Published Online: 2025 May 18 **Research Article**

Challenges and Solutions for Developing a Patient Safety Dashboard for Healthcare Facilities: A Qualitative Study

Ghasem Alizadeh Dizaj [1], Shahla Damanabi [1], Mohammad Esmaeil Hejazi [2], Samira Raoofi [3], Leila R. Kalankesh [1,*]

[1] Department of Health Information Technology, School of Management and Medical Informatics, Tabriz University of Medical Sciences, Tabriz, Iran
[2] Tuberculosis and Lung Disease Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[3] Department of Healthcare Management, Research Center for Evidence-Based Health Management, Maragheh University of Medical Sciences, Maragheh, Iran

[*] ***Corresponding Author:*** Department of Health Information Technology, School of Management and Medical Informatics, Tabriz University of Medical Sciences, Tabriz, Iran. Email: leila.kalankesh@gmail.com

Received: 1 February, 2025; **Revised:** 27 April, 2025; **Accepted:** 2 May, 2025

Abstract

Background: Patient safety dashboards are increasingly used to monitor and improve patient safety in healthcare. However, their effective development faces significant challenges. This qualitative study explores these challenges and identifies potential solutions.

Methods: A phenomenological approach was used to investigate the experiences of healthcare managers, patient safety officers, quality improvement specialists, and information technology professionals involved in patient safety dashboard development within healthcare facilities of Tabriz University of Medical Sciences in Tabriz, Iran. Participants were selected via purposive sampling. Inclusion criteria were direct experience with patient safety dashboard development within the past 5 years; exclusion criteria included no direct involvement or roles unrelated to patient safety. Data were collected through semi-structured interviews and analyzed using thematic analysis to identify challenges and solutions.

Results: A total of 20 individuals participated in this study. The study identified two main themes: Challenges and solutions in developing patient safety dashboards. Within these themes, five sub-themes related to challenges were identified: Data integration complexities, disparate data sources, lack of standardized metrics, resource constraints, and varying levels of digital maturity. Similarly, five sub-themes related to solutions were identified: Interoperability solutions, standardized metrics development, resource allocation, capacity building initiatives, and digital transformation strategies. A total of 72 individual codes were generated from the data, representing specific examples of challenges and solutions.

Conclusions: Addressing challenges and providing solutions for developing patient safety dashboards is vital for enhancing patient safety practices and driving quality improvement initiatives toward delivering high-quality, safe care to patients. By prioritizing data integration, standardized metrics, resource allocation, capacity building, and digital transformation efforts, organizations can develop dashboards to strengthen patient safety practices and continuously improve patient care.

Keywords: Patient Safety Dashboards, Healthcare Organizations, Quality Improvement, Challenges

1. Background

In today's rapidly evolving healthcare landscape, patient safety remains a critical aspect of quality care delivery (1, 2). Ensuring the well-being and protection of patients is not only a moral imperative but also a legal and ethical responsibility for healthcare organizations (3, 4). As such, the development and implementation of patient safety initiatives have garnered increased attention and importance in recent years (5-7). Among the various tools and strategies employed to enhance patient safety, patient safety dashboards have emerged as a valuable tool for healthcare organizations to monitor, evaluate, and improve their patient safety status and practices (8-11).

How to Cite: Alizadeh Dizaj G, Damanabi S, Hejazi M E, Raoofi S, R. Kalankesh L. Challenges and Solutions for Developing a Patient Safety Dashboard for Healthcare Facilities: A Qualitative Study. Health Scope. 2025; 14 (2): e160084. https://doi.org/10.5812/healthscope-160084.

Patient safety dashboards provide a visual representation of key patient safety indicators, allowing healthcare providers and administrators to track and analyze data related to adverse events, medical errors, and other patient safety concerns (12-14). By consolidating and presenting relevant information in a clear and concise manner, patient safety dashboards enable healthcare organizations to make informed decisions, identify areas of improvement, and implement targeted interventions to enhance patient safety outcomes (15, 16).

However, the development of a patient safety dashboard is not without its challenges (17). Healthcare organizations face numerous obstacles in designing and developing an effective dashboard that meets the needs of various stakeholders and aligns with specific organizational goals (18-21). To address these challenges and optimize the implementation of patient safety dashboards, healthcare organizations must explore potential solutions and best practices (22). Gaining insight into barriers and solutions to developing a patient safety dashboard is crucial for designing a successful intervention that drives sustainable improvements in patient safety outcomes (22-24).

2. Objectives

In this qualitative study, we seek to explore the challenges faced by healthcare organizations in developing a patient safety dashboard and examine the solutions employed to overcome these obstacles. By conducting in-depth interviews with healthcare leaders, administrators, and patient safety experts who have had experience and involvement in developing patient safety dashboards, we aimed to gain insight into the challenges and complexities of patient safety dashboard development and identify effective approaches to overcome these challenges.

3. Methods

3.1. Research Design

This qualitative study utilized a phenomenological approach to explore the challenges healthcare organizations face in developing patient safety dashboards and to identify potential solutions. Given the complexity of implementing patient safety dashboards and the importance of understanding the perspectives of those directly involved, a phenomenological approach was deemed most appropriate. This method allows for a rich and nuanced understanding of the challenges and potential solutions by focusing on the lived experiences of healthcare professionals. A phenomenological lens allows for an in-depth exploration of the lived experiences and subjective interpretations of key stakeholders who have prior experience and involvement in the patient safety dashboard development process.

3.2. Participant Selection

Participants were selected through purposive sampling (n = 20), ensuring a rich and diverse representation of healthcare professionals directly involved in patient safety initiatives. The sample included:

(1) Healthcare managers (n = 5): Responsible for overseeing operational aspects within healthcare organizations.

