Geospatial Analysis of Health Facility Distribution in Kenya: A County-Level Assessment

Naomi Sang, Grand Valley State University, MI, USA

Abstract— The geographic location of health facilities influences the health acess and health behaviors of individuals in the specific geographic area. Because of this there is a direct relation between health facility distribution and resulting health outcomes. Data visualization plays a key role in the determination of health facility distribution, identification of underserved areas and in informing decision-making on where to establish new health facilities.This paper explores the significance of data visualization in analysing health facility distribution, focusing on its impact on infant mortality rates. By using available data, health organizations can use visualizations to make decisions on where to establish new health facilities as well as what significant health promotion strategies to employ.

Index Terms— Geospatial analysis, Kenya, health facility, distribution, mortality rate, infant mortality rate, county

1 Introduction

Sustainable Development Goal 3 seeks to promote well-being and ensure healthy lives for all and at all ages. According to the World Health Organization [1], this implies a well-functioning health system providing promotive, preventive and curative care. Timely access to health facilities and services is key a factor in determining how well-functioning a health system is as it has a direct impact on health outcomes. The distribution of health facilities in a country, therefore, paints a picture of the health conditions of the country, providing a guide to what services are needed for the different populations. In this paper we will examine the distribution of health facilities in Kenya by analyzing the distribution of health facilities across the countries 47 counties. Using different visualizations, we will determine the distribution and hence identify underserved counties. Merging geographic and infant mortality rate data we will identify counties with poor health facility distribution and high infant mortality rates. We will also identify trends in infant mortality rates to help inform additional health promotion needs. All this will be to help inform decision making on where to establish new health facilities and what health promotion strategies to employ in a bid to reduce infant mortality rates in the areas with the new health facilities.

2 Literature Review

Existing literature in analyzing spatial access and distribution of health facilities have used different visualizations to estimate proportions of populations living near health facilities and interrogate geographical accessibility to health facilities. In a paper by Angela K. Moturi, Laurissa Suiyanka, Eda Mumo, Robert W. Snow. Emelda A. Okiro and Peter M. Macharia, titled “Geographic accessibility to public and private health facilities in Kenya in 2021: An updated geocoded inventory and spatial analysis” the authors use diverse maps to show the spatial variation of infection prevalence, proportion of populations within reach to health facilities and the spatial distribution of health facilities. The authors of the paper "Examining inequalities in spatial access to national health insurance fund contracted facilities in Kenya," Jacob Kazunguu, Angela K. Moturi, Samson Kuhora, Julia Ouko, Mathew Quaife, Justin Nonvignon and Edwine Barasa, use tables to show distribution of NHIF facilities by contract types, heatmaps to show travel times to NHIF contracted facilities and bar charts to visualize average travel times to NHIF contracted facilities.

The use of visualizations to communicate results in their research demonstrates the value of using visualization to communicate results and provide insights for decision-making and influence in healthcare. In this paper we will similarly implement the use of visualizations to identify health facility distributions, identify trends in infant mortality and inform decision making.

3 Target Audience for the Study

This geographic analysis of health facility distribution in Kenya paper is specifically written for Miss Kamul, the Regional Operations Manager of Health International, a Non-Governmental Organization (NGO) that establishes free health centres in developing countries such as Kenya. Miss Kamul is responsible for deciding which counties are ideal for the establishment of twelve new health facilities in 2025. She is also responsible for deciding which health promotion strategies can be employed in these twelve health facilities to ensure improved health outcomes overall.

Additionally, health researchers, community health workers training agencies, the Ministry of Health, county health departments, health NGOs and other health organisations are a suitable target audience for the paper. These individuals and institutions can use data visualization to make data-driven decisions on resource allocation, infrastructure development and the use of alternative forms of care such as mobile clinics and community health workers.

At an individual level, doctors looking to volunteer or dedicate their profession to working with underserved communities can use the visualizations to decide on counties to work in. Citizens looking to relocate or build a home can also look at the health facility distribution visualizations to determine where to purchases land.

4 Visualizations

The visualizations in this paper were created using data extracted from a health facilities dataset publicly available on Energy Data, an innovation of the World Bank Group and from an infant mortality rates dataset publicly available on the Kenya Bureau of Statistics website.

4.1 Current geographic distribution of health facilities in Kenya per county

Using python, the latitude and longitude columns in the health facilities dataset were used to plot a scatterplot showing the distribution of health facilities. The choice to use a scatterplot was informed by its ability to instantly present health facility geographic clusters making it possible to communicate health distribution patterns in the country. This simple visualization is necessary for Miss Kamul’s presentation to the board as it will provide rationale for her final decision while allowing the board members, with limited technical knowledge, to understand the rationale.

