LGJDX ISSN No: 1008-0562 Journal Of Liaoning Technical University Natural Science Edition

EXPLORING THE ROLE OF DATA VISUALISATION TOOLS AS AN AID FOR DECISION-MAKING IN THE HEALTHCARE SECTOR

[1]Rashidat Ayanbanke BUSARI & [2]Taofiki Adekola SANNI

[1]36 Union, Terrace Aberdeen. United Kingdom, Ab 10 1NN
[2]Department of Agricultural Economics,
Faculty of Agriculture,
University of Abuja, Nigeria.
Correspondence author: Email address: raahidatbusaei01@gmail.com

Abstract
In the era of data-driven healthcare, the vast and complex datasets generated by electronic health records, medical devices, and administrative systems pose significant challenges to decision-making. Data visualization tools, such as Power BI and Tableau, enable healthcare professionals to simplify and interpret these datasets, facilitating data-driven decisions and improving patient outcomes. This study evaluates the effectiveness of these tools in analyzing key metrics, including bed occupancy rates, emergency department utilization, and demographic distributions. Adopting a mixed-methods approach, the study integrates quantitative analysis of datasets from the Scottish Health and Social Care Open Database with qualitative insights to assess their application in decision-making. Results reveal that Power BI excels in providing broad overviews and temporal trends, while Tableau offers detailed demographic and location-specific insights. Both tools enhance decision-making by identifying trends and optimizing resource allocation. However, their effectiveness depends on data quality, user training, and addressing ethical concerns such as data privacy. The integration of advanced technologies like AI with visualization tools presents opportunities for predictive analytics, enabling proactive interventions. The study underscores the transformative potential of these tools in improving healthcare outcomes and optimizing resource utilization. The study recommended investing in training programs to enhance data literacy among healthcare professionals, fostering a data-driven decision-making culture, and exploring patient-centric visualization tools. These actions will unlock the full potential of data visualization in transforming healthcare outcomes and optimizing resource utilization.

Keywords: Data visualization, healthcare decision-making, Power BI, Tableau, resource optimization

Introduction

Healthcare systems generate vast amounts of data as a result of technological from various sources, including electronic health records (EHRs), medical devices, administrative systems, and research projects (Maktoubian and Ansari, 2019). However, the volume and complexity of this data often hinder its utility in decision-making**.** It is difficult for healthcare workers to gather and analyze the information properly because of the volume and complexity of the healthcare data (Sebastian and Peter, 2022). Traditional manual analysis and data processing techniques are

frequently time-consuming, prone to mistakes, and unable to handle the enormous volume of data produced in the healthcare industry (Roy et al., 2022). In today's data-driven world, decision-making in healthcare is increasingly reliant on the ability to analyze and interpret complex datasets. As noted by Dang et al (2020), decision-making is crucial in today's healthcare environment for providing high-quality care, optimizing resource allocation, and ultimately improving patient outcomes.

The enormous amount of data can be used by healthcare professionals to their advantage by using data visualisation tools (Wang et al., 2018). These tools make it possible to identify patterns, trends, and correlations that may not be obvious when using traditional data analysis techniques (Brown-Liburd et al., 2015). By visualizing the data, healthcare workers can immediately understand the most important facts, spot abnormalities or outliers, and quickly come to data-driven decisions (Sarker, 2021). By using visual components like charts, graphs, maps, and interactive dashboards (Peddoju and Upadhyay, 2020). Large datasets may be easily explored, analyzed, and interpreted with the help of these technologies, enabling healthcare professionals and decision-makers to make better decisions (Shahid et al., 2019). According to Wang et al. (2018), healthcare personnel can more successfully analyze and interact with data when using data visualisation tools. According to Shneiderman et al. (2019), visualisation technologies have the potential to enhance medical decision-making in the healthcare industry. These technologies enable precise evaluations, retrieval of clinical information, understanding of comparable events, visualisation of correlations, and display of dangers and alerts, among other benefits. However, there are limitations associated with data visualisation tools, such as the ability to broadcast patient databases, synchronize various viewpoints, categorize patients, and ensure collaboration and understandability.

The objective of this study is to evaluate the effectiveness of data visualisation tools. Key metrics such as bed occupancy rates, emergency department utilization, and demographic distributions were examined using Power BI and Tableau. It will establish how data visualisation tools can be optimized to improve healthcare decision-making in healthcare.

