Hospital Discharges in Austria: An Interactive Dashboard Creation

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Abstract

This study aims to design and develop an interactive visualization that displays hospital discharge data from the nine Austrian counties. The motivation behind this work lies in the need for accessible, intuitive tools to explore and analyze complex healthcare data, enabling domain experts to identify trends, make comparisons, and support evidence-based decision-making. The visualization seeks to answer two key questions: How can Austrian hospital discharge data be designed as an interactive visualization? And how can the data be communicated effectively through an interactive visualization to support domain experts in gaining an overview of hospital discharge data? To address these questions, several methodologies were employed. The 5 Design Sheet Methodology was utilized to systematically design the dashboard. This approach ensured clarity and effectiveness in representing the data by breaking down the design process into manageable steps. The creation of the dashboard was executed using Tableau, a data visualization tool. The hospital discharge data was sourced from Statistik Austria, together with population data to normalize between different counties. The normalization process was essential to provide a comparison between regions with varying population sizes. The dashboard was subjected to user testing involving four experts in the health domain and two experts in the data visualization domain. Additionally, 19 data visualization students provided feedback through a structured evaluation session. After interacting with the dashboard, experts participating in semi-structured interviews provided feedback on their experience. Overall, the feedback highlighted the dashboard's strength in combining geographic and temporal perspectives and praised the usefulness of interactive features such as dynamic filters and tooltips. Users appreciated the ability to customize the analysis to specific needs, with educators in emergency care using the dashboard to build region-specific training scenarios. Suggestions for improvement included optimizing performance, especially for the horizon plot, and adding advanced filtering options such as demographic breakdowns and co-occurring diagnoses. The designed dashboard displays trends and inter-correlations of various discharge categories from 2001 to 2022 in Austria. To enhance the user experience and facilitate deeper analysis, several interaction techniques were incorporated. Tooltips were implemented to display detailed information about hospital stay durations and patient numbers. Additionally, a map was linked with a bump chart to provide a clear view of each county's data through the years. This linkage allowed users to see geographic trends alongside temporal changes. Horizon charts were also included, with drag-able rows that allowed users to freely discover and compare different disease categories. These interactive features were designed with the aim of helping domain experts gain a comprehensive overview of disease patterns, predict trends, and gain more profound insights from the data. By transforming hospital discharge data into an interactive visualization, the dashboard was designed to make the information more accessible and useful for decision making in the healthcare sector. In conclusion, the combination of the 5 Design Sheet Methodology and semi-structured expert interviews facilitated the creation of an effective and user-friendly interactive visualization of hospital discharge data in Austria. This visualization not only provides a clear overview of historical trends but also empowers healthcare professionals to explore and analyze the data in ways that support informed decision-making.

Keywords

information visualization, dashboard, hospital discharge

1. Introduction

Public health is a crucial field that plays a central role in maintaining and improving the well-being of the population [1]. It relies heavily on the collection, analysis, and application of large volumes of data, which are essential for informed decision-making, optimizing resource allocation, and addressing emerging health challenges [2]. Hospital discharge data are particularly valuable for identifying public

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health trends, assessing the effectiveness of health interventions and understanding the most common diseases, which is also useful for planning the training of healthcare professionals [3]. This data includes key information on patient diagnoses, treatment outcomes and lengths of hospital stays, offering essential insights into the healthcare system. However, the sheer volume and complexity of hospital discharge data pose significant challenges in interpretation, making the use of visualization techniques necessary to support domain experts.

In Austria, hospital discharge data is collected across all nine federal states, reflecting the diverse demographic, geographic and healthcare characteristics of the country. This dataset, spanning from 2001 to 2022, provides a valuable resource for examining long-term trends in disease prevalence, evaluating healthcare delivery effectiveness and identifying regional disparities. The extensive nature of this dataset allows for a detailed analysis of public health dynamics over time and across different regions.

However, traditional visual representations often fall short in conveying the full complexity of such data. For example, column charts like the one used by Statistik Austria[1] (Figure 1) or the similar visualization published for Spanish hospital discharge data by ConSalud.es (Figure 2) provide only a static, high-level summary. While useful for general reporting, these types of charts lack the interactivity and analytical depth needed by healthcare professionals for informed decision-making. They are limited in their ability to reveal temporal patterns, regional disparities, and interrelationships among disease categories. This underscores the need for dynamic visualization tools that go beyond static summaries, enabling users to explore and interact with the data to uncover deeper insights.

