**Role of dashboards in improving decision making in healthcare: Review of the literature**

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ABSTRACT[[1]](#footnote-2)

The purpose of this study is to provide a comprehensive overview of how dashboards are contributing in aiding and improving the quality of decision making in healthcare. A literature search was performed for the related papers on PubMed, Web-science, IEEE Xplore Digital Library and ACM Digital Library. Both citation and hand searches were conducted to find relevant papers. Sixty-two full text papers were retrieved of which eight papers were included in the review. Significant heterogeneity was found in the process, outcomes analysis methods and techniques. There was considerable evidence that the use of data visualization dashboards in healthcare improves the quality of decision making in healthcare.

CCS CONCEPTS

•  **Human-centered computing~Visualization application domains**   • **Human-centered computing~Visual analytics**   • **Human-centered computing~Information visualization**   • Human-centered computing~Human computer interaction (HCI)   • **Applied computing~Health care information systems**)

KEYWORDS

Healthcare dashboard, clinical dashboard, decision making, decision support

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1. Introduction

A dashboard is an important data visualisation method to display a visual summarization of information to facilitate new accessible insights for improved decision making or management. A dashboard provides a way to present and expediently analyse information using different visual elements. They can also save time and costs in decision making given a dashboard can synthesize a large amount of information [[15](#bib15)]. Arguably, an optimal dashboard should be created by an interdisciplinary team consisting of software engineers, data scientists, user interface designers and indeed experts in human factors design. In healthcare, dashboards are divided between three major applications: 1) monitoring, 2) analysis and 3) management dashboards, all of which facilitate or aid decision making [[15](#bib15)]. A decision support system should include the aforementioned layers to deal with healthcare management and decision-making processes [[20](#bib20)]. Dashboards have been used to integrate data sources, e.g. patient information system, ward, catheterization laboratories (CathLab) etc. to calculate key performance metrics in healthcare units such as the door to balloon time (a key performance indicator in CathLab) [[22](#bib22)]. Dashboards can aggregate the available data and provide an intuitive summary with the vital visual elements to help healthcare professionals make more accurate decisions. Dashboards are also useful to present patient history and treatment at a glance, for example we can show the all of the patient records in one screen and we can observe patterns during specific time-periods [[21](#bib21)]. We can use data analytics to show different statistical analysis and patterns to enable physicians to make better decisions [[1](#bib1)] [[2](#bib2)]. A dashboard was developed to improve Heart Team efficiency and accuracy by providing a visualisation of treatment strategies based on the available useful information [[6](#bib6)]. One study evaluated the effect of implementing a dashboard for the STEMI patients to calculate the door to balloon time. It highlights the importance of monitoring, evaluation and providing feedback on ischemic time delays in STEMI patients. It was concluded that use of this dashboard named H2H (home to hospital) improved the overall performance and process and approx. 90% of the patients achieved the recommended door-to-balloon time of 60 minutes [[9](#bib9)]. Different other visualisation tools have been developed and evaluated to improve the clinical decision making and aid clinicians to make better decisions specifically in cardiac care with respect to ECG-lead misplacement [[3](#bib3)] [[4](#bib4)]. Optimal dashboard design provides functions that enable physicians to make decisions with high accuracy and confidence [[18](#bib18)]. One challenge in dashboard design is how to make dashboards easy to use and to summarize the data in a simple way [[26](#bib26)].

1. Methods

We conducted a rapid review of the literature that discuss research about dashboards in healthcare and decision making. In this study we desired to review the current evidence that exist for this emerging trend of using dashboards for aiding effective decision making in healthcare

* 1. Study inclusion criteria

*2.1.1 Intervention.* In this review, studies were included which address an evaluation of the use and impact of dashboards/visual displays on effective decision making in healthcare.

*2.1.2 Outcome measure.* The review included a review of all the study designs depicting the use and evaluation of dashboards for decision making in healthcare only. It also included studies introducing new dashboards/interfaces for aiding decision making.

* 1. Search strategy

Different electronic databases were interrogated using different keywords. Databases included PubMed, IEEE Xplore Digital Library, ACM Digital Library, web-science for the date 2008 to 2018. Search approach was established using different keywords (dashboards and decision making) and combining them with relevant terms (e.g. visual analytics, improving decision making, usability) for non-medical databases domain terms such as cardiac care, healthcare, Primary Percutaneous Coronary Intervention (PPCI) were added. A hand search of the reference list of relevant papers and citation search of the same papers was conducted as well.