Literature Review

Conceptual Review

Concept of Data Visualisation

Data visualisation is the visual depiction of data using graphical components to efficiently communicate information, patterns, and insights (Peddoju and Upadhyay, 2020). In the healthcare field, data visualisation serves as a powerful tool for visualizing complex datasets, including clinical, administrative, and public health data, to aid in understanding, analysis, and decision-making. Healthcare professionals, policymakers, administrators, and patients can easily comprehend complex information by presenting it in visual formats. Data visualisation in healthcare has various uses, enabling medical practitioners to examine and comprehend healthcare data more intuitively, and spot patterns, trends, and linkages that may be missed otherwise (Grove et al., 2012).

Data Visualisation Tools Used in Healthcare Sector

Tableau is a well-known data visualisation application known for its user-friendly interface and robust capabilities. It allows users to explore and analyze large datasets, discover patterns, and draw insightful conclusions (Liu et al., 2019). Tableau's visualisations have been employed in healthcare studies to showcase clinical data, patient outcomes, and resource allocation, aiding in decision-making and quality improvement efforts (Liu et al., 2019; Dunn Jr et al., 2017).

Power BI, developed by Microsoft, is a comprehensive business intelligence and data visualisation solution widely used in the healthcare industry. It offers advanced data integration, modeling, and interactive dashboard functionalities (Moseley & O'Mahony, 2020). Power BI has been praised for its ability to present financial data in a streamlined and visually appealing manner, empowering stakeholders to understand and analyze financial performance (Moseley & O'Mahony, 2020).

D3.js is a popular JavaScript library that allows users to create interactive and dynamic data visualisations for the web. Its flexibility and versatility enable the creation of customized and novel visual representations of healthcare data (Ramey et al., 2019). D3.js has been utilized in healthcare research to develop intuitive interfaces for analyzing gene expression data and facilitating interactive data exploration (Ramey et al., 2019).

Empirical Review

Martínez et al. (2016) conducted a literature review and presented case studies to explore the conceptual bases of data visualisation in this context. They highlighted the importance of data visualisation techniques in injury surveillance and prevention, showcasing their potential to enhance understanding and decision-making. To advance knowledge in this area, this research will focus on evaluating the effectiveness of data visualisation tools within healthcare settings.

Locoro & Ravarini (2020) explored the impact of visualisation tools on decision-making processes in organizations. Their literature review and analysis highlighted the importance of considering organizational context and user preferences when selecting visualisation tools for decision-making.

Edwards & Chen (2020) focused on the development of effective community network analysis tools based on visualisation psychology principles. They proposed a framework for designing these tools, emphasizing the significance of cognitive and perceptual factors. However, the study did not validate or refine the proposed framework, nor did it assess its applicability in real-world community health settings. This study aims to evaluate the effectiveness visualisation application tools in practical healthcare contexts. It will provide insights into the strengths and limitations of the tools and its applicability in real-world decision-making scenarios.

Park et al. (2021) explored the data use and preferences of public health professionals regarding data visualisation tools, highlighting the importance of user-friendly interfaces and customizable features and accessibility in data visualisation tools for effective decision using Qualitative study with interviews and focus groups. The study did not investigate the impact of customized data visualisation tools on decision-making outcomes and assess their usability in the healthcare sector. This study will use both qualitative and quantitative approaches.

Methodology

This research adopts a mixed-methods approach, integrating quantitative analysis with qualitative insights. By integrating the findings from both the quantitative analysis and the qualitative analysis of the literature review, the research design aims to provide a comprehensive understanding of the role of data visualisation in healthcare decision-making. This integrated approach ensures that empirical evidence from the quantitative analysis is combined with insights gained from the qualitative analysis, resulting in a more robust and holistic perspective on the topic.

Existing datasets from the Scottish Health and Social Care Open Database were analyzed to evaluate the effectiveness of data visualisation tools. Key metrics such as demographic distributions, bed occupancy rates and emergency department utilization, were examined using Power BI and Tableau.

Purposive sampling is employed in this study. According to Palinkas et al. (2015), purposive sampling is the process of choosing and locating cases connected to the phenomenon of interest. In this case, the study focuses on NHS Hospital bed information, monthly accidents, and emergency activities, and waiting times in Scotland. The purposive sampling strategy is chosen to ensure that the sample population reflects the research objectives and includes individuals who are most impacted by the research problem (Campbell et al. 2019).