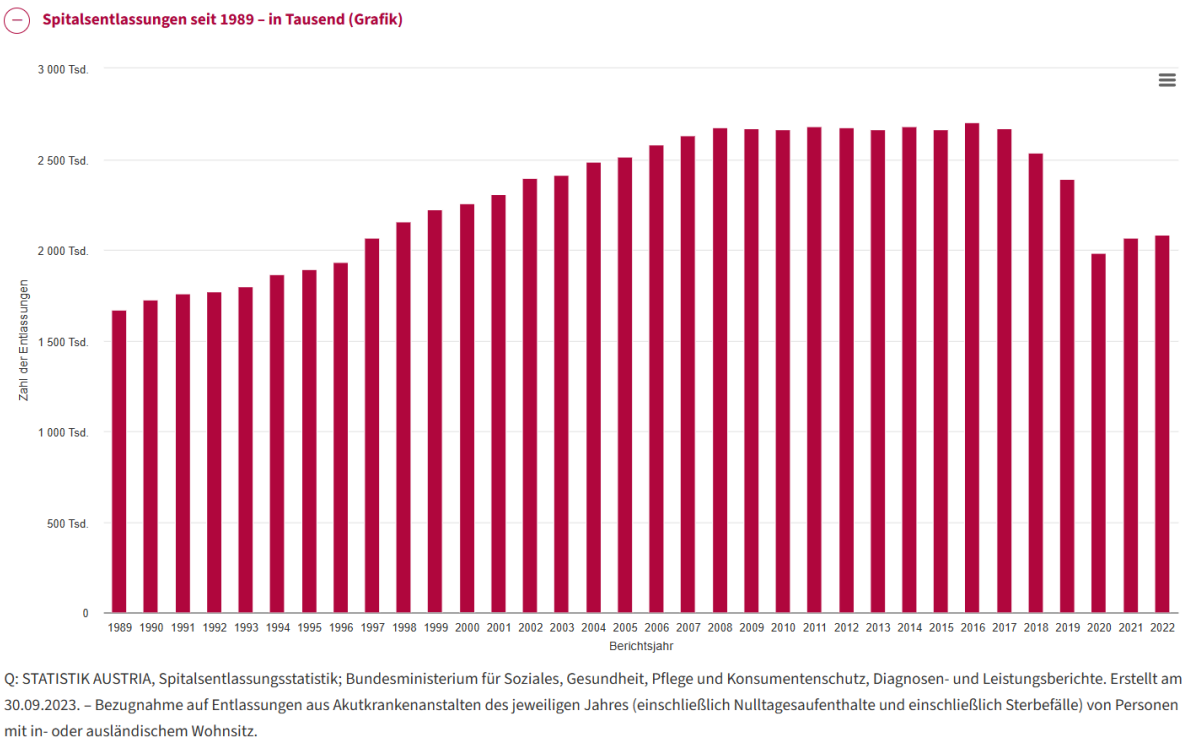

Figure 1: Column chart of the Austrian hospital discharges from 1989 to 2022 by STATISTICS AUSTRIA [4]

This study aims to tackle these challenges by designing and implementing an interactive dashboard tailored to the specific needs of health professionals. The main goal of the dashboard is to provide a dynamic visualization for exploring healthcare trends, facilitating detailed analysis of specific diseases and healthcare indicators, as well as enabling comparisons across different regions and time periods. By combining data visualization techniques with interactivity, the dashboard aims to help users navigate

[1]While the visualization from Statistik Austria (Figure 1) displays data from 1989 onward, the publicly accessible dataset used in this study only covers the years 2001 to 2022. The reason for this discrepancy is not documented in the publicly available sources.

Figure 2: Column chart of the Spanish hospital discharges from 2013 to 2022 by ConSalud.es [5]

through the hospital discharge data with greater ease and accuracy. This tool is not only intended to improve decision-making but also to be a key resource for planing the training of health students, like when planning example scenarios for practicing.

This work is driven by two central research questions:

1. How can Austrian hospital discharge data be designed as an interactive visualization?
2. And how can the data be communicated effectively through an interactive visualization to support domain experts in gaining an overview of hospital discharge data?

To address these questions and create a suitable visualization, a platform for creating interactive data visualizations, called Tableau, was used. It was selected for its versatility and user-friendly interface, which allows the creation of sophisticated visual representations of complex datasets [6]. The dashboard development follows the 5 Design Sheet Methodology, which is a structured and iterative approach that focuses on clarity, usability, and functionality in the design of interactive visualizations [7]. This methodology ensures the final dashboard meets the practical needs of its intended users while adhering to the best practices in design and data visualization.

The interactive dashboard includes several features designed to enhance its utility and effectiveness. It provides an overview of key healthcare trends at the national level, offering a snapshot of Austria's healthcare landscape. At the same time, users can drill down into specific conditions and diseases, allowing for in-depth analysis. The dashboard enables users to explore variations in disease prevalence, healthcare utilization, and other important metrics across Austria's nine counties, while also examining trends over different time periods. This functionality provides a comprehensive understanding of regional and temporal disparities in healthcare outcomes. Additionally, interactive elements such as filters, tooltips and dynamic comparisons between diseases improve the user experience, enabling users to tailor their exploration of the data according to their specific needs and interests, making it easier to uncover key insights.