(2) Patient safety officers (n = 4): Focused on the development and enforcement of safety protocols.

(3) Quality improvement specialists (n = 6): Engaged in activities aimed at improving overall care quality and safety measures.

(4) Information technology professionals (n = 5): Tasked with developing and maintaining technological solutions related to patient safety dashboards.

To facilitate in-depth exploration, inclusion criteria required participants to have at least three years of experience in their respective roles related to patient safety and dashboard development. A total of twenty participants were engaged in the study. Participant demographics, including professional background, years of experience, and organizational type, are detailed in Table 1.

Table 1. Demographic Information of the Interviewed Participants Involved in the Study

Role	Number of Participants	Average Years of Experience	Organizational Type
Healthcare managers	5	8.5	Health systems, clinics
Patient safety officers	4	6.2	Hospitals, health policy
Quality improvement specialists	6	7.3	Various healthcare settings
Information technology professionals	5	4.9	IT departments

3.3. Data Collection

Data were gathered through semi-structured in-depth interviews, allowing participants to articulate their experiences, challenges, and perspectives freely. The interview guide was developed based on a

comprehensive literature review and aimed to address key areas such as: (A) Experiences with existing patient safety dashboards; (B) challenges encountered during dashboard development; (C) perceived barriers to implementation; (D) suggestions for dashboard improvement and support.

Each interview lasted between 60 to 90 minutes and was conducted either in-person or via secure video conferencing platforms (e.g., Google Meet), depending on participant preference. All interviews were audio-recorded with participant consent and transcribed verbatim to ensure fidelity to the original dialogue. To establish rapport and trust, preliminary discussions aimed to clarify the study's purpose while emphasizing participant confidentiality and the voluntary nature of involvement. Participants were also assured their identities would remain anonymous throughout the study.

3.4. Data Analysis

The analysis utilized thematic analysis according to the six-phase process outlined by Braun and Clarke (25). This method consists of:

(1) Familiarization with the data: All researchers read and re-read the transcripts to immerse themselves in the data.

(2) Generating initial codes: Key pieces of data were highlighted and labeled to establish initial codes reflecting the participants' experiences and challenges.

(3) Searching for themes: Codes were organized into broader themes that encapsulated shared experiences and insights regarding patient safety dashboard development.

(4) Reviewing themes: Themes were evaluated to ensure they accurately represented the data and aligned with the research objectives.

(5) Defining and naming themes: Each theme was clearly articulated, with definitions crafted to encapsulate the essence of participants' experiences.

(6) Producing the report: The final analysis incorporated direct quotes from participants to illustrate each theme, providing a robust narrative that offered insights into the challenges and potential solutions identified.

To enhance the rigor and transparency of the analysis, a collaborative approach was taken, with all authors participating in the coding and theme development process. Peer debriefing sessions were held to discuss emerging themes and to validate interpretations.

3.5. Trustworthiness

To ensure the study's trustworthiness, we employed several strategies, including member checking, peer review, and reflexivity. Preliminary findings were shared with participants for verification, allowing them to confirm the accuracy and representation of their views. Colleagues and advisors provided feedback on the coding and themes to enhance credibility. Researchers maintained reflective journals throughout the study to document personal biases and assumptions; for instance, one researcher noted a background in healthcare administration that could influence the interpretation of managerial challenges. Discussions among researchers were conducted to mitigate bias, emphasizing the importance of diverse experiences and interpretations.

3.6. Ethical Considerations

Ethical approval (IR.TBZMED.REC.1402.904) was obtained from the Research Ethics Committee of Tabriz University of Medical Sciences, and all participants provided informed consent, affirming their voluntary involvement. The confidentiality and anonymity of all individuals and organizations were prioritized, ensuring no identifying information was shared in the reporting of results. Participants were informed of their right to withdraw from the study at any time without repercussions.

3.7. Data Reporting

Findings were structured in accordance with qualitative research guidelines. The research paper elaborates on the identified challenges and potential solutions in developing patient safety dashboards, enriched by direct quotes and illustrative examples from participant interviews.

4. Results

Semi-structured interviews were conducted with participants to explore their experiences with patient safety dashboard development, focusing on challenges, strategies, and the effectiveness of solutions. The data were analyzed using thematic analysis, revealing key patterns and themes presented in Table 2, which shows the challenges and solutions to developing a patient safety dashboard as expressed by participants. The study identified two main themes: Challenges and solutions in developing patient safety dashboards. Within these themes, five sub-themes related to challenges were identified: Data integration complexities, disparate data

sources, lack of standardized metrics, resource constraints, and varying levels of digital maturity. Similarly, five sub-themes related to solutions were identified: Interoperability solutions, standardized metrics development, resource allocation, capacity building initiatives, and digital transformation strategies. A total of 72 individual codes were generated from the data, representing specific examples of challenges and solutions.

4.1. Challenges Faced in Developing Patient Safety Dashboards

4.1.1. Data Integration Challenges

Healthcare leaders and administrators highlighted the complexity of integrating data from various sources such as electronic health records, incident reports, and quality measures. Issues such as data harmonization, standardization, and quality assurance were identified as significant barriers. Participants expressed concerns about the time-consuming and labor-intensive process of cleaning, aggregating, and integrating data to create a unified view for the dashboard. One of the participants said this:

Patient 7: "What stands out is the difficulty of making the data usable. It's not that we don't have data; it's that it comes from so many places, in so many forms. Getting it all aligned and reliable feels like a huge barrier to creating a dashboard that actually helps us improve patient safety".