Results and Discussion

Data Visualisation with PowerBI

Demographic Distribution

Age Distribution

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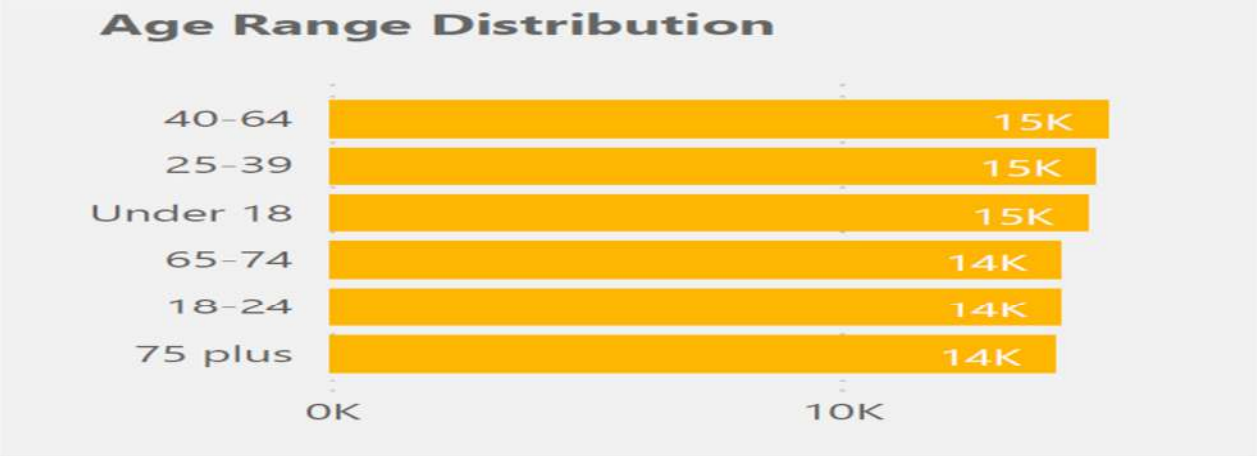

Fig 1 Age range distribution

Figure 1 presents data on the ages of patients visiting A&E departments in Scotland, illuminating important trends. It highlights that 15,000 people between the ages of 40 and 64 make up the bulk of those who visit these hospitals. This is followed by the under-18 age group, which sees 15,000 cases annually. Interestingly, the number of people visiting emergency departments drops precipitously after age 75, with only 14,000 people in that age bracket

Several important points can be inferred from these findings:

- Age Distribution: According to the statistics, those between the ages of 40 and 64 make up the bulk of those who visit the emergency department. There is a higher incidence of accidents, injuries, and health problems that requires rapid medical attention among people of this age.
- Pediatric Care: An impressive percentage of visits to emergency departments come from people under the age of 18. This emphasizes the value of pediatric care and the necessity of providing dedicated resources to meet the specific medical needs of children.

Age-Related Trends: There are a number of factors that contribute to the ageing patient population decline. The elderly may be less prone to accidents due to increased caution or access to better preventative care. Some illnesses that disproportionately affect the elderly may respond better to preventative care than to emergency services

