Visual Insights into Public Health: A Case Study of Hospital and ICU Data in Wisconsin

Drew Levin dslevin2@wisc.edu
Connor Eastman ceastman3@wisc.edu
Freddy Boelter fboelter@wisc.edu
Theo Ruzicka tnruzicka@wisc.edu

Abstract

In the evolving field of public health, data visualization serves as a crucial tool for enhancing decision-making and resource allocation. This project focuses on the development of interactive data visualizations tailored to the public health sector in Wisconsin, aiming to address critical issues such as hospital accessibility, ICU bed availability, and disparities in healthcare costs. Utilizing R with packages like ggplot2, Shiny, and tmap, we created three main visualizations: a detailed map displaying hospitals across Wisconsin, an interactive bar chart of ICU bed availability, and a clustered bar chart comparing healthcare payments and charges across different cities. Each visualization incorporates user feedback and theoretical insights from the data visualization literature to improve clarity, usability, and interactivity. The enhancements include adding population density layers to maps, introducing guided views and dynamic features in bar charts, and implementing interactive elements like hover-over effects for data clarity. These visualizations provide public health professionals with powerful tools to analyze complex datasets, thereby facilitating more informed decisions regarding healthcare service provision and policy-making. This report details our design process, from conceptualization to refinement, and discusses the practical applications and potential future developments of our work, emphasizing the role of interactive data visualization in advancing public health analytics.

1. Introduction

In the realm of public health, the efficient and effective visualization of data is not merely a technical exercise but a fundamental component of policy making and resource allocation. With the increasing availability of health-related data, there is a pressing need to transform these vast datasets into actionable insights that can guide public health decisions. This project, undertaken by our team, addresses this need by developing interactive data visualizations specifically designed for public health professionals in Wisconsin.

The primary objective of our initiative is to create visual tools that not only present complex data in an accessible format but also allow users to interact with this information to uncover tailored insights relevant to their specific contexts. This approach is particularly crucial in a diverse state like Wisconsin, where healthcare needs and resources vary significantly across urban and rural areas. Our visualizations focus on three key aspects: hospital distribution and accessibility, intensive care unit (ICU) bed availability, and disparities in health care costs across different regions.

This report unfolds the journey from the initial concept to the refined visualizations presented in Milestone 3. It details the iterative design process influenced by user feedback and grounded in robust data visualization theories. The evolution of our visualizations reflects a deep engagement with both the potential and the challenges of public health data, aiming to provide a synthesis of information that is as informative as it is navigable.

Through this work, we seek to contribute to the broader discourse on public health strategy in Wisconsin, offering tools that enhance the understanding of healthcare landscapes and facilitate the efficient allocation of medical resources. The following sections will describe the theoretical underpinnings of our designs, the specific public health questions each visualization addresses, and the practical implications of our findings.

2. Literature review

2.1 Sources of Inspiration

Our designs draw heavily on the principles established by notable figures in the data visualization field. Key inspirations include:

Edward Tufte: His concept of maximizing the data-ink ratio, from The Visual Display of Quantitative Information, emphasizes eliminating non-essential formatting to focus the viewer's attention on the data itself [Tufte, 2001].
Stephen Few: Few's Information Dashboard Design highlights the importance of effective visual communication through dashboards, guiding our dashboard-like approach to displaying interactive public health data [Few, 2006].

2.2 Approaches from Data Visualization Literature

Interactivity and Engagement: Yi et al. (2007) discuss the role of interaction in enhancing user engagement with data, influencing our incorporation of interactive features like dynamic filtering and detailed tooltips [Yi et al., 2007].
Geospatial Analysis in Public Health: The utility of geospatial visualizations in public health, as discussed by Boulos et al. (2011), underpins our geographic mapping of healthcare resources [Boulos et al., 2011].

