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Business Intelligence Dashboards for Patient Safety and Quality: A Narrative Literature Review

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Abstract

Business Intelligence (BI) dashboards are interactive data visualization displays identifying key patient quality and safety trends and metrics. Yet, it remains unclear whether dashboards are impacting clinical care for desired organizational outcomes. In this paper we summarize the positive and negative impacts of dashboards on safety and quality from the literature and those insights are used to develop a dashboard checklist tool. The research involved 3 phases. In Phase 1 a narrative literature review used "Dashboards AND ("Patient Safety" OR "Quality")" as primary search terms. In Phase 2, A SWOT (strengths, weaknesses, opportunities, threats) analysis was conducted based on the findings from the previous phase. Strengths and opportunities included focusing on metrics, clear goals, routine data review processes, transparency, quality improvement interventions and centralized monitoring. Weaknesses and threats included usability issues, cultural barriers, wrong metrics, tunnel vision and siloed development. Phase 3 involves translating the SWOT analysis to a checklist for evidence informed dashboard development and deployment.

Keywords

Business intelligence dashboards, visibility, quality improvement planning

Introduction

Dashboards are interactive data visualization displays that can be used to identify key trends and metrics for clinical quality, operations and patient satisfaction. In the patient safety context, dashboards are used to highlight trends and metrics on complications, adverse events and medical errors. The electronic display of summarized data in dashboards is referred to collectively as business intelligence (BI). Enterprise Data Warehouses (EDWs) can store data from disparate sources and facilitate dashboard displays either directly in electronic medical records (EMRs) or on dedicated platforms [3].

Recently, there has been a push towards developing standardized metrics on patient safety to evaluate health system performance such as the creation of consensus-based indicators in Canada for safe medication practices in inpatient and outpatient settings [14]. As a result, dashboards gained prevalence as an offshoot of balanced scorecards as a means of providing key performance indicators (KPIs) to assist with decision-making. Dashboards are increasingly being used as a benchmarking tool for mandated reporting on meaningful use and for regulatory purposes [6]. A key reason for dashboards is to integrate disparate and poorly organized data and to aggregate this data into a centralized location to highlight the most essential metrics [15]. According to the research, pouring over clinical incident reports for medication-related errors and near misses is a time consuming process with limited ability to see trends or systemic problems. A dashboard can more easily identify the most common error types, identify variation among institutions or providers and allow for reflective learning in a timely manner on medication related problems [22].

The literature is still unclear as to whether dashboards can have a broad impact on desired outcomes, and there is still limited research about the reach of dashboards to improve the health care system. As well, it is difficult to ascertain if there are certain dashboard development standards that should be developed to further safety and quality.

Objectives of the Research

The research objectives for this work were: (1) to summarize the positive and negative impacts of dashboards on safety and quality noted in the literature and (2) to use those insights to formulate a tool to be used when creating dashboards.

Methods

The research was conducted in three Phases. In Phase 1, a narrative literature review was used to identify relevant journal articles examining whether dashboards improved quality and safety, where outcomes improved and how dashboards may fall short or hinder safety and quality. A narrative review is a traditional review of the existing literature to orient research on a given topic [21]. Relevant articles were identified in PubMed®, CINHAL®, Web of Science® and IEEExplore® utilizing the primary search strategy of "Dashboards OR Business Intelligence" AND ("Patient Safety" OR "Quality")". Relevant citations within articles were explored to enrich the literature on the subject matter. In Phase 2, a SWOT (strengths, weaknesses, opportunities, threats) analysis was created from the literature findings to be followed by future plans to develop and test a template for building a checklist tool in phase 3. A SWOT analysis can be used for strategic planning within health care organizations and has been used for effective informatics deployment such as electronic medical records [19]. The process for developing a SWOT in this research was identifying positive and negative aspects from the dashboard literature to strategically plan BI development and deployment.

Results

Postive Impacts on Safety and Quality

Dashboards impact patient safety and quality by providing transparency in overall care delivery performance and highlighting the issues with the greatest opportunities for improvement, be it adverse drug reactions, readmissions or even sentinel events. BI provides the scaffolding to the myriad amounts of data and reports that would otherwise be extremely laborious to mine, analyze and summarize. The promise of dashboards for safety and quality is that dashboards highlight the most important trends and results for clinicians to allow them to engage in process changes rather than analytics.

An Australian study for example highlighted how dashboards provide information on quality and safety metrics that can be acted upon in real-time rather than waiting for survey results. The authors further noted that transparency and timeliness of performance data informs committees and allows them to take timely action [2]. A key aspect of the dashboard is that it is meant to be reviewed by perioperative service managers regularly and take action based on the scorecard in the dashboard [9].

An electronic display of key indicators can directly improve the provision and safe quality of a service. The development of summarized proportions using "speedometer" graphs in obstetrics can provide insight into overall clinical performance on deliveries along with maternal and newborn health. The metrics and benchmarking allows hospitals to monitor obstetric quality and undertake interventions for safer deliveries and process improvements related to care, such as reviewing the induction of labor and caesarean section rates [11]. Researchers have noted that the capability to link monitors and data sets in an intensive care unit into a cohesive dashboard holds great promise for improving quality, safety and outcomes. The dashboard meets the needs of clinicians to have a centralized monitoring tool rather than logging out of disparate systems to find relevant information. The BI tool allows for greater situational awareness by minimizing alarms to focus on the most critical information [5].