Gender Distribution

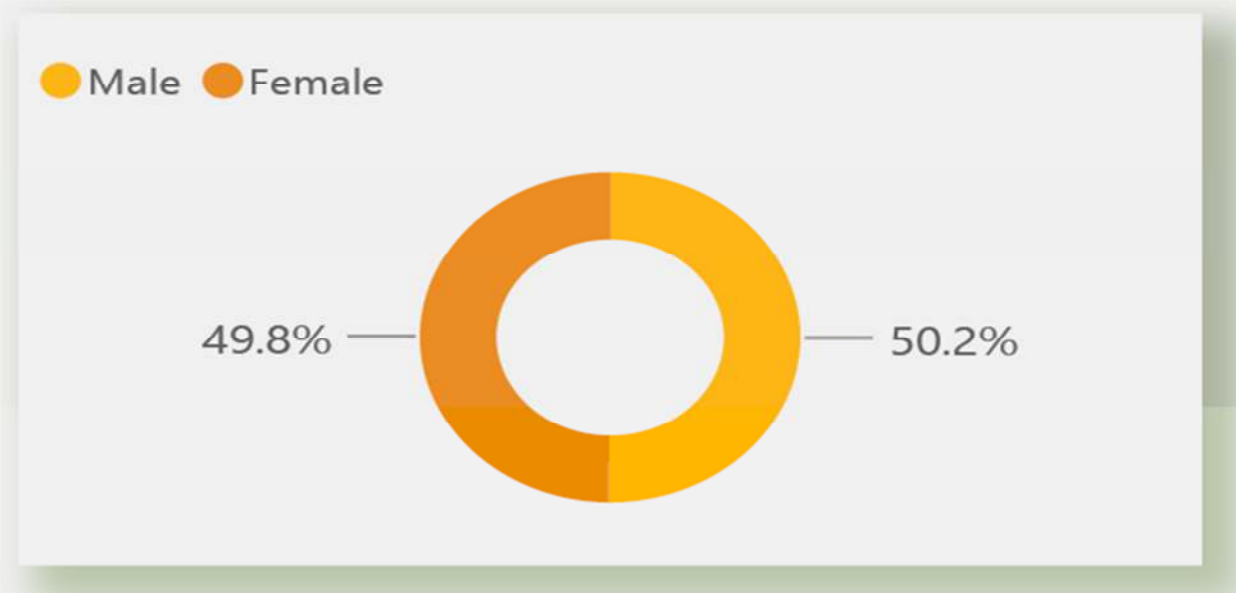

Fig 2 Gender Distribution

Figure 2 presents the gender breakdown of patients to Scotland's A&E departments, which gives useful information about the demographics of A&E use. The fact that men make up 50.2% of patients and women 49.8% of patients shows that people of both genders are similarly likely to seek emergency medical attention.

This gender balance in A&E visits is reflective of the demographic makeup of Scotland, which is roughly split between males and females. This correlation between gender ratios and A&E visits implies that the healthcare system is meeting the needs of both sexes fairly evenly. This similarity between patient and population characteristics is indicative of fair and equal use of healthcare services.

An additional noteworthy observation is the consistent ratio of male to female patients visiting emergency departments. This indicate that there has been no major change or disparity in the way men and women use the emergency department in Scotland. That is to say, both genders have maintained pretty stable rates of seeking emergency medical care.

Bed Occupation Rates

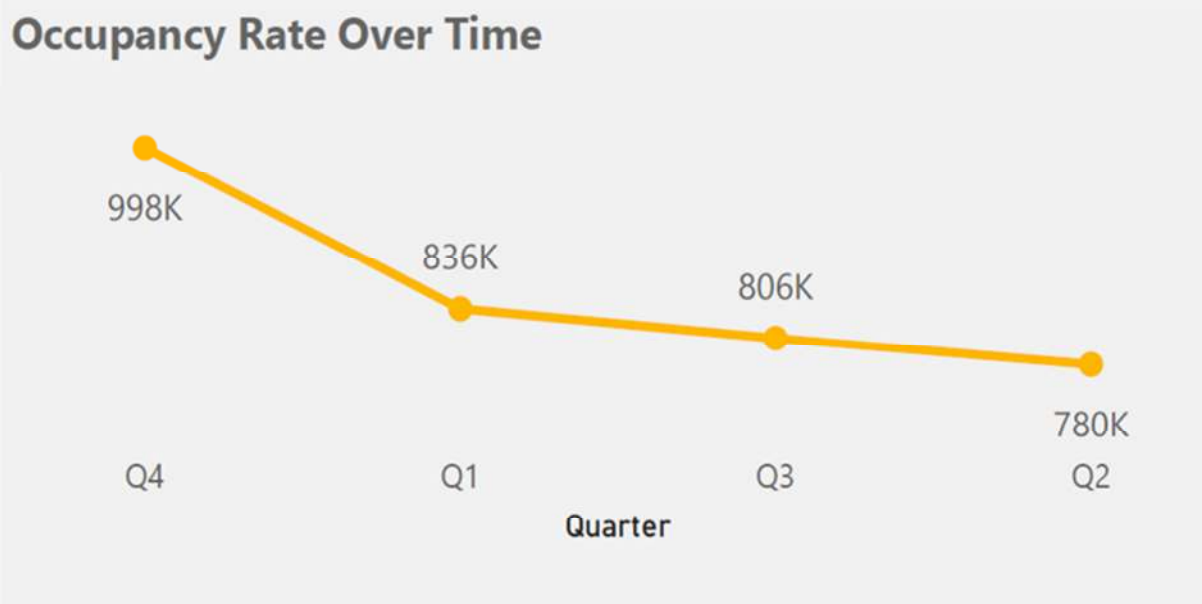

Fig 3 Occupancy rate over time

The bed occupancy rate shown in fig 3 is a crucial metric in healthcare management, as it reflects the utilization and capacity of a hospital's resources.

The most significant observation is the subsequent increase in bed occupancy. In the third quarter, the rate surged to 806,000, signifying an increase in demand for hospital services and a rise in patient admissions. The fourth quarter witnessed the highest bed occupancy rate in the observed period, reaching 998,000, which translates to nearly full capacity, indicating the hospital's resources were significantly strained during that period.

Resource Management: The rising bed occupancy rate is a reflection of the difficulties hospitals have in efficiently allocating their limited resources. It's possible that new patients will have to wait for treatment or care in the fourth quarter since hospitals may have trouble taking them in.