3. Designs

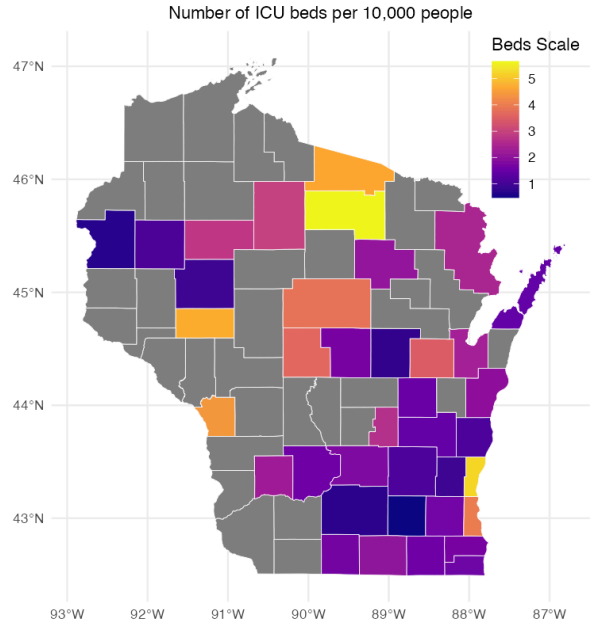
3.1 Interface

3.1.1 Overall Design

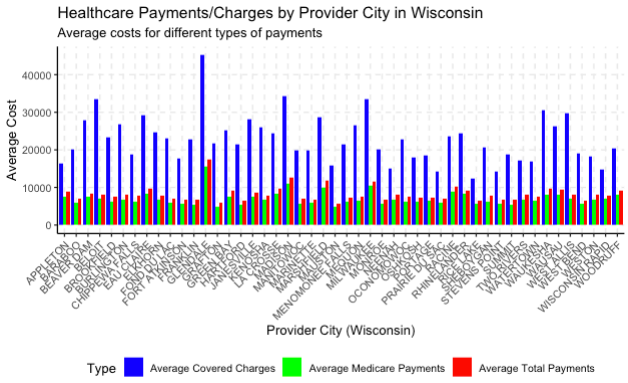
Our interface is designed for ease of use, accommodating both technical and non-technical users. This visualization consists of four different plots organized in an aesthetically pleasing manner to increase readability and visual appeal. Each plot in the visualization is appropriately labeled and separated with headers, separators, and legends boosting comprehensibility of each graph. It first features an interactive map that shows the location of all hospitals in the state of Wisconsin via color-coded markers. Once a hospital marker is clicked, a pop-up appears with information on that hospital such as name, address, city, state, zip code, county, hospital type, and hospital sub category. The next plot is a static bar plot of the average covered charges, average total payments, and average medicare payments for the hospitals in 48 major cities in Wisconsin. This graph also features color coded bars in the graph with each color meaning depicted by a legend below the graph. The x-axis labels each graph chunk representing its respective city. The y-axis labels the count on the average cost. Below the map are two plots side by side. The plot on the left is a static heat map of the total number of ICU beds per 10,000 people in each county in Wisconsin. This visualization features a longitude and latitude coordinate grid in the background to provide better spatial orientation for the viewer. The plot on the right interacts with the above bar graph visual via brush points. When first rendered, the graph defaults to showing the average covered charges, average total payments, and average medicare payments in Appleton, WI . Once a range is selected on the x-axis in the graph above, it plots the average covered charges, average total payments, and average medicare payments for hospitals in the selected cities. This visual plots each of the above features in a bar plot conjointly while color coding each bar for ease of readability. The graph also depicts which each bar represents on the x-axis and the count on the average cost on the y-axis.

3.1.2 Components and Interactivity

Hospital Map: Implemented using tmap, this component allows users to interact with data by clicking on hospitals plotted on the map of Wisconsin, revealing detailed information relevant to public health planning.



ICU Bed Availability: Developed using ggplot2 and tmap, this heatmap visualizes the number of ICU beds per 10,000 people in each county. Counties are color-coded from purple to yellow, with yellow indicating a higher concentration of ICU beds and gray representing counties with no ICU beds. To enhance interactivity, features such as clickable counties that display detailed bed counts and other relevant information could be added.