* 1. Study selection

All the results were screened based on the title and abstract. Full text copies were retrieved for the relevant studies for further review and scrutiny. All the papers were reviewed thoroughly and papers directly relevant to the study were identified.

* 1. Analysis Strategy

A spreadsheet was used for preliminary analysis, all the relevant studies were included in the form of a matrix to collect the information on the following parameters*.**Study, design, sample selection type and size****, i****ntervention of the study****, o****utcome measures****, k****ey design used for the dashboards****, a****nalysis, tools and results****, l****imitations****.*** A narrative synthesis of the data was carried out with the focus on how dashboards helping in betterdecision making in the included studies, type of dashboards being used, evidence of their impact andanalysis carried out for the evaluation. Meta-analysis for these studies were not suitable because of theheterogeneity of design, outcomes and analysis in identified papers.

1. Results
   1. Study selection

A total of 551 papers were identified through the electronic database search of which 63 papers were identified as potentially relevant. 58 full text articles were reviewed for the further screening out of which 8 papers were selected for this study as rest (n=46) were not explicitly addressing the role of dashboard in clinical decision making.

* 1. Study characteristics

One study used a questionnaire to evaluate the decision-making effectiveness using the dashboards in the hospitals using business analytics [[23](#bib23)]. Interviews and eye tracking studies were used to measure the success of a proposed dashboard display for aiding decision making in emergency departments (ED) [[11](#bib11)]. Two studies used questionnaires and observation to assess the confidence of decision-making for treatment choice through dashboard [[5](#bib5)] [[8](#bib8)]. This study opted for both qualitative and quantitative techniques to analyse if the proposed dashboard (now called the MVA 2.0 system) aids decision making in ICU [[10](#bib10)]. In another study, to evaluate the best possible visualization of the system (CLABSI), six visualization mockups and interviews were used [[17](#bib17)]. Two other studies used comparative visual analytics approach to compare the use of data for better decision making of blood test result [[18](#bib18)] [[14](#bib14)].

* 1. Context of use

**M**ost popular users of the dashboard were healthcare staff. Four studies were carried out for the basic healthcare unit [[18](#bib18)] [[23](#bib23)] [[14](#bib14)] [[17](#bib17)]. Two studies focused on patient’s decision making for the preferred treatment choice [[5](#bib5)] [[8](#bib8)]. Other studies targeted dashboards for the emergency department and ICU [[11](#bib11)] [[10](#bib10)]. Moreover, dashboards were focused on specific users; including patients [[5](#bib5)] [[8](#bib8)] nurses, directors, physicians [[23](#bib23)] [[11](#bib11)] [[10](#bib10)], analysts, insurance providers [[18](#bib18)], healthcare consumers and practitioners [[17](#bib17)] [[14](#bib14)]. The basic purpose for the dashboards was to provide vital information in such a way that makes decision making easier.

* 1. Outcome

A study targeted Taiwan hospitals showing the effectiveness of decision making using dashboards in multiple departments [[23](#bib23)]. The proposed dashboard displayed the overall performance of the department as well as individual care stage of each patient in the emergency department, the provision of such information aided decision making with respect to available resources as well as next level (future) care required for the patient [[11](#bib11)]. Dashboards designed for patients to make a treatment choice showed a significant difference in the confidence of decision making [[5](#bib5)][8]. The proposed system delivers multivariate biometric data by transforming it into temporal resolution helping the ICU staff by providing all the critical information on one screen and improving the accuracy of decision making [[10](#bib10)]. Providing three different comparative dashboards for three different users of the same healthcare unit, which allows each user (physician, analysts, insurance providers) to interpret an insight visualization combined with graph showing blood test result, money spend over time and also geospatial money spending to aid decision making to each respectively [[18](#bib18)]. Two focus groups evaluate the best possible visualization of system CLABSI (central line-associated blood stream infection) for effective decision making, six visualization mockups were presented, showing heatmaps and boxplots as the preferred visual aid for decision making [[17](#bib17)]. This study used different comparative interfaces to visualize and analyse the psychiatry of patients including demographics, visit time, and treatment etc. psychiatry. Ad-hoc filter data with instant updates to data view allow for the evaluation of treatment opinion and better aid decision making [[14](#bib14)].