4.1.2. Disparate Data Sources

The diverse array of data sources available in healthcare organizations presented challenges in consolidating and aligning data to develop a comprehensive patient safety dashboard. Participants noted issues with inconsistent data formats, coding standards, and data governance practices. The lack of a standardized approach to data collection and reporting hindered efforts to create a cohesive and accurate representation of patient safety metrics. In this regard, one of the participants in the study states that:

Patient 11: "The data...it feels scattered, like pieces of a broken mirror. Each system holds a fragment, a glimpse, but to see the whole reflection – to truly understand what the dashboard is telling us – requires immense effort. It's a constant struggle to force these disparate pieces to fit, to speak the same language, to trust that the image we're creating is accurate".

4.1.3. Lack of Standardized Metrics

Participants emphasized the need for standardized measures to effectively measure patient safety outcomes. The lack of performance indicators and quality measures in some areas creates challenges in benchmarking and comparing safety initiatives across organizations. Stakeholders emphasized the importance of defining clear, measurable, and relevant metrics to ensure the validity and reliability of dashboard data. One participant said in this regard:

Patient 2: "It's like navigating in the dark. You know you need to measure something, to track patient safety, but there's no shared map, no common language. Each department, each facility, is using its own yardstick. You're left wondering, 'Are we truly improving? Are we even measuring the same things?' The lack of standards creates this unsettling feeling of uncertainty".

4.1.4. Limited Resources

Resource limitations, including budget constraints and staff shortages, were identified as barriers to developing a patient safety dashboard. Overall, organizations struggle to allocate sufficient funds and personnel to support dashboard initiatives. Participants emphasized the need to invest in technology, training, and organizational support to overcome resource challenges and ensure the successful development of dashboard projects. One of the participants stated in this regard:

Patient 13: "It feels like you're constantly being asked to do more with less. The vision for the dashboard is there, the desire to improve patient safety is strong, but the resources...they're stretched so thin. You're juggling budget limitations, staffing shortages, and the constant pressure to prioritize".

4.1.5. Varying Levels of Digital Maturity

The disparity in digital maturity and IT infrastructure in healthcare organizations creates challenges in the adoption and use of patient safety dashboards. Participants noted that organizations with limited technological capabilities face challenges in implementing data-driven solutions and effectively exploiting dashboard insights. Efforts to increase digital maturity, foster data-driven cultures, and promote technology adoption were identified as key strategies to address digital readiness challenges. One of the participants mentioned this in this regard:

Patient 1: "You start with this excitement, this belief that you can create a unified view of patient safety. But then you run headfirst into the reality of legacy systems and IT silos. The dream of a seamless deployment

quickly fades as you grapple with compatibility issues, interoperability challenges, and the sheer complexity of integrating everything. The gap between the vision and the reality feels immense".

4.2. Solutions Employed to Address Challenges

4.2.1. Interoperability Solutions

To overcome data integration challenges, healthcare organizations must implement interoperability solutions such as data mapping, standardization protocols, and data exchange mechanisms. Stakeholders emphasized the importance of adopting data interoperability standards and frameworks to facilitate the integration and seamless exchange of data across systems. Collaborative efforts to foster data sharing and interoperability are key strategies in addressing barriers to data integration. One of the study participants stated this:

Patient 18: "Implementing data governance practices brings a sense of order to the chaotic world of data. You're establishing standards, defining clear processes, and ensuring data quality. It's like bringing structure to a previously unstructured environment, creating a sense of control and confidence in the data you're using to make decisions about patient safety".

4.2.2. Standardized Metrics Development

Organizations should prioritize the development and implementation of standard metrics in areas lacking them for patient safety dashboards, ensuring consistency and alignment with organizational goals. Collaborative initiatives to define key performance indicators (KPIs), quality measures, and safety measures are necessary to create a common framework for monitoring and evaluating patient safety outcomes. Participants emphasized the importance of stakeholder involvement in metric development processes to promote buy-in and adoption of standard measures. In this regard, a participant said:

Patient 5: "Developing standardized metrics and defining common KPIs is a process of building trust, fostering collaboration, and creating a shared purpose around patient safety. You feel like you're all rowing in the same direction, guided by these agreed-upon metrics".

4.2.3. Resource Allocation and Capacity Building

Healthcare organizations should prioritize resource allocation and capacity-building efforts to address resource constraints and support the development of patient safety dashboard initiatives. Investments in employee training, technology infrastructure, and data management capabilities are necessary to increase organizational capacity to implement dashboards. Initiatives aimed at improving data management skills, digital literacy, and project management capabilities are critical in overcoming resource constraints. One of the participants in this research said:

Patient 19: "Imagine the possibilities if employees were empowered with the right training and the organization fully committed to removing barriers. You envision a workforce confident in their ability to develop and utilize patient safety dashboards, a culture where continuous improvement is not just a goal but a reality. It's a call to action, a plea for organizations to invest in their people and create an environment where patient safety can truly thrive".

4.2.4. Digital Transformation Initiatives

Organizations should carry out digital transformation activities to increase their digital maturity and readiness to develop a patient safety dashboard as one of the basic priorities. Strategies such as technology upgrades, data analysis tools, and IT infrastructure improvements are needed to support dashboard development and use. Most stakeholders, such as IT leaders and senior managers, emphasized the importance of fostering a culture of innovation, collaboration, and continuous improvement to drive digital transformation efforts and ensure the success of dashboard projects. A participant said this point:

Patient 3: "There's a palpable sense of anticipation as we begin to upgrade our technology infrastructure and deploy advanced analytics tools. It feels like we're on the cusp of a transformation, moving from a data-constrained environment to one where information flows freely. The promise of increased digital maturity, of being able to implement dashboards that truly inform our decisions, fills us with excitement".