The insights generated by this interactive dashboard have the potential to inform a wide range of public health applications. For example, they could be used to identify emerging disease hotspots, assess the impact of public health interventions or monitor the long-term effects of healthcare policy changes. By turning complex and large datasets into actionable knowledge, this study contributes to the broader goal of using data-driven tools to improve public health outcomes. It highlights the crucial role of innovative data visualization strategies in unlocking the potential of complex datasets, enabling public health professionals to make more informed decisions that can improve the health and well-being of populations. By focusing on interactivity and clarity, this study also emphasizes the importance of creating tools that are not only data-rich but also user-centric, ensuring that health domain experts have suitable tools to explore the existing data effectively.

2. Methodology

The development of this visualization followed a structured process, involving key stages such as data collection, design methodology, implementation and evaluation. Each phase was carefully planned to ensure that the final product not only met the needs of its intended users but also aligned with overarching goals of accessibility, functionality and relevance to public health analysis. By focusing on a user-centered approach, the process aimed to create a tool that would be both practical and insightful, helping health professionals navigate complex data effectively.

2.1. Data Collection and Characteristics

The dataset for this study was sourced from Statistik Austria, the national statistical office, which provides comprehensive healthcare data collected from hospitals across Austria. The data spans from 2001 to 2022 and includes detailed records of hospital discharges across all nine counties. It contains key information such as disease categories, the number of discharged patients and the total days spent in hospitals[8].

To enable more meaningful regional comparisons, population data for each county was also obtained from Statistik Austria. This data was important for adjusting the raw patient numbers, ensuring that comparisons between counties with different population sizes were fair and accurate. By calculating the number of patients per 10,000 people, a standardized measure of healthcare use was created. This helped provide a more balanced view of regional healthcare differences and prevented biases that could result from uneven population distributions.

The diseases were categorized using the International Statistical Classification of Diseases and Related Health Problems (ICD-11), developed by the World Health Organization (WHO). This system is widely used to organize and code a large variety of diseases and health problems, making it easier to analyze and compare data. The hospital discharge dataset by Statistik Austria includes a wide range of diseases, which is why the ICD-11 system helps group them in a clear and consistent way. The ICD-11 codes were used to create categories that form the basis of the bump chart, which shows how these categories compare or change over time. This makes it easier to see patterns or trends in the data. For more detailed information, the horizon plot breaks down the diseases within each category, giving a closer look at the individual conditions. Using the ICD-11 system ensures that the analysis follows a standard recognized worldwide. This makes the results easier to understand while keeping the data organized and reliable [9].

The dataset is multivariate, combining categorical data like disease categories, quantitative data like patient numbers, spatial data like county locations, and temporal data like annual records. The diversity of data types presented a challenge for visualization, as it was important to represent all aspects of the data comprehensively and in a user-friendly manner. Ensuring the accuracy and completeness of the data was also critical, as the reliability of insights derived from the dashboard directly depended on the integrity of the dataset.

2.2. Design Methodology

The dashboard design followed the 5 Design Sheet Methodology, a structured and iterative approach that emphasizes clarity, usability, and functionality in the creation of interactive visualizations [7]. This methodology divides the design process into five stages: ideation, concept sketching, refinement, prototyping, and implementation. Each stage contributed to shaping a visualization tool tailored to the needs of health professionals.

The first stage, ideation, involved brainstorming visualization strategies to represent the dataset's complexity. As part of this phase, a nurse, a paramedic, and two EMTs were consulted to gather qualitative insights into their professional needs, use cases, and typical challenges when working with healthcare data. This interaction was conducted in semi-structured interviews, focusing on what information they frequently need, how they compare trends across regions or diseases, and where

current reporting tools fall short. Their input helped define key functional goals for the dashboard, such as the ability to identify frequent diseases, track regional differences and support the ideation of educational training examples.

The concept sketching stage focused on translating the ideation outcomes into visual form. The team created layout sketches exploring different visual approaches and interactions methods (see Figure 3). These sketches were presented to two data visualization researchers and a group of 19 data visualization students in a class setting. Their structured feedback focused on clarity, usability and interaction design. This feedback directly influenced the refinement stage, where sketches were adjusted based on clarity of layout, labeling and user flow.