Healthcare Costs Bar Chart: It features a multi-bar format with each city's average payment costs displayed in three distinct colors—blue for Average Covered Charges, red for Average Total Payments, and green for Average Medicare Payments. This color coding, alongside the clear labeling of both the x-axis (cities) and y-axis (costs), helps differentiate data points easily. To enhance user interaction, elements like hover effects could display precise values and details on demand, clickable bars might reveal deeper insights per city, and filters could adjust

visible data, thereby allowing users to tailor the information display to their needs.

3.1.3 Usage and Findings

Our interactive visualizations have empowered public health professionals to derive critical insights tailored to Wisconsin's diverse healthcare landscape. The map of hospitals has highlighted areas with insufficient medical facilities, enabling targeted improvements in hospital coverage. The ICU bed availability heatmap has been particularly effective for real-time decision-making, identifying counties at risk due to limited critical care resources. Additionally, the bar charts illustrating healthcare costs have provided a clear picture of financial disparities, guiding policy discussions aimed at cost regulation and equity.

Significantly, our tools have facilitated a deeper understanding of regional differences in healthcare access and expenses. For instance, users can easily compare healthcare costs across different cities, spotting trends and anomalies that are vital for fiscal and resource planning. This capability not only enhances immediate strategic decisions but also supports long-term policy development focused on achieving more equitable healthcare provision across the state.

3.2 Synthesis

3.2.1 Visualization Tasks and Designs

Assessing Hospital Accessibility: The geographic data combined with population density metrics helps public health professionals identify underserved areas.

Monitoring ICU Capacity: The dynamic nature of the ICU bed visualization supports real-time decision-making in public health crisis scenarios.

Analyzing Cost Disparities: Insights from the cost analysis visualization inform discussions and policies aimed at addressing healthcare financial inequalities.

Users can perform comparative analyses to spot which cities have higher or lower healthcare costs across different payment types in the Healthcare Costs bar chart. The setup could also facilitate trend identification, where patterns over time or among payment types could be discerned, aiding stakeholders in understanding regional disparities or effects of policy changes.

4. Conclusion

4.1 Key Takeaways

Empowerment through Visualization: The project showcases how sophisticated data visualizations can enhance decision-making capabilities in public health.

Benefits of Interactivity: Interactive features transform static data into a rich, user-driven exploration tool, promoting deeper engagement and understanding.

Public Health Applications: The visualizations are tailored to meet specific challenges in Wisconsin's public health sector, offering models that could be adapted for broader applications.

5. Contribution

Drew Levin coordinated our project's main research question, effectively organizing the writeup into manageable sections for each team member and ensuring that all aspects of the project aligned cohesively with our goal to enhance public health decision-making through interactive data visualizations in Wisconsin. Theo Ruzicka led the development of the interactive map, meticulously selecting and filtering datasets to accurately represent hospitals across Wisconsin. Freddy Boelter focused on the heatmap visualization of ICU bed availability, analyzing data to depict critical healthcare capacities. Connor Eastman not only enhanced the overall user experience and interactivity of the visualizations, integrating dynamic features like hover effects and guided views, but also took charge of the bar graphs that illustrated the average healthcare costs across different regions, ensuring accessibility for both technical and non-technical users. Together, the team collaborated on integrating feedback from professors and peers to refine the visualizations, making them more user-friendly and informative for strategic decision-making in healthcare.

6. References

Stat436 Final Visualization Project. GitHub, GitHub, https://github.com/ceastman3/stat436_final_vis. Accessed 6 May 2024.

Wisconsin Hospital Information. shinyapps.io, shinyapps.io, https://fboelter34.shinyapps.io/stat436_final_vis/. Accessed 6 May 2024.

Tufte, Edward. "The Visual Display of Quantitative Information." Accessed May 6, 2024. https://www.edwardtufte.com/tufte/books_vdqi.

Few, Stephen. "Information Dashboard Design." Accessed May 6, 2024. http://public.magendanz.com/Temp/Information%20Dashboard%20Design.pdf.