Seasonal Variations: Bed occupancy rates have been shown to fluctuate, which may be indicative of seasonality in healthcare demand. Hospitals must be aware of these trends if they are to use their resources effectively. If the rise is due to seasonal flu or another determinable source, hospitals will be able to better prepare for it.

Impact on Patient Care: Consistently high bed occupancy rates can have an effect on the standard of care provided to patients. More people in a facility means more stress for workers, which can lead to longer wait times and even the possibility of medical mistakes.

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Top 7 Bed Occupancy Rates By Location

Location	PercentageOccupancy
S92000003	92,307.20
S08000031	90,324.05
S08000024	80,855.37
S08000020	77,736.02
S08000030	73,867.30
G405H	70,298.18
S08000022	66,051.81
Total	**551,439.93**

Fig 4 Top 7 Bed Occupancy rate by location

- High Bed Occupancy in S08000003: The most noticeable fact is the astronomically high bed occupancy rate of 92,307.20 in location S08000003. Normal medical institutions can't handle this many patients at once. Overcrowding, lengthier wait times, and difficulties in providing quality care are all possible outcomes of such a high bed occupancy rate, which may imply a serious strain on healthcare resources.
- S08000031 and S08000024: S08000031 and S08000024 are close behind with bed occupancy rates of 90,324.05 and 88,855.37, respectively. They are also high, which suggests that they may be experiencing some of the same difficulties as the number one spot.
- Moderate to High Occupancy Rates: Bed occupancy rates for the remaining destinations on the list fall between 77,736.02 and 66,051.81 per cent. Not as high as the top three, but still significant enough to warrant a significant increase in hospital capacity. To ensure patients in these areas receive timely and sufficient care, healthcare administrators must closely track and control bed availability.

Emergency Department

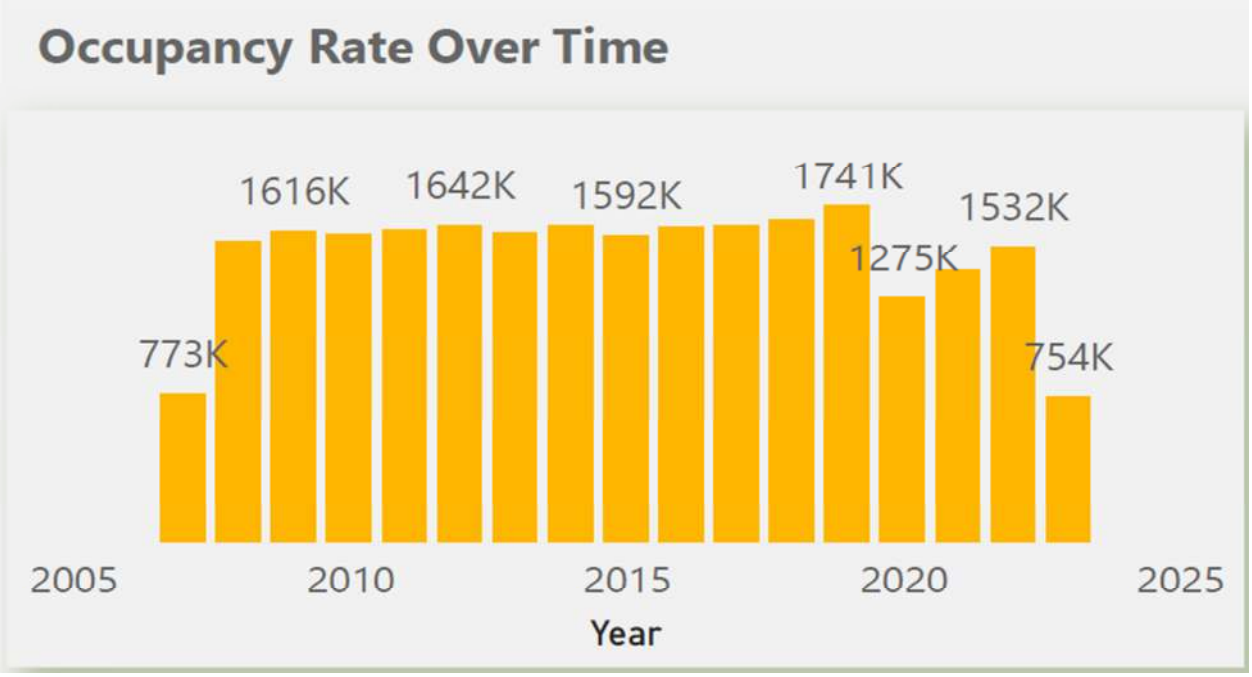

Fig 5 Emergency department occupancy rate over time

Fig 5 is a graph depicting the average emergency department occupancy rate over the past two decades. It shows some interesting patterns and shifts.