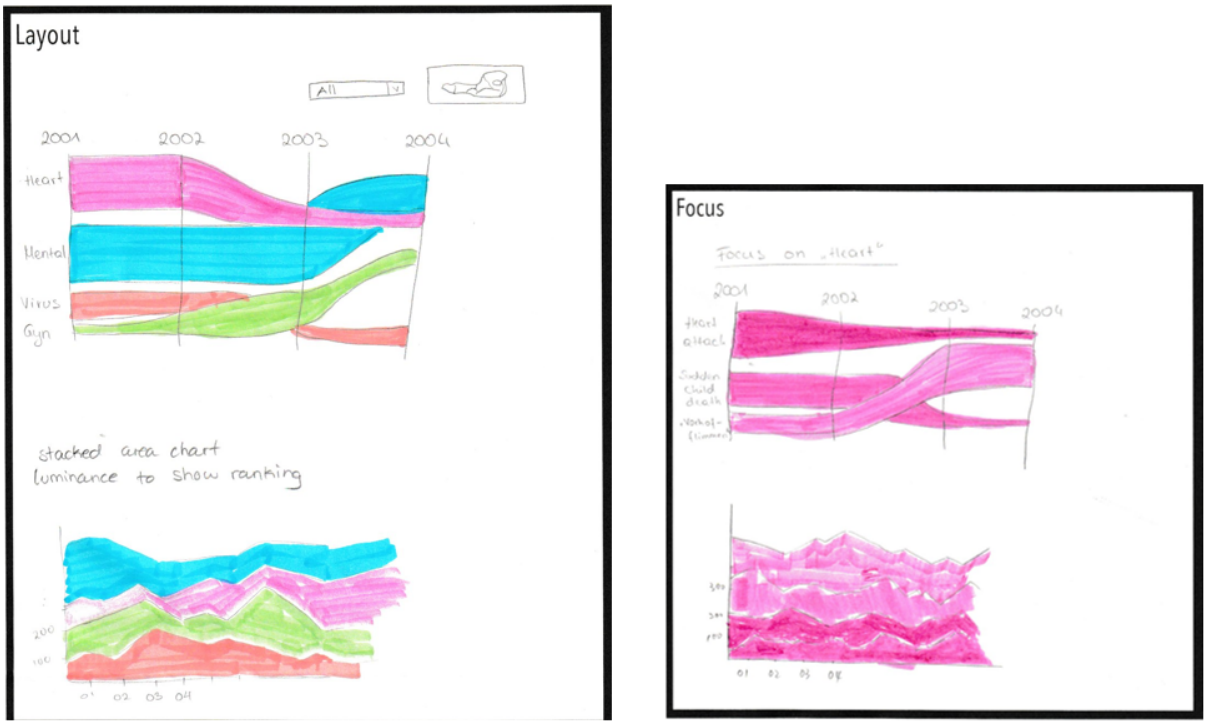

Figure 3: Hand-drawn draft of the 5-Design-Sheet-Method, showing the first ideas of a bump chart and stacked area chart [7].

The prototyping stage involved creating a functional mockup of the dashboard using sample data to test the layout and individual visualization components. This phase was essential for identifying potential issues such as cluttered designs, unclear visual encodings, or confusing dashboard elements. By testing and refining the design iteratively, it was ensured that the final product was both user-friendly and functional [10]. The implementation stage involved developing the dashboard in Tableau, a powerful platform for creating interactive data visualizations. The capabilities of Tableau allowed for the seamless integration of various visualization techniques and interactivity features.

2.3. Visualization Techniques

The dashboard integrates several carefully selected visualization techniques to effectively represent the diverse characteristics of the hospital discharge dataset. The final choices were guided by an iterative evaluation process involving feedback from data visualization experts and 19 students. During early prototyping stages, alternative visualizations such as stacked area charts, line charts and treemaps were explored. However, they were found to either obscure detailed trends, overwhelm the viewer when displaying many categories, or lack sufficient interactivity.

A key component chosen through this process is the bump chart, which provides a temporal view of changes in disease rankings over time. Inspired by the work of Tai et al. (2023) on leading causes of death [11], the bump chart was favored over stacked area charts because it clearly conveys rank

changes and comparative trends without becoming visually cluttered. The line widths in the bump chart represent the number of discharges, while their vertical position reflects the rank of each disease category, helping users easily spot shifts in prevalence.

The choropleth map is another essential component, offering a spatial view of healthcare utilization and disease distribution across Austria. By normalizing patient numbers based on population size, the map enables meaningful comparisons between regions with different population densities. The map is fully interactive, allowing users to hover over counties for additional details or apply filters to view specific subsets of the data.

The horizon plot was included as a supplementary visualization to provide a detailed temporal analysis of specific diseases within a selected category. Its layered design allows for comparing multiple variables within a compact visual space, making it easier for users to track trends and perform comparisons. Interactivity was a primary focus throughout the design process. Dynamic filters, tooltips, and draggable elements were implemented to enhance user engagement and customization. These features allow users to tailor their data exploration, focusing on specific diseases, regions, or time periods of interest.

2.4. Evaluation and Feedback

The dashboard was shown to four health domain experts (nurse, paramedic, two EMTs), two data visualization researchers and 19 data visualization students to assess its usability, functionality, and effectiveness. This evaluation involved semi-structured interviews and thinking aloud while using the dashboard with the domain experts and researchers. A focus group was conducted with the students while presenting them the dashboard. These interviews aimed to gather feedback on the dashboard's performance, particularly regarding design, interactivity, and the clarity of insights provided [12, 13, 14].

3. Results

The completed dashboard integrates three main components: a bump chart, a choropleth map, and a horizon plot. Together, these components provide a comprehensive and interactive tool for exploring hospital discharge data, meeting the diverse needs of health domain professionals. Each component was carefully selected and designed to balance usability, analytical depth, and visual appeal, ensuring users can navigate through the dataset with ease.

