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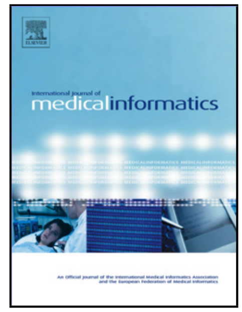

Title: Dashboards for Improving Patient Care: Review of the Literature

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HIGHLIGHTS

- There is heterogeneity in the setting where dashboards are used.
- There is heterogeneity in the design of dashboards and users targeted.
- Dashboard use may be associated with improved outcomes in some contexts.
- It is unclear what dashboard characteristics are related to improved outcomes.

Dashboards for Improving Patient Care: Review of the Literature

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KEYWORDS: Clinical Dashboard; Quality Indicators, Health Care; Decision Support Systems, Clinical; Decision Making, Computer Assisted; Performance Measurement

Abstract

Aim: This review aimed to provide a comprehensive overview of the current state of evidence for the use of clinical and quality dashboards in health care environments.

Methods: A literature search was performed for the dates 1996 to 2012 on CINAHL, Medline, Embase, Cochrane Library, PsychInfo, Science Direct and ACM Digital Library. A citation search and a hand search of relevant papers were also conducted.

Results: One hundred and twenty two full text papers were retrieved of which 11 were included in the review. There was considerable heterogeneity in implementation setting, dashboard users and indicators used. There was evidence that in contexts where dashboards were easily accessible to clinicians (such as in the form of a screen saver) their use was associated with improved care processes and patient outcomes.

Conclusion: There is some evidence that implementing clinical and/or quality dashboards that provide immediate access to information for clinicians can improve adherence to quality guidelines and may help improve patient outcomes. However, further high quality detailed research studies need to be conducted to obtain evidence of their efficacy and establish guidelines for their design.

1. Introduction

Dashboards are a tool developed in the business sector, where they were initially introduced to summarize and integrate key performance information across an organization into a visual display as a way of informing operational decision making [1]. Originally derived from the concept of balanced scorecards (which are internally focused and look at current organizational performance), quality dashboards provide information on standardized performance metrics at a unit or organizational level to leaders, to assist with operational decision making [1]. A clinical dashboard is designed to "provide clinicians with the relevant and timely information they need to inform daily decisions that improve the quality of patient care. It enables easy access to multiple sources of data being captured locally, in a visual, concise and usable format."[2] The key characteristics of quality and clinical dashboards, which separate them from computerized decision support systems (CDSS) or data provided by an electronic medical record (EMR) system include *a) the provision of summary data on performance measured against metrics (often related to quality of care or productivity*) and b) *the use of data visualization techniques (such as graphs) to provide feedback to leaders or individual clinicians.* With the introduction of Health Information Technology (HIT) the feedback provided by quality and clinical dashboards can be as near to 'real time' as possible; this is in contrast to more traditional methods of feedback on performance which often give data back to a provider or group days or weeks after an event has taken place [3].

Increasingly, health care organizations are introducing dashboards as a way of measuring and improving the quality of care provided by their organizations. For example, in the UK a 'quality dashboard' is being developed by the Department of Health for England and Wales to provide a measure of National Health Service (NHS) Trust (provider) performance, including information about the number of registered nurses per bed, doctor-to-bed ratio, staff and patient survey results, hospital acquired infection rates and mortality ratios [4]. This information will then be used by commissioners (purchasers) of healthcare to inform their decision making about the quality and outcomes of the services they commission. More generally, three recent reports have called for comprehensive, real time HIT to be integrated into clinical and management processes in NHS Trusts in order to improve quality of care and patient safety [5-7]. In the United States (US), the Hospital Compare website (http://www.medicare.gov/hospitalcompare/search.html) provides information about the quality of care at over 4000 hospitals receiving public funding to help consumers make decisions about where to get healthcare and to encourage hospitals to improve the quality of care that they deliver. In Canada online clinical and financial dashboards have been employed by national, provincial, regional and hospital organizations to report on indicators of health system performance such as mortality and birth rates, admission and readmission rates, emergency room visits and wait times (too illustrate a few)[8-12]. In 2013 the Canadian Institute of Health Information (CIHI), a national body whose partners include Health Canada, Statistics Canada and ministries of health from each of the provinces and territories, began working on a project aimed at strengthening its pan-Canadian reporting on healthcare system performance. This national effort emerged in response to a consultation process undertaken by

CIHI with healthcare system managers from across Canada. Managers suggested that healthcare organizations are currently reporting on many healthcare system indicators and this has led to "indicator chaos". CIHI's work is expected to lead to a more structured and coordinated a reporting system on indicators of health system performance for specific groups (e.g. Canadian citizens, provincial ministry of health policy makers, and regional health authorities and health care facilities executives and managers), and interactive web and business intelligence tools that will facilitate managerial and executive decision-making [8].