5. Discussion

This study provides a holistic insight into the challenges of and solutions for developing patient safety dashboards in healthcare organizations. The findings underscore the multifaceted nature of these challenges, including data integration complexities, lack of standardized metrics, resource limitations, and varying levels of digital maturity. By addressing these barriers, healthcare organizations can leverage dashboards to enhance patient safety outcomes and

foster a culture of continuous care quality improvement.

5.1. Challenges in Developing Patient Safety Dashboards

The challenges identified in this study align with findings from previous research. For instance, a study by Ahmed et al. highlighted the difficulties healthcare organizations face in integrating data from disparate sources, echoing our participants' concerns about data harmonization and data quality assurance (26). The participants in our study emphasized that the labor-intensive process of cleaning and aggregating data often detracts from the strategic use of dashboards, which mirrors the findings expressed in studies by Kirkendall et al. and Classen et al. (27, 28). These studies also found that the lack of data interoperability not only hinders the development of dashboards but also limits the potential for real-time decision-making and effective patient safety monitoring.

Moreover, the issue of lacking standardized metrics in some domains of patient safety is a recurring theme in the literature. As noted by Sorber et al., the absence of universally accepted performance indicators complicates benchmarking efforts and compromise the reliability of safety metrics across different healthcare settings (29). Our findings reveal the need for collaborative efforts to establish standardized measures, as participants stressed the importance of involving stakeholders in the metric development process to ensure optimal buy-in and successful implementation of patient safety dashboards. Multiple studies have emphasized the importance of engaging diverse stakeholders, including health professionals, patients, and leadership, in the metric development process (13, 30).

Similar to the study by Jean Pierre et al. resource constraints emerged as another significant obstacle in our study, consistent with findings from other research (31). A study by Vasileiou et al. illustrated how budget limitations and staff shortages hinder the effective development and maintenance of quality improvement initiatives, including patient safety dashboards (32). In accordance with the findings of another study, participants in our research reflected these sentiments, emphasizing the necessity for organizations to allocate sufficient resources to support initiatives of patient safety dashboards, including investments in related technology and training (33).

5.2. Solutions for Enhancing Dashboard Development

The solutions proposed by participants in this study align with existing research. The emphasis on interoperability solutions, such as data mapping and standardization protocols, is supported by research from Badirova et al., which advocates for the establishment of robust data governance frameworks to facilitate seamless data exchange across systems (34). Participants highlighted that collaborative efforts to foster data sharing are essential for overcoming integration challenges, which is consistent with recommendations from the Institute of Medicine (2015) regarding the importance of data interoperability in improving patient safety (35).

Furthermore, the call for developing standardized metrics resonates with the recommendations made by the National Quality Forum (NQF), which emphasizes the need for consensus on KPIs to enhance the comparability of patient safety outcomes across healthcare organizations (36). Our findings suggest that involving stakeholders in the metric development process not only fosters alignment but also enhances the validity of the data collected, thereby supporting effective decision-making, which is consistent with the study by van de Baan et al. (30). Williams et al. also report in a study that engaging interdisciplinary input in dashboard development enables successful implementation and utilization for quality improvement (13).

The importance of resource allocation and capacity building reflects broader trends in healthcare improvement initiatives. As highlighted by the World Health Organization, investing in training and technology is critical for enhancing organizational capacity to implement and sustain quality improvement projects (37), including patient safety dashboards. Participants in our study recognized that building employee competencies in data analysis and dashboard usage is vital for maximizing the impact of these tools. Research has shown that employee analytical skills are essential for effectively utilizing big data and improving organizational outcomes (38, 39).

Lastly, the need for digital transformation initiatives to increase organizational readiness for implementing patient safety dashboards is a crucial finding. Previous studies have shown that organizations with higher digital maturity are better positioned to utilize data-driven solutions effectively (40, 41). Our participants stressed the importance of fostering a culture of innovation and continuous improvement, which is supported by the literature as a key factor in successful digital transformation efforts (42).

5.3. Implications for Healthcare Practice and Policy

The implications of this study for healthcare practice and policy are significant. By addressing the identified challenges and implementing the proposed solutions, healthcare organizations can enhance patient safety outcomes (43). The findings suggest that effective patient safety dashboards can facilitate data-driven decision-making, enabling organizations to proactively monitor safety concerns and implement targeted interventions. This aligns with the work of Mojeed Dayo et al., who argue that transparency and data utilization are essential components of high-quality healthcare delivery (44).

From a policy perspective, the study highlights the need for initiatives that promote data standardization, interoperability, and digital readiness (45). As Shoemaker-Hunt et al. point out in a review, policymakers should consider incentivizing data sharing and collaboration among stakeholders to advance patient safety practices (46). The recommendations provided by participants emphasize the necessity for a coordinated approach to developing patient safety dashboards, which can ultimately lead to improved healthcare quality and patient outcomes.

Overall, this study contributes to the growing body of literature on patient safety dashboards by identifying key challenges and proposing actionable solutions. By addressing the barriers to effective dashboard development and fostering a culture of data-driven quality improvement, healthcare organizations can enhance their patient safety practices, ultimately delivering safer and higher-quality care to patients. Future research should continue to explore the long-term impacts of dashboard implementation on patient safety outcomes and the effectiveness of various strategies for overcoming identified challenges. Challenges identified in this qualitative study could help prioritize and focus on interventions required for facilitating the development of patient safety dashboards in practice. Moreover, the provided solutions have the potential to be translated into actionable steps in the real world. Overcoming the challenges in developing patient safety dashboards could pave the way for achieving patient safety improvement programs as well as digital maturity in this regard.