3.1. Visualization

The bump chart, seen in Figure 4, is a key feature of the dashboard, visualizing temporal trends and changes in the rankings of various disease categories over time. This component helps users intuitively understand how healthcare demands have evolved from 2001 to 2022. For example, the bump chart reveals a steady increase in diseases of the eye and adnexa (pink line), indicating growing healthcare demands in ophthalmology. Such trends are vital for forecasting resource needs and planning targeted interventions. Furthermore, the interactive features, like a tooltip and the filter options of the chart allows users to focus on specific time periods or disease categories, enhancing its value for customized analysis. Users can detect emerging patterns, such as assessing the impact of policy changes on healthcare utilization.

The choropleth map, also seen in Figure 4, adds a spatial view to the analysis, highlighting regional differences between the nine Austrian counties. This feature helps users identify geographic hotspots where certain conditions are more common, such as higher rates of cardiovascular diseases in specific counties. By normalizing the data according to population size, the map ensures fair comparisons across regions with differing demographics. The choropleth map is particularly useful for regional planning, enabling resource allocation and addressing disparities. The map's interactivity further enhances its utility, allowing users to apply filters and examine temporal shifts in spatial patterns.

The dashboard offers a set of filter options, seen in Figure 4, that allow users to dynamically adjust all visualizations simultaneously, ensuring a consistent and focused analysis experience. Users can filter by

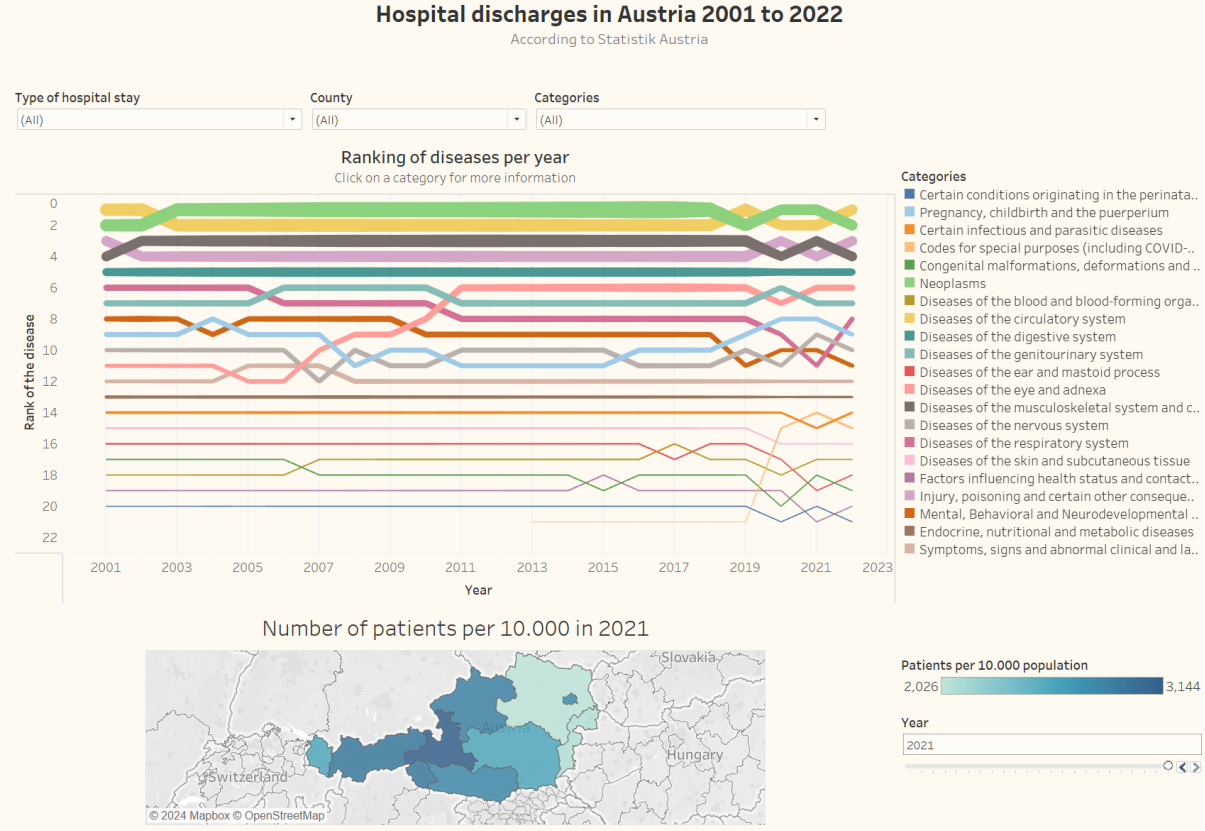

Figure 4: The main view of the dashboard, showing the bump chart and choropleth map.

