



# The Role of Data Visualization in Enhancing Patient Health Literacy

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## ABSTRACT

This paper examines how data visualization can serve as a powerful tool to improve patient health literacy by translating complex health information into accessible visual formats. Health literacy, a vital factor in effective healthcare, is influenced by diverse factors such as education, socioeconomic status, and culture. Data visualizations provide a bridge to understanding, allowing patients to more easily comprehend critical health information and, consequently, make informed decisions about their care. The paper investigated the various types of data visualizations used in patient education, discussing design principles for creating effective health-related visual content that can engage patients across health literacy levels. Furthermore, the study examined case studies illustrating successful applications of data visualizations in real-world healthcare settings. In conclusion, the paper addresses the ethical considerations and challenges in employing data visualization as a communication tool, emphasizing the need for culturally competent and inclusive design approaches to maximize comprehension and patient safety.

**Keywords:** Data Visualization, Health Literacy, Patient Education, Healthcare Communication, Ethical Design.

## INTRODUCTION

Health literacy is defined as the capacity to obtain, process, and comprehend basic health information and services needed for appropriate health-related decisions. It reflects an individual's ability to seek, find, understand, and utilize health information effectively. This definition does not encompass only the patients' ability but should concern everyone. The importance of health literacy is particularly observed through improved health outcomes, increased patient safety, more efficient and effective health care, and better communication between patients and health care professionals. Health literacy is associated with education, socioeconomic status, and culture. Performance in health literacy tends to improve with educational attainment as well as across generations of individuals. Language and cultural barriers are also factors; therefore, people whose primary language is not English or who may have recently immigrated to a new country are more likely to struggle with health literacy. Empowering patients with health literacy enables them to take action in favor of their own health [1, 2]. A basic feature of health care is patient education. This allows patients to have better information and technology to improve their health or better manage an existing chronic condition. Making the patient understand the condition they are suffering from, rather than having a fear of it, may have disease-modifying effects in some people. This can lead to better utilization of healthcare available rather than inappropriate usage of healthcare services. On the other hand, lack of patient education resulting in patients' ignorance can have grave effects on the therapeutic approach, an increase in the number of hospital re-entry cases, progressive loss of life and human resources, morbidity leading to loss of finance, strain on human resources, increased incidence of disability, malabsorption, and infertility, which can be partially prevented by giving patient education so that they can prevent or delay the complications associated with diabetes. Patients' illiteracy or lack of education about the complications associated with diabetes will have a direct impact on healthcare, the job market, the country, as well as on their socioeconomic status. Inadequate health literacy applies to the mandating of medical instructions, inadequate understanding, and as a result, an increase in the rate of complications and hospital admissions. The inability to understand post-operative instructions may have

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serious, even life-threatening ramifications. Therefore, it is essential to invest time in educating patients about their health problems to ensure their personal safety [3, 4].

### **Understanding Data Visualization and Its Benefits in Healthcare Communication**

Data visualizations are increasingly used in healthcare settings as a way of facilitating communication with patients on a variety of topics. They can simplify difficult concepts and make abstract or large numbers easier to comprehend. There are many benefits to communicating health-related data with visual tools rather than with words or numerals alone. Visual tools designed to help patients understand their health in a new way can engage patients in their own health, make it easier for patients to understand the health concepts clinicians are trying to communicate, improve retention of health-related information, reinforce health-related behavior change, and reduce overwhelm or anxiety. Data visualizations can serve a variety of functions as communicative tools: they can provide context, make larger abstract numbers easier to understand, tell a story, or simply show spread [5, 6]. Data visualizations can be static, printed charts, or digitally interactive and can represent data using a variety of visual forms including bar and line charts, maps, scatter plots, and infographics, each with its unique benefits and best use cases. For example, infographics can be a balanced portrayal of quantitative and qualitative data and are designed to tell a story quickly and clearly, usually to a broad audience. Interactive tools can empower patients to dig for deeper levels of data while still providing an overview for those wanting less information. In this way, digital tools can be used for patients at varying levels of health literacy, while printed handouts can offer the same information in a one-sheet form. In the context of communication in healthcare, the narrator or healthcare provider can decide which forms of data visualizations are needed for which patient or population, thus opening doors to personalized medicine and patient empowerment. Importantly, visual representations tell a story, not just a fact, thereby allowing at a glance comparison of participants [7, 8].