5.4. Conclusions

In conclusion, the study underscores the critical importance of addressing challenges and implementing solutions to develop effective patient safety dashboards in healthcare settings. By leveraging insights from existing literature and stakeholders' perspectives, healthcare organizations can enhance patient safety practices through the strategic development and utilization of patient safety dashboards. The study's findings highlight key challenges, including data harmonization, lack of standardized metrics, resource constraints, and digital maturity, which impede the successful implementation of dashboard initiatives.

Collaborative efforts to address these challenges, such as leveraging interoperability solutions, developing standardized metrics, allocating resources effectively, and enhancing digital maturity, are essential for optimizing the impact of patient safety dashboards and driving continuous improvement in patient care. By prioritizing data integration, standardizing metrics, enhancing resource allocation, building organizational capacity, and fostering digital transformation, healthcare organizations can overcome barriers to dashboard implementation and leverage data-driven insights to improve patient safety outcomes.

Acknowledgements

We would like to appreciate of the cooperation of Clinical Research Development Unit, Imam Reza General Hospital, Tabriz, Iran in conducting of this research.

Footnotes

Authors' Contribution: Study concept and design: G. A. and L. R. K.; Acquisition of data: G. A. and S. R.; Analysis and interpretation of data: G. A. and S. R.; Drafting of the manuscript: G. A. and L. R. K.; Critical revision of the manuscript for important intellectual content: G. A., L. R. K., and S. R.; Administrative, technical, and material support: G. A., L. R. K., S. R., and S. D.; Study supervision: L. R. K., S. R., and M. E. H.

Conflict of Interests Statement: The authors declare no conflict of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: This work was a part of a Ph.D. thesis and approved by the Tabriz University of Medical Sciences Ethics Committee, with the approval number: IR.TBZMED.REC.1402.904 .

Funding/Support: This study was supported by Tabriz University of Medical Sciences, Tabriz, Iran.

Informed Consent: All participants provided informed consent, affirming their voluntary involvement.