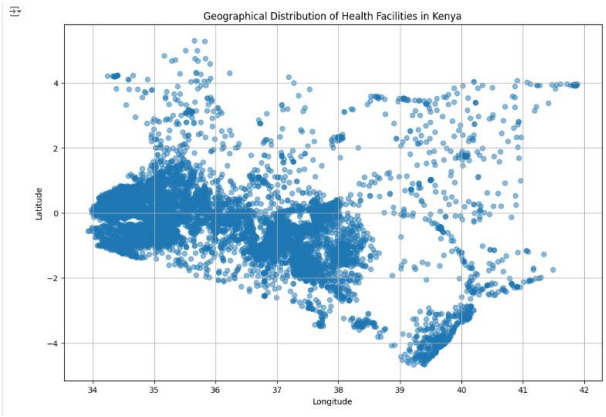

Fig. 1. Geographic distribution of health facilities in Kenya.

A heat map was also employed to visualize the distribution of health facilities. Using different color intensities, the heat map visualization displays the concentration of health facilities in specific regions of the country. The ability to zoom in and out of the heatmap to view finer details such as county and town names on the map informed the choice to plot a heatmap using python.

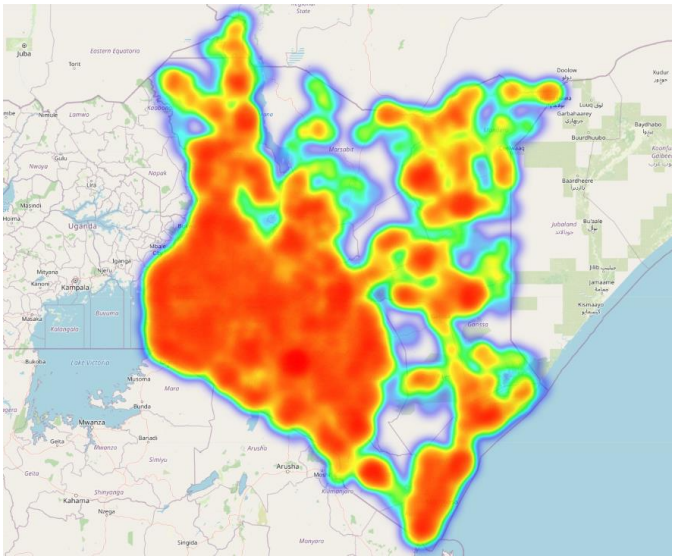

Fig. 2. Heatmap visualization of the geographic distribution of health facilities in Kenya.

Fig. 3. Heatmap zoom in view providing detailed information about the geographic region.

The scatterplot and heatmap visualizations provide the insight that the Northeastern and Southeastern regions of Kenya have the lowest and poorest distribution of health facilities. From this initial visualization Miss Kamul can get a broad idea of the counties she should consider for the establishment of the new health facilities.

4.2 a.) What are the ten counties with the least number of health facilities?

Using the County and Facility columns in the health facilities dataset, we plotted a bar chart highlighting the number of health facilities by county. The count() method in python counted the number of health facilities in each county while the head() method returns only the top ten counties with the least number of health facilities. For ease of interpretation, we sorted the bars in ascending order.

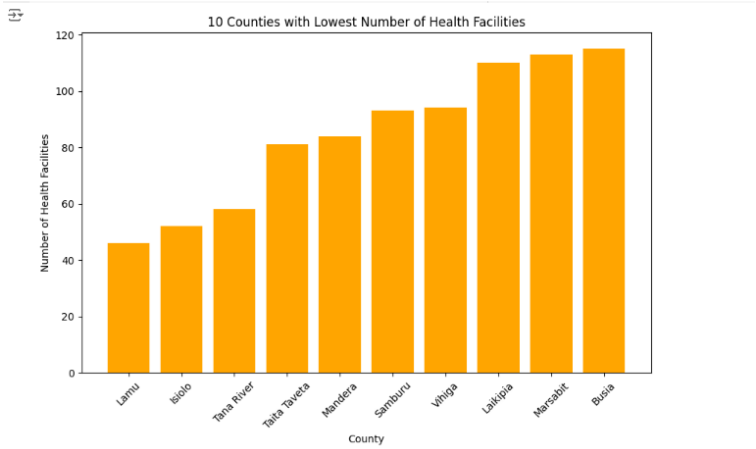

Fig. 4. Bar chart visualization of the ten counties with the lowest number of hospitals in ascending order.

From the bar chart, we can observe that the ten counties with the lowest number of health facilities are all located in the northeastern and southeastern regions of Kenya except for Vihiga and Busia.

4.2 b.) What are the ten counties with the highest mortality rates?

The bar chart in Fig.5 was created by merging the health facilities and infant mortality rate datasets. Using python, we combined the male and female columns in the infant mortality dataset to create an average infant mortality rate per county. This overview combine technique was employed to reduce attributes and produce a more representative visualization. The produced average infant mortality rate and county attributes were plotted to create a bar chart of the top 10 counties with the highest average infant mortality rates.
Unlike the visualization in Fig.4, there is more diversity in the geographic regions of the ten counties plotted in this bar chart. This visualization provides more insights to support Miss Kamul decisions.