Increasing Trend (2005-2019): The data shows that the occupancy rate rising from 2005 to 2020. Beginning in 2007 at 773,000, it jumped to 1,616,000 in 2009 and then to 1,741,000 in 2019. This trend indicates that there was a continuous rise in the need for emergency department visits during that time. Population increase, shifts in healthcare consumption norms, and developing medical requirements are all possible explanations for this pattern.

Fluctuations (2009-2023): The data show that while the growing tendency is clear, there were also considerable swings during this time. The average occupancy rate, for example, fell from 1,616,000 in 2009 to 1,592,000. in 2015, then rose to 1,741,000 in 2019, and then fell to 754,000 in 2023. Changes in healthcare policy, economic climate, and public health events (epidemics, pandemics) could all play a role in the ups and downs of emergency department visits.

Capacity Planning: The constant increase underscores the need of healthcare facilities and hospitals making investments in capacity planning. The rising number of patients necessitates a sufficient number of beds, nurses, and medical equipment.

Resource Allocation: Changes in occupancy rates between 2009 and 2022 highlight the need for adaptable resource allocation.

Figure 4 shows that there is a large variation in the number of attendees across departments, with 84% of attendees coming from the emergency department and only 16% coming from the minor injury unit or other departments. This finding also underscores the importance of having adequate personnel, equipment, and space in the emergency room to deal with the resulting high volume of patients.

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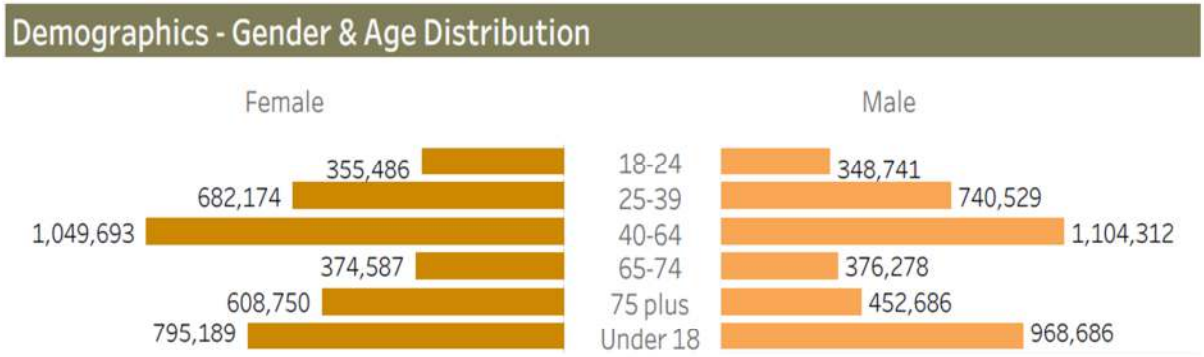
Data Visualisation with Tableau

Demographic Distribution

Figure 6 depicts the age and gender breakdown of patients visiting emergency departments in Scotland, which shed light on the characteristics of those in need of medical care.



Fig

6 Gender by Age distribution

- Gender Disparities in Age Groups: There is a small gender gap in the 18–24 age range, with slightly more women (355,486) than men (348,741) visiting emergency departments. Several reasons may be at play here, including disparities in medical attention sought by men and women and maybe higher injury rates among young men. Conversely, there is a large gender gap between the ages of 25 and 39, with 682,172 females and 740,529 males. This finding may be explained by the fact that women of reproductive age are more likely to seek medical attention.
- Gender Balance in Middle-Aged Groups: Among individuals aged 40-64, both genders seek emergency care at relatively similar rates, with approximately 1,049,693 females and 1,104,312 males recorded. This suggests that healthcare needs in this age group are fairly evenly distributed between genders.
- Elderly Population: Among individuals aged 65-72, the numbers are quite close for both females (374,578) and males (376,278). This balance may be due to the fact that both genders experience age-related health issues in this group. In the 75 plus age group, however, there's a notable gender difference. More females (608,750) are recorded compared to males (452,686). This could be attributed to the longer life expectancy of females, making them more likely to seek emergency care in advanced age.
- Pediatric Care: There are 1,968,686 men and 795,189 females in the under-18 age bracket respectively. This may indicate gender-based disparities in the prevalence of childhood injuries.

Bed occupancy Information

Figure 7 displays important information regarding the occupancy rates of various Scottish bed. The demand for hospital services and the efficacy of resource allocation are directly reflected in bed occupancy rates, making them an essential metric for healthcare systems.