References

1. Erickson SM, Outland B, Joy S, Rockwern B, Serchen J, Mire RD, et al. Envisioning a Better U.S. Health Care System for All: Health Care Delivery and Payment System Reforms. *Ann Intern Med*. 2020;**172**(2 Suppl):S33-49. [PubMed ID: 31958802]. https://doi.org/10.7326/M19-2407.
2. Widmer MA, Swanson RC, Zink BJ, Pines JM. Complex systems thinking in emergency medicine: A novel paradigm for a rapidly changing and interconnected health care landscape. *J Eval Clin Pract*. 2018;**24**(3):629-34. [PubMed ID: 29280244]. https://doi.org/10.1111/jep.12862.
3. Nora CRD, Junges JR. Segurança do paciente e aspectos éticos: revisão de escopo. *Revista Bioética*. 2021;**29**(2):304-16. https://doi.org/10.1590/1983-80422021292468.
4. Jamal N, Young VN, Shapiro J, Brenner MJ, Schmalbach CE. Patient Safety/Quality Improvement Primer, Part IV: Psychological Safety-Drivers to Outcomes and Well-being. *Otolaryngol Head Neck Surg*. 2023;**168**(4):881-8. [PubMed ID: 36166311]. https://doi.org/10.1177/01945998221126966.
5. World Health Organization. *Patient safety incident reporting and learning systems: technical report and guidance*. Geneva, Switzerland: World Health Organization; 2020. Available from: https://www.who.int/publications/i/item/9789240010338.
6. Khan A, Spector ND, Baird JD, Ashland M, Starmer AJ, Rosenbluth G, et al. Patient safety after implementation of a coproduced family centered communication programme: multicenter before and after intervention study. *BMJ*. 2018;**363**:k4764. [PubMed ID: 30518517]. [PubMed Central ID: PMC6278585]. https://doi.org/10.1136/bmj.k4764.
7. Ullah Z, Sulaiman M, Ali SB, Ahmad N, Scholz M, Han H. The Effect of Work Safety on Organizational Social Sustainability Improvement in the Healthcare Sector: The Case of a Public Sector Hospital in Pakistan. *Int J Environ Res Public Health*. 2021;**18**(12). [PubMed ID: 34205758]. [PubMed Central ID: PMC8296406]. https://doi.org/10.3390/ijerph18126672.
8. Bersani K, Fuller TE, Garabedian P, Espares J, Mlaver E, Businger A, et al. Use, Perceived Usability, and Barriers to Implementation of a Patient Safety Dashboard Integrated within a Vendor EHR. *Appl Clin Inform*. 2020;**11**(1):34-45. [PubMed ID: 31940670]. [PubMed Central ID: PMC6962088]. https://doi.org/10.1055/s-0039-3402756.
9. Jeffries M, Gude WT, Keers RN, Phipps DL, Williams R, Kontopantelis E, et al. Understanding the utilisation of a novel interactive electronic medication safety dashboard in general practice: a mixed methods study. *BMC Med Inform Decis Mak*. 2020;**20**(1):69. [PubMed ID: 32303219]. [PubMed Central ID: PMC7164282]. https://doi.org/10.1186/s12911-020-1084-5.
10. van Elten HJ, Sulz S, van Raaij EM, Wehrens R. Big Data Health Care Innovations: Performance Dashboarding as a Process of Collective Sensemaking. *J Med Internet Res*. 2022;**24**(2). e30201. [PubMed ID: 35191847]. [PubMed Central ID: PMC8905474]. https://doi.org/10.2196/30201.
11. Helminski D, Kurlander JE, Renji AD, Sussman JB, Pfeiffer PN, Conte ML, et al. Dashboards in Health Care Settings: Protocol for a Scoping Review. *JMIR Res Protoc*. 2022;**11**(3). e34894. [PubMed ID: 35234650]. [PubMed Central ID: PMC8928055]. https://doi.org/10.2196/34894.
12. Martinez DA, Kane EM, Jalalpour M, Scheulen J, Rupani H, Toteja R, et al. An Electronic Dashboard to Monitor Patient Flow at the Johns Hopkins Hospital: Communication of Key Performance Indicators Using the Donabedian Model. *J Med Syst*. 2018;**42**(8):133. [PubMed ID: 29915933]. https://doi.org/10.1007/s10916-018-0988-4.
13. Williams AA, Jallo J, Yoo EJ. Improving the Quality of Visualization Dashboards in Critical Care: A Mixed-Methods Study. *Am J Med Qual*. 2021;**36**(4):215-20. [PubMed ID: 32812436]. https://doi.org/10.1177/1062860620946109.
14. Field M, Fong K, Shade C. Use of Electronic Visibility Boards to Improve Patient Care Quality, Safety, and Flow on Inpatient Pediatric Acute Care Units. *J Pediatr Nurs*. 2018;**41**:69-76. [PubMed ID: 29395791]. https://doi.org/10.1016/j.pedn.2018.01.015.
15. Wu E, Villani J, Davis A, Fareed N, Harris DR, Huerta TR, et al. Community dashboards to support data-informed decision-making in the HEALing communities study. *Drug Alcohol Depend*. 2020;**217**:108331. [PubMed ID: 33070058]. [PubMed Central ID: PMC7528750]. https://doi.org/10.1016/j.drugalcdep.2020.108331.
16. Khairat SS, Dukkipati A, Lauria HA, Bice T, Travers D, Carson SS. The Impact of Visualization Dashboards on Quality of Care and Clinician Satisfaction: Integrative Literature Review. *JMIR Hum Factors*. 2018;**5**(2). e22. [PubMed ID: 29853440]. [PubMed Central ID: PMC6002673]. https://doi.org/10.2196/humanfactors.9328.
17. Sittig DF, Wright A, Coiera E, Magrabi F, Ratwani R, Bates DW, et al. Current challenges in health information technology-related patient safety. *Health Informatics J*. 2020;**26**(1):181-9. [PubMed ID: 30537881]. [PubMed Central ID: PMC7510167]. https://doi.org/10.1177/1460458218814893.
18. Naik N, Hameed BMZ, Sooriyaperakasam N, Vinayahalingam S, Patil V, Smriti K, et al. Transforming healthcare through a digital revolution: A review of digital healthcare technologies and solutions. *Front Digit Health*. 2022;**4**:919985. [PubMed ID: 35990014]. [PubMed Central ID: PMC9385947]. https://doi.org/10.3389/fdgth.2022.919985.
19. Ahn J, Campos F, Hays M, Digiacomo D. Designing in Context: Reaching Beyond Usability in Learning Analytics Dashboard Design. *J Learn Analytics*. 2019;**6**(2):70–85. https://doi.org/10.18608/jla.2019.62.5.
20. Conte F, Vitale P, Vollero A, Siano A. Designing a Data Visualization Dashboard for Managing the Sustainability Communication of Healthcare Organizations on Facebook. *Sustainability*. 2018;**10**(12). https://doi.org/10.3390/su10124447.
21. Lau MK, Bounthavong M, Kay CL, Harvey MA, Christopher MLD. Clinical dashboard development and use for academic detailing in the U.S. Department of Veterans Affairs. *J Am Pharm Assoc (2003)*. 2019;**59**(2S):S96-S103 e3. [PubMed ID: 30713078]. https://doi.org/10.1016/j.japh.2018.12.006.
22. Rabiei R, Almasi S. Requirements and challenges of hospital dashboards: a systematic literature review. *BMC Med Inform Decis Mak*. 2022;**22**(1):287. [PubMed ID: 36348339]. [PubMed Central ID: PMC9644506]. https://doi.org/10.1186/s12911-022-02037-8.
23. Abell B, Naicker S, Rodwell D, Donovan T, Tariq A, Baysari M, et al. Identifying barriers and facilitators to successful implementation of computerized clinical decision support systems in hospitals: a NASSS framework-informed scoping review. *Implement Sci*. 2023;**18**(1):32. [PubMed ID: 37495997]. [PubMed Central ID: PMC10373265]. https://doi.org/10.1186/s13012-023-01287-y.
24. Richter Lagha R, Burningham Z, Sauer BC, Leng J, Peters C, Huynh T, et al. Usability Testing a Potentially Inappropriate Medication Dashboard: A Core Component of the Dashboard Development Process. *Appl Clin Inform*. 2020;**11**(4):528-34. [PubMed ID: 32785904]. [PubMed Central ID: PMC7425799]. https://doi.org/10.1055/s-0040-1714693.
25. Braun V, Clarke V. Toward good practice in thematic analysis: Avoiding common problems and be(com)ing a knowing researcher. *Int J Transgend Health*. 2023;**24**(1):1-6. [PubMed ID: 36713144]. [PubMed

Central ID: PMC9879167]. https://doi.org/10.1080/26895269.2022.2129597.