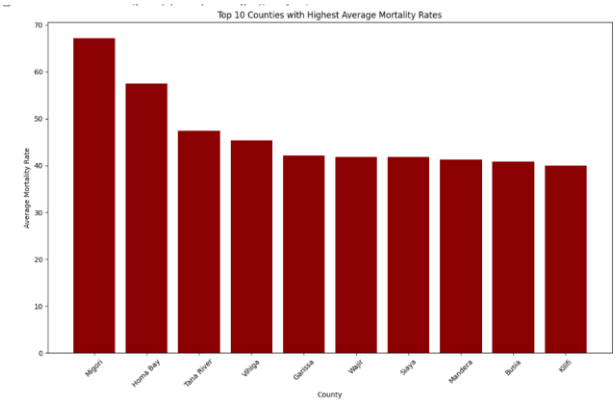

Fig. 5. Bar chart visualization of the ten counties with the highest average infant mortality rates.

Looking at Fig.4 and Fig.5 we can identify Busia, Mandera, Tana River and Vihiga as the four counties with both high infant mortality rates and a low number of health facilities. From this insight, Miss Kamul can plan to build the 12 health facilities in these 4 counties or to increase the number of counties to be visualized and identify more counties with low number of health facilities and high infant mortality rates.

4.3 Comparison of male vs female infant mortality rates per county

Research outcomes from Health International's market research, indicated that culture is a key social factor influencing access to care specifically for female infants as male children in Kenya are thought to be more 'valuable'. From this outcome, Miss Kamul is considering the introduction of a health communication campaign to debunk this stereotype in conjunction with village elders and county health offices.

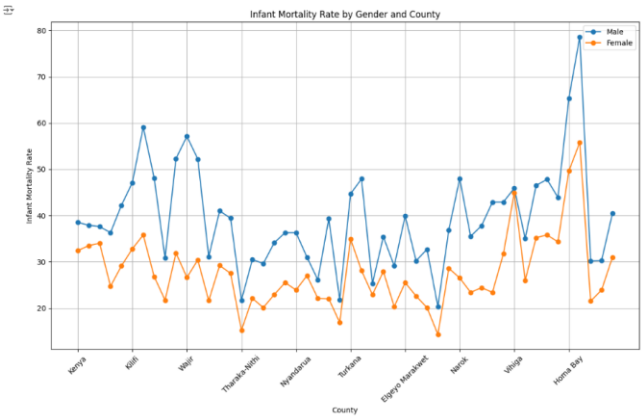

Fig. 6. Line graph visualization of trends in infant mortality rate by gender and county.

Contrary to market research results, the data used reveals that male infants have a higher mortality rate compared to female infants. This insight is crucial in the determination of messages to be designed for the health communication campaign Miss Kamul plans on employing.

This insight can also prompt further research to determine why the existing data contradicts with the market research. Are female infant deaths not reported as much as male infant deaths? Are there other determinants of health, other than culture, affecting the mortality of male infants more than female infants? These are some of the questions that will need to adressed.

5 Discussion

The visualizations created in this paper were created to cater to Miss Kamul hence are easy to follow and insights can be picked within a few seconds. From the bar charts highlighting the counties with low number of health facilities and those with high infant mortality rates, Miss Kamul has the choice to either present Busia, Mandera, Tana River and Vihiga as her four counties of choice or to prompt us to include more counties in the analysis.

The insights picked from the line graph in Fig.6 provide a surprising view on the trends of male vs female infant mortalities. This revelation will lead to questioning of the market research outcomes or may prompt the use of a different data set for verification. Miss Kamul is faced with the decision to continue with her initial health communication campaign but instead of working on messages advocating for girl child health now work on message advocating for male infants.

Two limitations to consider while interpreting the visualizations and making decisions is that overview techniques such as chainsaw and combine were applied to reduce the quantity of data for more interpretable visualizations. The datasets used in this paper, also, are from 2021 and 2017 respectively hence may not be representative of the current state of health facility distribution and infant mortality rates.

Considering the questions that have come up while writing this paper, in the future, we will work on integration of more specific data such as road network and populations dataset to help verify the outcomes yielded from the visualizations above.

6 Conclusion

The integration of geospatial analysis and effective visualizations can lead to individuals and institutions making informed decisions that have huge positive or negative health outcomes on populations. Additionally, if the two are used strategically one can find gaps in their health care systems and identify areas for further study.

Acknowledgments

The author wishes to thank Professor Leidig for his guidance and resourcefulness in the learnings and completion of this project.

References

[1] World Health Organization. AccessMod: geographic access to healthcare.

[2] Kazungu J, Moturi AK, Kuhora S, Ouko J, Quaife M, Nonvignon J, Barasa E. "Examining inequalities in spatial access to national health insurance fund contracted facilities in Kenya." 2024 Int J Equity Health doi: 10.1186/s12939-024-02171-x. PMID: 38637821; PMCID: PMC11027528.

[3] Moturi AK, Suiyanka L, Mumo E, Snow RW, Okiro EA, Macharia PM. "Geographic accessibility to public and private health facilities in Kenya in 2021: An updated geocoded inventory and spatial analysis". 2022 Nov. Front Public Health. doi: 10.3389/fpubh.2022.1002975. PMID: 36407994; PMCID: PMC9670107.