However, what is currently unclear is the impact that introducing quality and/or clinical dashboards have upon desired outcomes. Existing evidence evaluating the effect of introducing HIT systems such as Computerized Physician Order Entry (CPOE) highlight how unintended consequences can occur once such systems are introduced [13-18], and the evidence base supporting the effectiveness of CDSS to improve patient outcomes is equivocal [19]. Similarly, the literature on the effects of using quality measures to improve performance at an organizational level highlights the problems that dashboards can introduce, such as incentivizing certain behaviors or outcomes at the expense of others. Consequences can include tunnel vision (i.e. only focusing on the aspects of performance that are measured, while at the same time displacing other important but unmeasured aspects of performance) and measurement fixation (an emphasis on meeting the target rather than the overarching purpose of care) [20-22]. Whilst the use of visual information can help reduce information overload and improve understanding of data and the ability to remember information [23], it is unclear how the different types of visual display used in dashboards may affect comprehension and decision making, although the way in which information is presented (e.g. icon displays vs. tables, pie charts and bar graphs) has been shown to impact on the accuracy of decisions taken by clinicians [24] . At a time when health care organizations are being encouraged to introduce dashboards in order to improve quality of care and patient safety, it is important to review the effect of quality and clinical dashboards on care processes and patient outcomes and to understand how variations in the design of dashboards impact their effectiveness.

1.1. Objectives

This review of published literature was conducted to assess the current state of evidence for the use of clinical and quality dashboards in health care environments. The objectives of the review were to:

- Evaluate outcomes (patient and care process) associated with the implementation of clinical and/or quality dashboards
- Identify if and how clinical and/or quality dashboards impact on clinician decision making and behavior
- Determine the most common design approaches to display information in dashboards

2. Methods

We conducted a rapid review of literature related to quality and clinical dashboards. There is no consensus on the exact methods for conducting a rapid review, which is a "streamlined approach to synthesizing evidence in a timely manner." [25]. In this instance we wished to gain an overview of existing evidence in a newly developing field of enquiry, in order to provide consensus for future research and to respond to rapid developments in health system and policy development. Rapid reviews exercise different approaches to rationalizing some elements of a more traditional systematic review methodology (such as limiting search strategies, record screening processes) to produce overviews of evidence in shorter time frames [26]. The aim of the review, in conjunction with the time and resources available meant that it was an appropriate method for our study.

2.1 Study Inclusion Criteria

Intervention: Studies were included in the review if they described an evaluation of the use and impact of quality or clinical dashboards. A definition of each type of dashboard is provided in Table 1. It was recognized that some systems may integrate the functionality of both a quality dashboard and a clinical dashboard. A dashboard may be viewed on a computer screen or via another form of display such as an interactive whiteboard. We did not include paper-based systems.

Quality Dashboard	**Health IT** that provides a **visual display of quality or productivity indicators (metrics)** to enable managers at the organizational and/or ward/unit level to identify areas of practice for improvement.
Clinical Dashboard	**Health IT** that provides **a visual display of quality or productivity indicators** to individual clinicians to "provide clinicians with the relevant and timely information they need to inform daily decisions that improve the quality of patient care"[27]. They may provide data at the level of the patient, at the level of the healthcare professional (showing all patients that they are caring for and comparing them with their peers and national benchmarks), or may allow the user to move between viewing information at both of these levels [28].

Table 1: Definition of Quality and Clinical Dashboards

Participants: All healthcare professionals and managers at the organizational and/or ward/unit level within healthcare organizations using the dashboard.

Study design: All study designs were included in the review as long as they took place within a healthcare organization.

Performance and Outcome measures: All reported performance and outcome measures reported in reviewed literature were considered. This included qualitative and quantitative data on both measureable impacts and staff/patient perceptions. Studies without a formal evaluation component were excluded and where a dashboard was one part of an intervention, where the visual display of metrics was not provided by Health IT (i.e. print outs of dashboards) and where it was not possible from the results to distinguish between the impact of the dashboard and the other intervention components.

