Population Distribution: Figure 2 provides a geospatial representation of population distribution within the Neya district. The concentration of population in the southern part of the district is a crucial demographic insight. This information is valuable for tailoring healthcare services to areas of higher population density, aligning with principles of equitable resource allocation[10].

Health Center Placement: The distribution of health centers, as depicted in Figure 3, showcases concentrated placements in the northwest and southeast

of the Neya district. This spatial arrangement suggests relatively better access to healthcare facilities for residents in these regions. The identification of such patterns aids in recognizing areas where healthcare infrastructure may require reinforcement to bridge potential gaps[11].

In conclusion, the integration of table insights and geospatial visualizations provides a comprehensive view of the healthcare landscape in the Neya district. The identified disparities in healthcare accessibility and population distribution offer valuable inputs for evidence-based decision-making in public health planning. Addressing these geographic variations is essential to ensuring equitable healthcare services and improving health outcomes for all residents.

Acknowledgments

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