Fig 7 Top 4 bed occupancy rates by location

- Highest Bed Occupancy Rate (Location: S92000003 - 92,307 beds filled): With the highest bed occupancy rate, this location clearly meets a high need for medical care. Population density, illness frequency, and the accessibility of medical facilities are all possible explanations for this high utilisation rate. In order to meet this increased need, it is necessary to increase spending on healthcare facilities, equipment, and personnel.
- Second Highest Bed Occupancy Rate (Location: S08000031 - 90,324 beds filled): The location with the second-highest bed occupancy rate is not far behind the first. Similar factors mentioned above likely influence this high rate. It's important to explore whether the healthcare infrastructure in this area is adequately sized to accommodate the demand. Additionally, strategies for optimizing bed utilization should be considered to ensure efficient resource allocation.
- Third Highest Bed Occupancy Rate (Location: S08000024 - 80,855 beds filled): The occupancy rate is lower than the top two, but it still indicates a significant need for medical care in this area. Health care planning and resource allocation can be more effectively adapted to a region's unique requirements by better understanding those demands.
- Fourth Highest Bed Occupancy Rate (Location: S08000020 - 77,736 beds filled): Bed availability is relatively high here as well. Understanding the exact factors contributing to this rate, such as demographics or proximity to healthcare facilities, can aid healthcare decision-makers in the long run.

Emergency Department

Figure 8 shows the average yearly occupancy rates in Scottish emergency department between the years 2006 and 2024.

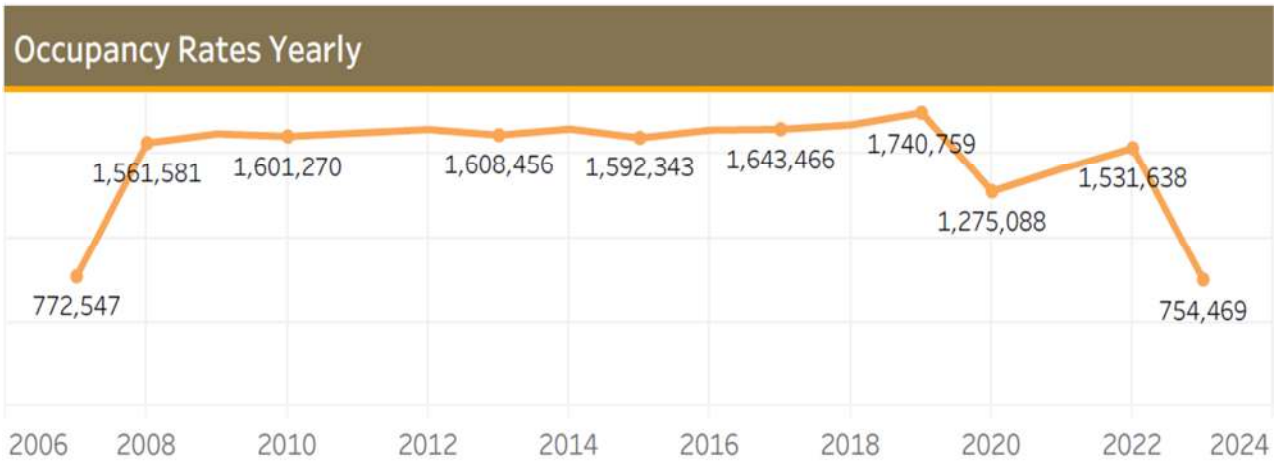


Fig 8 Bed occupancy rate yearly

The chart shows a steady rise in the A&E department's bed occupancy rate beginning in 2006. There has been a rising need for emergency medical care in Scotland, as seen by the increase in the occupancy rate.

- In 2006, the occupancy rate was 772,547, indicating that the A&E department was serving a significant number of patients.
- By 2008, the occupancy rate had surged to 1,561,581, signifying a substantial increase in demand within just two years.
- In 2010, the rate further rose to 1,601,270, indicating that the A&E department was consistently operating at high capacity.
- Although there was a slight dip in occupancy in 2012 (data not provided), it rebounded to 1,608,456 in 2014, indicating that this was not a lasting decrease.
- By 2018, the occupancy rate reached 1,643,466, underscoring the sustained pressure on emergency healthcare services.
- The data indicates a significant drop to 1,275,088 in 2020, which could be due to the impact of the COVID-19 pandemic, as it disrupted healthcare patterns worldwide.
- The most recent data point in 2023 shows a further decline to 754,469. This drop may be attributed to various factors, such as changes in healthcare delivery, resource allocation, or the aftermath of the pandemic.