26. Ahmed K, Temate–Tiagueu YT, Amlung J, Stover DL, Peters PJ, Brooks JT, et al. Integrating data from disparate data systems for improved HIV reporting: Lessons learned. *Online J Public Health Inform*. 2018;**10**(1). https://doi.org/10.5210/ojphi.v10i1.8370.
27. Kirkendall ES, Ni Y, Lingren T, Leonard M, Hall ES, Melton K. Data Challenges With Real-Time Safety Event Detection And Clinical Decision Support. *J Med Internet Res*. 2019;**21**(5). e13047. [PubMed ID: 31120022]. [PubMed Central ID: PMC6549472]. https://doi.org/10.2196/13047.
28. Classen D, Li M, Miller S, Ladner D. An Electronic Health Record-Based Real-Time Analytics Program For Patient Safety Surveillance And Improvement. *Health Aff (Millwood)*. 2018;**37**(11):1805-12. [PubMed ID: 30395491]. https://doi.org/10.1377/hlthaff.2018.0728.
29. Sorber R, Giuliano KA, Hicks CW, Black JH. Patient Safety Indicators are an insufficient performance metric to track and grade outcomes of open aortic repair. *J Vasc Surg*. 2021;**73**(1):240-249 e5. [PubMed ID: 32442611]. [PubMed Central ID: PMC7721207]. https://doi.org/10.1016/j.jvs.2020.04.517.
30. van de Baan FC, Lambregts S, Bergman E, Most J, Westra D. Involving Health Professionals in the Development of Quality and Safety Dashboards: Qualitative Study. *J Med Internet Res*. 2023;**25**. e42649. [PubMed ID: 37307058]. [PubMed Central ID: PMC10337379]. https://doi.org/10.2196/42649.
31. Jean Pierre N, Arsene MA, Emmanuel M, Fiacre RR. Designing Dashboard for Healthcare and Resource Information for CHUK. *Int J Adv Engin Manag*. 2024;**6**(12):432-40. https://doi.org/10.35629/5252-0612432440.
32. Vasileiou A, Sfakianaki E, Tsekouropoulos G. Exploring Sustainability and Efficiency Improvements in Healthcare: A Qualitative Study. *Sustainability*. 2024;**16**(19). https://doi.org/10.3390/su16198306.
33. Davy A, Borycki EM. Business Intelligence Dashboards for Patient Safety and Quality: A Narrative Literature Review. In: Otero P, Martin PSS, Martin S, Huesing E, editors. *MEDINFO 2021: One World, One Health – Global Partnership for Digital Innovation*. Amsterdam, Netherlands: IOS Press; 2022. https://doi.org/10.3233/shti220113.
34. Badirova A, Alangot B, Dimitrakos T, Yahyapour R. Towards robust trust frameworks for data exchange: A multidisciplinary inquiry. *Open Identity Summit 2024*. Gesellschaft für Informatik eV; 2024. p. 15-26.
35. Agency for Healthcare Research and Quality. *Six Domains of Healthcare Quality*. 2015.
36. National Quality Forum. *Consensus-based Entities Regarding Healthcare Performance Measurement*. 2009. Available from: https://www.qualityforum.org/About_NQF/HHS_Performance_Measurement.aspx.
37. World Health Organization. *Global strategy on digital health 2020-2025*. Geneva, Switzerland: World Health Organization; 2021. Available from: https://www.who.int/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf.
38. Al-Talafhah KMA, Aplop F, Daradkeh M, Wibawa MB, Marniati M. editors. Big data analytics and healthcare performance: A unified model : AIP Publishing. *1st International Postgraduate Conference On Ocean Engineering Technology And Informatics 2021 (Ipcoeti 2021)*. 2023.
39. Kim BJ, Tomprou M. The Effect of Healthcare Data Analytics Training on Knowledge Management: A Quasi-Experimental Field Study. *J Open Innov: Technol, Market, Complexity*. 2021;**7**(1). https://doi.org/10.3390/joitmc7010060.
40. Basile LJ, Carbonara N, Pellegrino R, Panniello U. Business intelligence in the healthcare industry: The utilization of a data-driven approach to support clinical decision making. *Technovation*. 2023;**120**. https://doi.org/10.1016/j.technovation.2022.102482.
41. Snowdon A, Hussein A, Danforth M, Wright A, Oakes R. Digital Maturity as a Predictor of Quality and Safety Outcomes in US Hospitals: Cross-Sectional Observational Study. *J Med Internet Res*. 2024;**26**. e56316. [PubMed ID: 39106100]. [PubMed Central ID: PMC11336495]. https://doi.org/10.2196/56316.
42. Dias C, Escoval A. Hospitals as learning organizations: fostering innovation through interactive learning. *Qual Manag Health Care*. 2015;**24**(1):52-9. [PubMed ID: 25539491]. https://doi.org/10.1097/QMH.0000000000000046.
43. Mistri IU, Badge A, Shahu S. Enhancing Patient Safety Culture in Hospitals. *Cureus*. 2023;**15**(12). e51159. [PubMed ID: 38283419]. [PubMed Central ID: PMC10811440]. https://doi.org/10.7759/cureus.51159.
44. Mojeed Dayo A, Janet Aderonke O, Chikwudi Cosmos M, Geneva Tamunobarafiri I, Samira A. The role of data-driven initiatives in enhancing healthcare delivery and patient retention. *World J Biol Pharm Health Sci*. 2024;**19**(1):234-42. https://doi.org/10.30574/wjbphs.2024.19.1.0435.
45. Weise M, Böhms M, Allaix D, Sánchez-Rodríguez A, Rigotti M. Importance of Digitalization and Standardization for Bridge and Tunnel Monitoring and Predictive Maintenance. *ce/papers*. 2023;**6**(5):592-9. https://doi.org/10.1002/cepa.2144.
46. Shoemaker-Hunt S, Hall K, Hoffman L. Advancing Patient Safety: Reviews From the Agency for Healthcare Research and Quality's Making Healthcare Safer III Report. *J Patient Saf*. 2020;**16**(3S Suppl 1):S1-2. [PubMed ID: 32809993]. [PubMed Central ID: PMC7447167]. https://doi.org/10.1097/PTS.0000000000000761.