"type of hospital stay," such as long-term care, acute care or other categories, to analyze how different types of hospitalizations impact healthcare trends across Austria. Additionally, the filter for "county" allows users to select from all nine Austrian counties, making it possible to compare healthcare trends between different regions. Users can also filter by "categories," selecting one or more disease categories to view in the visualizations, which enables more targeted analysis based on specific health conditions.

In terms of interactivity, when a user clicks on a county in the choropleth map, the bump chart is automatically updated to show the relevant disease categories and trends for that specific region. This interactive filtering ensures that users can explore the data from different perspectives, whether they are interested in regional patterns or specific disease trends, and allows for a more in-depth and personalized exploration of healthcare data across Austria.

When a user clicks on a disease in the bump chart, a subpage opens that displays a horizon plot for a more detailed temporal analysis of the selected disease category. This plot includes all subcategories within the chosen ICD-11 classification, such as various forms of neoplasms or infectious diseases. Its compact, layered design enables users to spot temporal trends, anomalies, or spikes in healthcare utilization that may not be visible in more aggregated views. For example, a sudden rise in septicaemia cases in specific regions becomes evident through this visualization, which could signal changes in diagnostic practices or emerging public health issues. An example of this visualization is shown in Figure 5, which displays trends within the neoplasms category.

The horizon plot also supports comparative analysis, allowing users to examine multiple diseases side-by-side within the same category. A key feature is the drag-and-drop functionality, which lets users reorder disease rows to better suit their investigative needs. This personalization makes it easier to detect correlations, assess disease burden over time, and understand the broader context of a specific condition. Together, these capabilities make the horizon plot a powerful tool for uncovering detailed and category-specific healthcare insights.

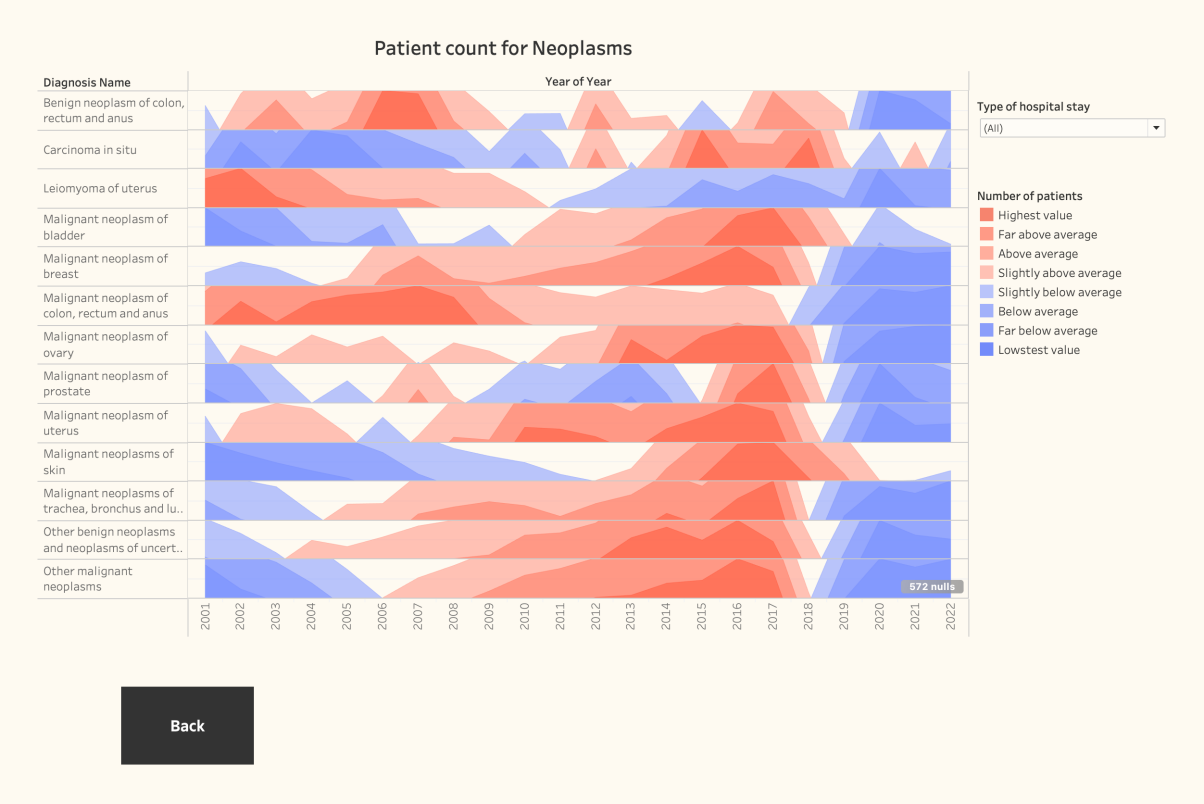

Figure 5: Horzion plot view of the category "Neoplasms".