* 1. Dashboard characteristics

Since all the included studies address dashboards for decision making, different visual representations were used. Most of the studies found tables and different graphs as appropriate methods for providing important information. Study [[23](#bib23)] did not specify any single representation but provide different graphs that have a great deal of variability, given that dashboard design have not yet been standardized, hence hospitals have their own bespoke designs with the combination of color coding, graphs, tables etc. One study [[11](#bib11)] uses icons and a color coding scheme to display patient information with respect to a specified threshold. Other studies [[5](#bib5)] used colored graphs or tables to differentiate the treatment choices, effects and other significant data. Whereas two studies opted for a combination of graphs, tables and traffic lights as visualization media [[18](#bib18)] [[14](#bib14)]. Only study [[17](#bib17)] used heat map, boxplot and tree maps for the information representation. Alongside theses display medias, various buttons or icons are also available for the users to access the related detailed information.

1. Discussion

The aim of this review was to evaluate the evidence on the trend of adopting dashboards as a tool to aid decision making in healthcare. Overall, the results of all 8 studies focused on the effectiveness of clinical decision making using dashboards, i.e. more than 150 hospitals of Taiwan believed that visual analytical display has contributed in making better clinical decisions. Paper [[23](#bib23)] introduced a dashboard in ICU displaying the critical patient information with the stage of care provided giving a precise yet brief summary of important data to make effective and fast decision [[10](#bib10)]. Dashboards for aiding decision making at the patient’s bedside, summarizes all the treatment choices along with the effectiveness and side-effects with different color codes to provide the user with ‘useful and actionable’ data [[5](#bib5)] [[8](#bib8)]. While [[11](#bib11)] [[18](#bib18)] [[17](#bib17)] [[14](#bib14)] articles show the contribution of dashboards in aiding decision making in different medical department of healthcare organizations. How information is being displayed also plays a vital role in decision making [[24](#bib24)] [[19](#bib19)]. In this review we have observed the use of different display media. Most of the studies used a combination of color codes and different types of graphs or tables [[12](#bib12)-[17](#bib17)] , however, studies [[18](#bib18)] [[14](#bib14)] used traffic lights to highlight and display important results based on the traffic lights alert system where red indicates actions to be takes or attention required, orange shows the borderline results and green indicates the normal condition with no actions required. This follows the recommendation on risk presentation in a general context where red/yellow/green is universally understood and considered as a straightforward method of addressing risk information [[7](#bib7)]. Although all the reviewed studies indicated the usefulness of a clinical dashboard in terms of decision making with positive effects on outcomes, there are still a few limitations with the design study sample size, evaluation/analysis evidences, targeting specific department/organization only.

1. Future research

There are number of unaddressed issues in the evidence of designing a study for the presentation and evaluation of decision making through dashboards. It is important to consider the effectiveness of display medium/form. Dashboards are often displayed as a screensaver for the computer terminals which allow users to access the information [[12](#bib12)] [[25](#bib25)] [[13](#bib13)] whereas some dashboards are continually available to the clinicians [[16](#bib16)] and some dashboards require user initiative or a login to see the required information. It would be insightful to evaluate the effectiveness of how dashboard has been presented in terms of clinical decision making. Further work also needs to be conducted to identify the areas where dashboards can be most effective to aid decision making for better patient care.

* 1. Review of Limitations

**A**lthough we have included several established electronic research databases in our review search process, we could not search through all databases. We did not include studies in different languages which may have limited the findings. Similarly, for accessing the related articles and studies excluded by the first reviewer was then assessed by the other reviewer. This was to ensure the papers excluded by first reviewer are not related (rather than having both the reviewer assessing independently).

* 1. Conclusion

This review was conducted to evaluate the current scientific research evidence available on the use of dashboards for aiding decision making in healthcare. Eight studies were identified that evaluate dashboards across a variety of contexts. It is evident that studies have considerable heterogeneity with regards to dashboard designs, experimentation and settings in terms of study design, sample size, display media, analysis techniques, and the type of users (patients, managers, nurses, clinician) who have been targeted as the users of dashboards. The result of this review suggests that there are evidence available on the clinical use of dashboards for aiding decision making which can improve the quality of decisions/outcomes. However, a great deal of research is still to be done providing a key opportunity for researchers.

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