Table 2. Challenges and Solutions to Developing a Patient Safety Dashboard Expressed by Participants

Categories and Challenges	Solutions	Examples of Solutions
Data integration		
Complexity of integrating data from various sources		
Merging EHR data with incident reports	Implementation of interoperability solutions	Use of FHIR standards
Combining patient demographics from multiple facilities	Standardization of data formats for separate systems	Utilization of HL7 messaging standards to streamline data input
Difficulty in integrating data from monitoring devices	Using middleware for data collection and integration	Deployment of integration platforms like Mirth Connect
Data quality heterogeneity across systems		
Inconsistent data entry leading to duplicates	Development of data mapping and standardization protocols	Creating a centralized data dictionary for definitions
Missing fields in patient safety reports	Implementation of automated data validation checks	Use of data quality tools like Talend or Informatica
Variations in safety terminology used across departments	Training staff on standardized data entry practices	Conducting regular data quality training sessions
Fragmented data sources		
Patient data fragmentation across multiple hospital systems	Establishing secure data exchange mechanisms	Use of APIs for data sharing
Limited visibility of patient incidents across platforms	Creating a centralized data warehouse	Implementation of platforms like Microsoft Azure or Amazon Redshift
Difficulties in accessing historical incident reports	Regular update and sync data across systems	Use of ETL tools like Apache NiFi
Disparate data sources		
Inconsistent data formats		
Varying coding for diagnoses (ICD-10 vs. SNOMED)	Introducing data standardization initiatives	Adopting a unified coding system across the organization
Different formats for medication orders across departments	Enforcing adherence to standard formats for data entry	Implementing databases that support standard formats (e.g. LOINC)
Lack of uniform categorization for patient safety events	Establishing training programs on data entry standards	Conducting workshops on data entry and classification
Lack of standardized data collection practices		
Different departments collecting patient safety data in various formats	Implementing data governance frameworks	Establishing data governance committees to oversee practices
Variations in how incident reports are documented	Standardization of reporting templates and procedures	Developing and distributing standardized report formats
Inconsistent definitions for critical safety events	Reviewing and updating data collection guidelines regularly.	Hosting quarterly meetings to reassess reporting standards
Lack of standardized metrics		
Absence of KPIs in some areas		
Difficulty in tracking HAI rates	Engaging stakeholders for metric development	Work in collaborate to define metrics like HAI rates, readmission rates
Inability to measure patient fall rates consistently	Creating a list of essential metrics with inputs from clinical staff	Using a consensus to establish a standard metric
Gaps in measuring staff compliance with safety protocols	Protocols to evaluate patient safety compliance by staff	Conducting periodic assessments
Challenges in patient safety performance comparison across organizations		
Inability to benchmark patient safety outcomes between healthcare facilities	Fostering adoption of a common evaluation framework	Utilizing established frameworks like the NQF's measures
Difficulty in sharing best practices	Organizing collaborative meetings between institutions	Creating a shared online platform for data sharing
Limited resources		
Budget constraints		
Limited funding for new technologies and dashboard development	Advocating for strategic resource allocation	Developing a business case to present to stakeholders for funding
Constraints on hiring additional data staff	Exploring grants and external funding options	Research grant opportunities for technology improvements
Budget cuts impacting existing projects	Establishing prioritization criteria for projects	Creating a prioritization matrix for funding allocation
Staff shortages		

Categories and Challenges	Solutions	Examples of Solutions
Difficulty in hiring data analysts	Invest in capacity-building initiatives	Providing workshops for training existing staff on data analytics
Overworked existing staff leading to burnout	Offer incentives for attracting and retaining talent	Implementing retention programs, like professional development support
Lack of specialized IT support for dashboard development	Partner with academic institutions for internships	Holding IT training courses for employees in cooperation with IT institutions
Insufficient organizational leadership support		
Competing priorities that divert attention from dashboard projects	Creating cross-functional teams	Establishing project teams with representatives from IT, clinical staff
Lack of executive buy-in for patient safety initiatives	Conducting awareness sessions for leadership	Organizing/holding workshops demonstrating potential dashboard benefits
Varying levels of digital maturity		
Disparities in IT infrastructure		
Some departments using legacy systems while others use advanced software	Promoting digital transformation initiatives	Investing in new technologies like cloud-based EMRs
Inefficient data retrieval processes	Conducting infrastructure assessments and mappings	Creating an upgrade roadmap for IT systems
Variability in tech support capabilities across departments	Standardizing IT support practices	Implementing a unified IT ticketing system for all departments
Resistance to technology adoption		
Clinicians reluctance to use new dashboard tools	Encouraging a culture of innovation	Sharing success stories and benefits of data-driven decisions
Fear of employees losing some of the financial benefits of their jobs due to automation	Involving staff in design and implementation of patient safety dashboards	Conducting focus groups for feedback and concerns
Challenges in training staff on new systems	Using gradual training approaches with pilot programs	Implementing peer-assisted learning sessions
Challenges with integrating legacy systems		
Difficulty in connecting old systems to new data platforms	Developing plans for seamless technology integration	Creating a phased implementation strategy for system upgrades
Legacy systems' incompatibility with modern software	Allocate resources to upgrade legacy systems	Utilizing APIs to bridge the gap between legacy and new systems

Abbreviations: FHIR, fast healthcare interoperability resources; API, application programming interfaces; ETL, extract, transform, load; KPI, key performance indicator; HAI, hospital-acquired infection; NQF, National Quality Forum.