### **Effective Design Principles for Health-Related Data Visualization**

Quality communication requires cutting back on clutter, tailoring the design to the target audience, and ensuring relevance. When designing visualizations for health, particularly for patients, data should be presented in a way that is engaging and fits with the reader's mentality; the most relevant information should not be overshadowed. Presenting data in an organized, clear, and understandable manner is especially important. In addition to appealing to the reader's psychology, the reader's health literacy must be taken into consideration. Various strategies exist for designing visualizations of health data to attract the general population. Clarity and simplicity are essential for everyone, not only older adults or less-educated individuals. Headings and chart labels must be legible, and the data should be kept simple and free of clutter. Each graphic needs to present a single message. Striking the right tone to promote engagement is also crucial; colors that communicate the appropriate mood and highlight danger or benefits are effective in communicating health messages [9, 10]. A given culture may perceive colors differently than your own, so color choice is important. The information presented in the graphic should follow the person's eyepath. The whisker chart also clusters by lifestyle on the y-axis, making the point label information in the x-axis of the whisker chart less relevant; it is difficult to see whether it is an average or a minimum. The charts also make it difficult to make comparisons within a category since each piece of information is scattered throughout. Finally, the use of the disease severity scales in the whisker chart adds yet more unnecessary clutter; the data would be clearer if the severity score were represented in a table [11, 12]. To be accessible, digital-based visualizations should be compliant. This means that keyboard navigation and screen reader access are important. As well as ensuring usability by individuals with disabilities, visualizations should consider cultural competence in design. Different cultures have different perspectives on health, and not everyone interprets data visualizations in the same way. Symbols, colors, text, and visual explanations that are used in visualizations should be evaluated to ensure they are not inadvertently offensive to a particular group of individuals. In some populations, lower levels of health literacy must be taken into account. People with lower health literacy may have difficulty memorizing instructions, handling complex visual aids, and abstracting succinct lessons from large chunks of information. They may not realize that they need help or be too embarrassed or proud to ask for it. People from these backgrounds often mistrust health professionals and institutions, which is why reflecting positive social role models is a good addition to many health-related visualizations. When people in a group with lower health literacy can relate to a character or story, it often works better for conveying the message in a visual [13, 14].

### **Case Studies: Successful Applications of Data Visualization in Patient Education**

Corresponding author: Yan Li Abstract Data visualization can play a critical role in enhancing patient health literacy by processing complex health data into intuitive forms. We will present a series of case

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studies showcasing how specific visualizations have been employed in hospital and healthcare settings. A Tailored Activity Program project utilized individual patient physical activity data to create visual data to provide feedback on the progress and trends of individual and group performance. Before and after project evaluation of individual patient and professional caregiver feedback indicated that analysis of de-identified patient data expressed through graphics and data visualization improved understanding and engagement. A school-age immunization infographic designed in consultation with the technical and clinical team was found to have been successful in assisting in understanding and uptake of immunizations for refugee children attending community health clinics. A research project developed with Aboriginal community-controlled health services aimed to distill and present key morbidity data on alcohol use in a culturally appropriate line graph. Consumers overwhelmingly preferred lines to bar graphs and percentages to raw numbers. In the final phase of the project, we gained feedback from a secondary education audience on the inclusion of simplified line graphs in booklets aimed at health promotion for Indigenous youth. Participants engaged with and understood the percentages of alcohol users rather than the occurrence of five incidents. While there was a preference for a line over a bar, the data visualizations were difficult to comprehend without context and an understanding of the factors that may have influenced the trajectories of the data. However, the line graph was preferred. Invaluable insights were also gained into the age at which young people started drinking and their main source of alcohol. Data visualization tools proved to be a popular and welcome addition to presentations to carers and professionals in both the above 'co-production' of data visualization projects, aiding understanding of tangible progress and the amount of daily activity. Patients perceived both line and bar graphs to be less complex, without a preference for one over the other. It was thought that the use of percentages for total daily activity was more meaningful than dots to represent the individual. Each consumer group had its own preferences and engaged with the visualizations differently, with adolescents preferring interactivity. The outcomes were surprising to the project team, who had anticipated the difficulties associated with extracting meaningful and understandable data and statistical information from individual patients [15, 16]. The role of information designers in creating the final version of data visualization is critical to avoiding misinterpretation and misunderstanding of the data. They confer with clinical and health service stakeholders to interpret data and to create a salient and clear infographical version of the information derived from statistical data. Usually, a co-design approach is informed by clinical and practical realities and the questions that clinicians or clients may have addressed by 'reading' a graphic; i.e., does the decline and eventual leveling coincide with the application of specific care strategies or plan output levels? Data visualization strategies are also used to engage and retain a non-clinical audience's attention and awareness of health priorities. Conclusions Data visualization appears to play an important role in making navigation and interaction with sophisticated health data accessible for users who may not be data literate but are keen to understand a phenomenon. It can be successfully transferred to children, young people, carers, and a non-clinical audience. It is critically dependent on strong information design with a thorough understanding of data and the story it tells by clinical and non-clinical experts [17, 18].