Summary of Results

Demographic Distribution: Power BI highlighted the age distribution of patients visiting emergency departments in Scotland, revealing a high prevalence of visits among individuals aged 40-64 and children under 18. Tableau provided additional insights into gender disparities, noting that females in the 75+ age group were more likely to seek emergency care, possibly due to longer life expectancy.

Bed Occupancy Trends: Power BI showcased seasonal variations in bed occupancy, with significant peaks in the third and fourth quarters, indicating strain on hospital resources. Tableau's location-specific analysis identified regions with the highest bed occupancy rates, enabling targeted resource allocation.

Emergency Department Utilization: Both tools revealed a steady increase in emergency department visits over two decades, highlighting the growing demand for emergency healthcare services. Tableau further illustrated yearly fluctuations, including a notable decline in 2020, likely attributable to the COVID-19 pandemic.

Comparative Analysis of Tools: While Power BI excels in providing broad overviews and temporal trends, Tableau offers granular insights into specific demographics and locations. Both tools are invaluable but cater to slightly different analytical needs.

Data visualisation tools in terms of Power BI and Tableau significantly enhance decision-making in healthcare. They simplify complex datasets, improve communication among stakeholders, and support evidence-based decisions. For instance, visualising bed occupancy rates can inform capacity planning, while demographic analyses can guide resource allocation.

However, challenges persist. The effectiveness of these tools relies on the quality of underlying data, which may be affected by inaccuracies or inconsistencies. Additionally, ethical concerns such as data privacy and the potential for visualisation bias must be addressed. The study also emphasizes the need for technical training to ensure healthcare professionals can effectively use these tools.

The integration of advanced technologies, such as AI and machine learning, with data visualisation tools presents exciting opportunities. Predictive analytics could further enhance decision-making by forecasting trends and outcomes, enabling proactive interventions.

Conclusion

This study underscores the transformative potential of data visualisation tools in the healthcare sector. By translating complex data into actionable insights, these tools empower healthcare professionals to improve patient outcomes, optimize resource allocation, and enhance service quality. While both Power BI and Tableau offer significant benefits, their utility depends on the specific needs and expertise of the organization.

Recommendations

1. Investment in Training: There must be a development programmmes to enhance data literacy and proficiency in visualisation tools among healthcare professionals.
2. Fostering of a Data-Driven Culture: There is a need for the encouragement in the routine use of data visualisation in decision-making processes.
3. Exploration of Patient-Centric Tools: There must be adequate investment in visualisation tools that empower patients to engage with their health data.
4. Integration of Advanced Technologies: There must be a Leverage on AI and machine learning to enhance predictive analytics capabilities.

References

Brown-Liburd, H., Issa, H. & Lombardi, D., (2015). Behavioral implications of Big Data's impact on audit judgment and decision making and future research directions. Accounting horizons, 29(2), pp.451-468.

Campbell, S., Greenwood, M, & Prior, S., (2019). Purposive sampling: complex or simple? Research Case Examples.PubMed Central.25(8), pp. 652–661. doi: 10.1177/1744987120927206

Dang, A., Arora, D. & Rane, P., (20200. Role of digital therapeutics and the changing future of healthcare. Journal of Family Medicine and Primary Care, 9(5), p.2207.

Grove, S.K., Burns, N. & Gray, J., (2012). The practice of nursing research: Appraisal, synthesis, and generation of evidence. Elsevier Health Sciences.

Maktoubian, J. & Ansari, K., (2019). An IoT architecture for preventive maintenance of medical devices in healthcare organizations. Health and Technology, 9, pp.233-243.

Palinkas, A., Horwitz, S., & Green, C., (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Administration and Policy in Mental Health and Mental Health Services Research 42(5): 533–544.

Park, S. et al., (2021). Impact of data visualisation on decision-making and its implications for public health practice: a systematic literature review. *Informatics for Health and Social Care*, 47, 2022(2), pp. 1–19.

Peddoju, S.K. & Upadhyay, H., (2020). Evaluation of IoT data visualisation tools and techniques. Data visualisation: Trends and challenges toward multidisciplinary perception, pp.115-139.

Roy, S., Meena, T. & Lim, S.J., (2022). Demystifying supervised learning in healthcare 4.0: A new reality of transforming diagnostic medicine. Diagnostics, 12(10), p.2549.

Sarker, I.H., (2021). Data science and analytics: an overview from data-driven smart computing, decision-making and applications perspective. SN Computer Science, 2(5), p.377.

Sebastian, A.M. & Peter, D., (2022). Artificial intelligence in cancer research: trends,

Shneiderman, B. (2014). The big picture for big data: visualisation. Science, 343 6172, 730.

Wang, Y., Kung, L. & Byrd, T.A., (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. Technological forecasting and social change, 126, pp.3-13.