A number of case studies on dashboard development highlight how the technology has improved safety and health outcomes. A dashboard created at the Children's Hospital of Philadelphia to measure medication alerts led to a successful quality improvement project reducing alert burden on pharmacists and allowing them to devote more attention to clinically relevant alerts. The continuous quality improvement cycle using the dashboard resulted in a decrease in the number of alerts overridden for drug-drug interactions [20]. An iterative approach to dashboard design developed at MedStar Health that was end-user focused allowed for key metrics and data from patient safety event reporting systems to be available for review. Feedback from users using the iterative approach was largely positive and allowed clinicians to hone in on variables of interest to address safety. The MedStar dashboard reduced the burden on data analytics and allowed for greater awareness of safety events such as reviewing how common fall hazards were in a specific department [17].

Loma Linda University Health System in a similar vein outlined their experience building dashboards from the EDW to improve clinical outcomes. The health system defined clinical outcomes as length of stay, readmissions and mortality. The team compared results across diagnostic areas to performance benchmarks from other hospitals and the targets set by the Centers for Medicare and Medicaid Services. Once clinical areas with the greatest opportunity for improvement were identified then quality improvement projects were initiated using dashboards to track key metrics and trends. A few of the results demonstrating improvements in the quality of care were the following: a 27% reduction in sepsis mortality rate and 25% reduction in sepsis readmissions, a 60% reduction in congestive heart failure mortality, a 30% reduction in pediatric pneumonia readmission rate and a 34% reduction in blood units administered without clinical necessity [13].

Negative Impacts on Safety and Quality

Dashboards may hinder safety through usability issues and cultural or governance barriers when deploying data visualizations. Developers of dashboards need to ensure the data displayed is accurate and intuitive. A potentially inappropriate medication dashboard in the United States Veterans Affairs system underwent usability testing using direct observation and "think-aloud" techniques coupled with a questionnaire on the user experience. The observation and "think-aloud" testing identified more hazards in the dashboard then the survey. A lack of usability testing with end-users can directly lead to patient harm if the display is inaccurate or provides misleading data [18]. Barnett et al [2] identified how siloed governance models are in conflict with the multidisciplinary function of clinical analytics needed to turn data into action. The authors further noted cultural barriers to dashboard adoption when data on performance for specific hospital units is exposed. The resistance to data transparency on performance and siloed governance lead to dashboard failures through user rejection or refusal to utilize them.

Dashboards fail when there is a lack of quality or process improvement planning prior to development. A study of 120 primary care physicians using a dashboard over a five-month period on colorectal cancer screening and HbA1c results for diabetes patients found no correlation between views and change in quality scores. Thirty-one physicians or 26% of total participants did not even view the dashboard. The authors found that a dashboard alone does not impact quality improvement [23]. BI detracts from safety and quality when it focuses on the wrong measures and has faulty data or loading issues. Barnett et al [2] identified issues with accurate labelling of data and code changes that corrupted extracted data. Loreto et al [11] noted that manual processing and checking of data loaded into dashboards is a hindrance to keeping the information relevant and allowing for more immediate changes to address safety. Safety hazards from dashboard development include "noise" by including irrelevant or too much data, difficult to decipher visualizations and a narrow focus on certain measures while ignoring the larger picture [1,7,24]. Dashboards can limit clinical focus to aspects of performance that are measured at the expense of other aspects that impact outcomes, highlighting the need for the visibility of balancing metrics. [10,12,16].

SWOT Analysis (Template for Future Checklist)

A SWOT analysis compiled from the literature highlights the strengths and pitfalls in creating dashboards to improve patient safety and quality. The key findings highlighted in the SWOT analysis are in Table 1 and can serve as the basis of a checklist for creating an effective dashboard to maximize the potential for improving outcomes.

Table 1- SWOT Analysis

Strengths	Weaknesses
• Focused metrics • Routinely reviewed • Clinical feedback • Transparency • Quality improvement interventions	• Usability issues • Cultural barriers • Poor governance • Wrong metrics • Not viewed
Opportunities	**Threats**
• Clear goals • Benchmarking • Direct stakeholder involvement • Data review process • Real-time action • Centralized monitoring	• Tunnel vision (e.g., missing balancing metrics) • Stale data • No oversight • Siloed development • No action or quality improvement plan

Discussion

Most studies highlighting dashboard creation identify an iterative process involving users to ensure acceptability and integration into clinical workflows [8,13,17,20]. On the flip side, the published studies are limited by mostly focusing on the experience of single institutions. The limited research about the broad reach of dashboards makes it difficult to ascertain if there are certain standards that should be developed to further safety and quality. The case study approach also limits the generalizable knowledge about the impact of dashboards to the broader health care delivery ecosystem.

Studies that have focused on evaluating dashboards primarily focus on the process of creating and using them rather than the specific design elements that enhance the safety or quality of care. Research demonstrating effective use of dashboards generally focuses on the clinical committees setting the safety and quality agenda and identifying the key metrics for improvement and less so on the individual clinicians who have dashboards available for review.

A literature review of eleven research articles on dashboards impacting patient care rated only one study as having high quality. The studies reviewed were noted to be unclear about which dashboard characteristics are related to improvements in outcomes and did not specify how clinicians can incorporate dashboards into daily practice [4]. The poor quality of the research literature on dashboard use to improve outcomes limit the conclusions that can be drawn on the impact of the technology on safety and quality.

Conclusions

Making performance metrics and benchmarking available on a dashboard in itself will not spur improvements in patient safety and quality. The literature begins to clarify that a quality improvement project and an action plan to test changes to the process of delivering care are needed to fulfill the objective of dashboards to enhance outcomes. Clinical committees on safety and quality not only need to meet regularly to review data but critically ask themselves what actions they are going to take based on the metrics presented. As a result, data governance and clinical review are essential for identifying opportunities and building meaningful dashboards to address them.

Iterative design of dashboards is necessary to hone in on the visualizations used to identify safety and quality metrics and how they shift over time. The strengths, opportunities, weaknesses and threats identified in this literature review can help form a thoughtful dashboard checklist during the development and deployment process.

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