#### **Challenges and Ethical Considerations in Using Data Visualization for Patient Understanding**

In healthcare communication, challenges correspond to the inherent responsibilities and ethical considerations associated with arming people with data and information about their health. Although data visualization is capable of addressing some of the limitations of traditional numerical and textual depictions of health information, it also has its own unique challenges. A primary concern with data visualization, particularly for patient health literacy, is the potential for misinterpretation. Visuals that are access-dependent or rely on visual abstractions, for example, may further impact the cognitive load of individuals with low health literacy. Another ethical concern lies with the idea of data overload, which can stem from detailed depictions of information that make it appear more scientific. When designing graphics, it is important to strike a balance between depicting only the information that the audience needs and adequately addressing professional interests. An emphasis on the small details may, for example, introduce more noise and make the big picture unclear. These choices require a careful assessment of the purpose, audience, and context of use. The representation of individual-level data may also represent an ethical concern, particularly for sensitive health issues such as mental health, rare conditions, or genetic information. This is particularly true in vulnerable populations or closed communities. There is also a unique set of ethical issues surrounding accountability and responsibility for the truth in health data, including consent and rights to patients' own health data. Finally, in the healthcare context, data can easily be selected to support existing biases. Furthermore, the underlying data can perpetuate potential harms. For example, existing institutional or socially stratifying attitudes

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can be inadvertently upheld if certain individual and health system-level outcomes are inappropriately overdramatized to the exclusion of others. Along these lines, the data used for data visualization should be context-indicative, and the problems or questions addressed by the visualization should not be misleading or should not be unsettling. Best practices for responsible data visualization also include ensuring transparency and trust. This includes collecting and displaying data in a way that ensures patient privacy and reduces the risk of individual patient identification. All data held should be non-critical for the identification of individuals. Data-driven concepts and findings should be clearly identified as such and appropriately distinguishable from outcome-contributing factors due to the data not available effect. Engagement with knowledge users should facilitate truthful framing of key messages derived from data visualization, including possible representational slant and data sufficiency. Healthcare providers must be trained to communicate the data behind the visuals with appropriate sensitivity and give consideration to the health-related life values of the audience or participant. It requires the consideration of preconceived health literacy levels and core values of individual patients. Unless a robust training package for data visualization in healthcare communication is in place, and accountability feasible, the responsibility of these tools weighs heavily on the part of the knowledge user as they are responsible in terms of outcomes. This risk related to these tools should not be viewed as an absolute reason against their utilization, but it calls for well-informed judgment and sufficient expertise on the part of their handlers [19, 20].

### CONCLUSION

Data visualization holds significant potential to enhance patient health literacy, translating complex health data into clear, visually intuitive information. When thoughtfully designed, data visualizations can bridge literacy gaps and empower patients to make informed decisions, thereby fostering better health outcomes. However, creating effective visual content requires attention to design principles that account for clarity, simplicity, and cultural competence. Ethical considerations, including data privacy, potential for misinterpretation, and audience accessibility, must also guide the development of health-related visualizations. By addressing these aspects, data visualization can become a valuable asset in promoting equitable healthcare and improving health literacy across diverse populations.

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