The tooltip seen in Figure 6, which displays patient numbers over time when hovering over the horizon plot, adheres to Shneiderman's Mantra of "Overview first, zoom and filter, then details-on-demand" [15]. This mantra emphasizes the importance of providing users with a broad overview of the data, followed by the ability to explore the data through zooming or filtering, and finally offering detailed information only when requested. In this case, the tooltip provides the "details-on-demand" by showing patient numbers at a specific point in time when hovering over the horizon plot, allowing users to access granular data without cluttering the main visualization. This approach enhances the user experience by maintaining a clean overview while offering the ability to explore specific data points, ensuring that the tool remains both intuitive and informative.

3.2. Feedback

Feedback from the same four health domain experts (nurse, paramedic, two EMTs) showed that the dashboard effectively met its goal of offering both high-level overviews and detailed analyses of the data. Experts appreciated how the dashboard combined geographic and temporal views, which provided a well-rounded understanding of healthcare trends. This approach allowed users to see patterns and changes across different regions and time periods, making it easier to spot key trends and issues. Participants also highlighted the value of the interactive features, such as dynamic filters and on-demand details, which allowed users to adjust the analysis to fit their specific needs. These features provided a more flexible and personalized experience, enabling users to explore the data in ways that were most relevant to them. For instance, educators in the ambulance field found the tool particularly helpful when planning training scenarios. They could use the dashboard to create patient examples based on the most common diseases in their region, making the practice more realistic and useful for their students. Healthcare professionals also mentioned that being able to dive into the data and focus on particular disease categories, time periods, or regions helped them better understand local healthcare trends. This feature added even more value to the dashboard, making it a useful tool for both broad

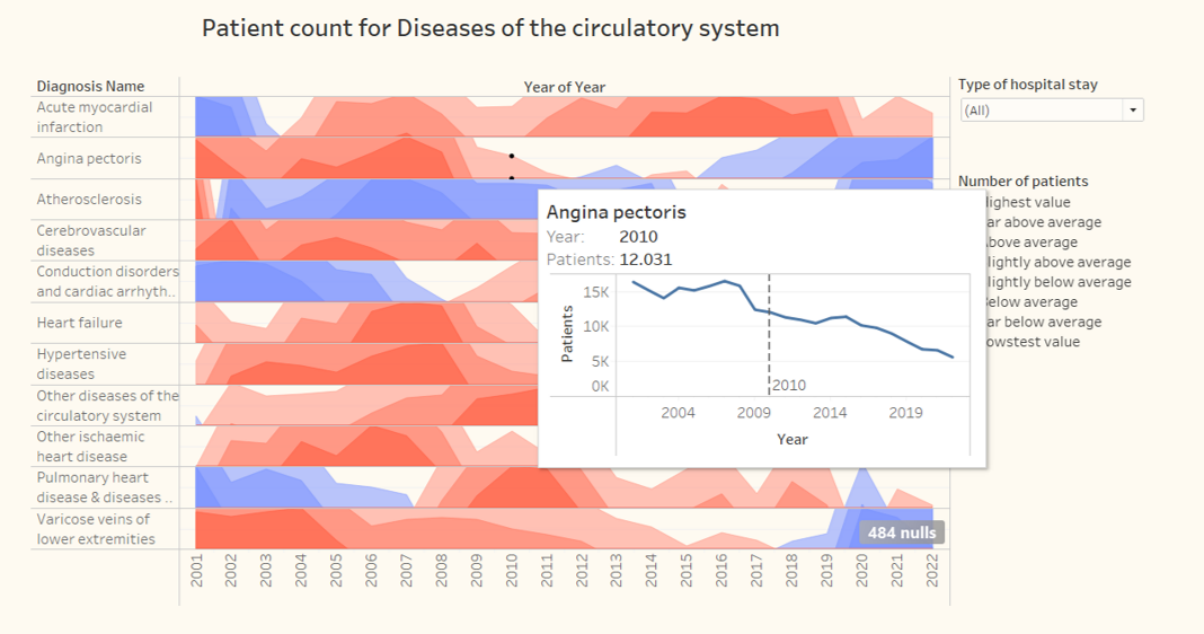

Figure 6: Example of the tooltip in the horizon plot, giving more detailed information about the development of patient numbers over time.

overviews and detailed data analysis.

Despite its strengths, the dashboard revealed some limitations during the evaluation process. Performance issues were noted when loading the horizon plot. Additionally, domain experts expressed a desire for more advanced filtering options, such as the ability to explore co-occurring diagnoses or filtering data by demographic factors like age and gender. Addressing these limitations in future iterations will improve the dashboard's functionality.

Overall, the completed dashboard represents an advancement in visualizing hospital discharge data. By combining temporal, spatial, and categorical perspectives, it empowers health domain professionals to uncover insights into Austria's hospital discharges. The iterative development process, guided by expert feedback, ensures that the tool remains user-centered and adaptable to the evolving needs of the users. Future enhancements, including addressing performance issues and incorporating additional analytical features, will further strengthen the dashboard's usability.

4. Discussion

The dashboard addresses the challenges of visualizing complex healthcare data by offering a user-friendly tool that integrates multiple perspectives. Through its combination of temporal, spatial, and categorical views, users can uncover trends and anomalies that static representations might obscure. The coordinated use of visualization techniques such as bump charts, choropleth maps, and horizon plots enables both broad and detailed data exploration.

However, the project faced several limitations. One significant issue is the absence of hospital-specific data, such as hospital locations or patient travel patterns. This restricts the accuracy of regional analyses, particularly when patients seek treatment outside their home counties. For instance, patients near regional borders may utilize facilities in neighboring areas, skewing local healthcare utilization statistics. Including such data would improve the dashboard's ability to reflect real-world dynamics. The COVID-19 years in the dataset introduced additional complexity. Disruptions such as postponed elective procedures and altered diagnostic behaviors during the pandemic led to anomalies that deviate from typical healthcare trends. These disruptions are evident in visualizations like Figure 5, where early cancer diagnoses drop sharply due to delays in medical visits [16]. Future enhancements could include filters or annotations to help users contextualize these outliers. Performance was another challenge, occasionally

affecting responsiveness. Optimizing data processing and visualization rendering is necessary to ensure smooth interactions, particularly as the dataset grows.

Despite these challenges, feedback from domain experts confirms the dashboard's value. Its interactivity and clarity allow users to tailor analyses to their specific needs, making it a practical tool for public health professionals, educators, and analysts.

4.1. Future Work

Future development will address the current limitations, focusing on deeper analysis and broader applicability. This includes adding data on hospital locations, patient mobility, and regional health outcomes to support granular investigations. For example, visualizing patient travel distances could reveal access barriers or underserved regions. Performance optimization will be another priority. This could involve transitioning to more powerful platforms, such as Tableau or custom-built solutions, and implementing pre-visualization data filtering to reduce lag. These improvements aim to enhance usability and support more complex visual queries. Additional user evaluations will be conducted to expand the feedback base. By involving healthcare practitioners, policymakers, and administrators, future iterations can better accommodate diverse needs. Specific enhancements may include advanced filtering, improved navigation, and predictive tools such as trend forecasting, which would help users plan interventions and allocate resources more effectively. Finally, addressing anomalies, like those caused by the COVID-19 pandemic, will be important. Developing mechanisms to detect and flag unusual data trends could help users distinguish between short-term disruptions and long-term patterns.

5. Conclusion

This study demonstrates how interactive visualization can bridge the gap between raw data and actionable public health insights. By integrating diverse views and prioritizing user interactivity, the dashboard supports a range of analyses, from national overviews to disease-specific investigations. Tools like dynamic filtering and coordinated subviews empower users to explore hospital discharge data meaningfully and intuitively. The design approach, grounded in the 5 Design Sheet Methodology and refined through expert feedback, ensures that the dashboard remains accessible to both technical and non-technical users. Its potential applications span education, resource allocation, and trend monitoring, showcasing how thoughtful visual design can support real-world decision-making.

With future expansions, like additional data sources and predictive analytics, the dashboard could become a comprehensive resource for ongoing public health analysis. The underlying methodology can also inform similar efforts in other domains, such as environmental monitoring or economic planning.

5.1. RQ1: How can Austrian hospital discharge data be designed as an interactive visualization?

The interactive dashboard effectively presents Austrian hospital discharge data by combining temporal, spatial and categorical perspectives. Design features such as dynamic filters, coordinated views and tooltips allow users to explore data in a tailored and intuitive manner. This enables both high-level overviews and focused analysis, helping users gain targeted insights without overwhelming them. The visual structure empowers domain experts to identify regional disparities, track disease patterns and perform comparative analyses across multiple dimensions.

5.2. RQ2: How can the data be communicated effectively through an interactive visualization to support domain experts in gaining an overview of hospital discharge data?

Effectiveness in this context refers to how well the visualization communicates complex information in an accessible manner, supporting comprehension and decision-making without requiring specialized

technical knowledge. While the perception of effectiveness can vary depending on the context and the needs of individual users, feedback from domain experts suggests that the dashboard meets this goal. The clean design, interactive elements, and coordinated views enable domain experts to quickly filter and isolate trends based on disease, region, or time, making it easier to focus their analysis on specific areas of interest. The dashboard has been particularly useful in various applications, such as helping educators design realistic training scenarios and allowing healthcare professionals to identify emerging health issues. Based on user feedback and its relevance to key tasks, the dashboard effectively supports informed analysis and communication of healthcare data.

Summary

Interactive visualizations are key to making complex healthcare data more accessible and actionable. This dashboard showcases how combining multiple views with interactivity can turn raw discharge data into a valuable analysis tool. While challenges such as missing data and performance issues persist, the current version establishes a solid foundation. Future enhancements and further evaluations will refine the tool and broaden its application in public health.

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