2.2. Search Strategy

We searched the following electronic databases using the search strategies listed in Appendix 1: CINAHL, MEDLINE, MEDLINE In-Process & Other Non-Indexed Citations, EMBASE, Cochrane Library (Wiley), PsychINFO, Science Direct and ACM Digital Library for the dates 1996 to Nov/Dec 2012. Search strategies were developed using free text terms referring to the technology (‘dashboard’ and ‘scorecard’) and combining them with relevant subject headings (e.g. ‘benchmarking’, ‘physicians’ practice patterns’, ‘Electronic Health Records’) and, for non-health care databases, domain terms such as ‘health’ and ‘nursing’. Due to limited time and resources available for translation, the search was restricted to studies in English, French, German, and Spanish. A hand search of the reference lists of identified relevant papers and a citation search of relevant papers was also conducted. All search results were collated in an EndNote library, where duplicate references were identified and removed.

2.3 Study Selection

All retrieved records were screened based on title and abstract using the algorithm in Figure 1. Full text copies of potentially eligible papers were retrieved and re-screened. As appropriate for a rapid review a 'liberal accelerated' approach to both rounds of screening was taken, where one reviewer reviewed all records/full text papers and a second reviewer reviewed records/full text papers excluded by the first reviewer [25]. This approach is less time and resource intensive than having two reviewers review all records/full text papers while maximizing inclusion, increasing the number of records/full text papers identified in comparison to a single reviewer [26].

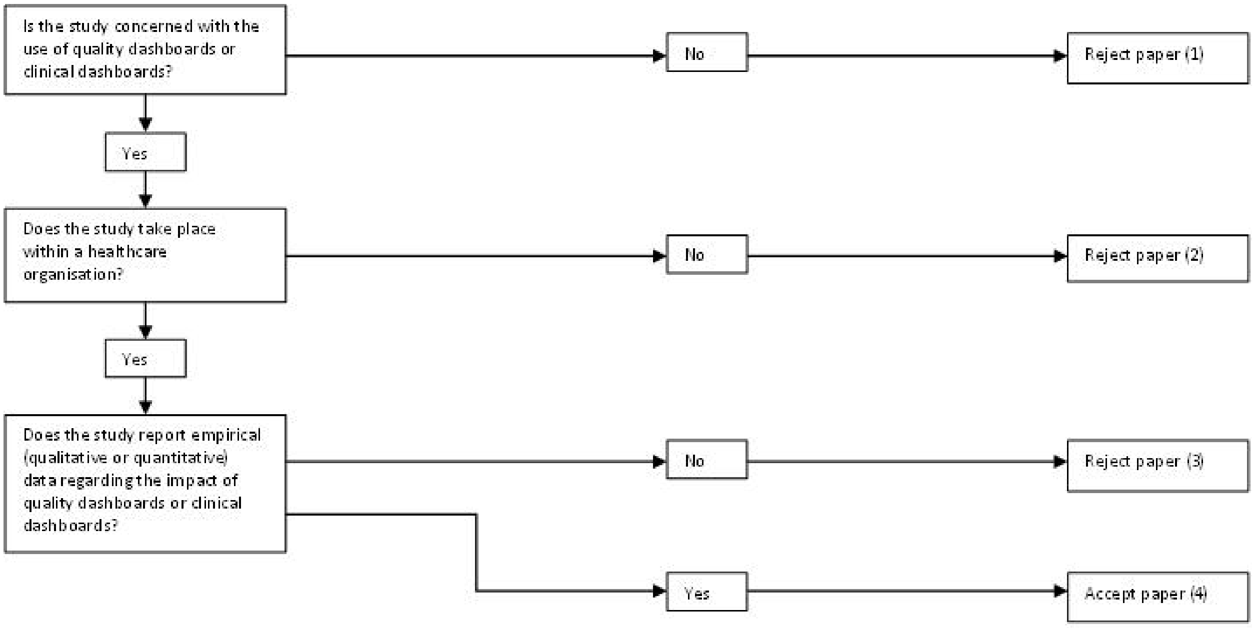

Figure 1: Algorithm for screening records

2.4 Data extraction, analysis and synthesis

Initial data extraction for included studies was undertaken by a single reviewer who used a matrix constructed on an Excel spreadsheet to collate information for each study on:

- Study design, sample type and size, and setting
- Nature of the intervention and (where present) control condition and any changes made to the intervention during the period of the study
- Any reported process and outcome measures
- Specific features of the dashboard used (e.g. nature and type of visualization of data)
- Factors influencing implementation or outcomes

Extracted data was checked by a second reviewer and disagreements were resolved through discussion.

A narrative synthesis of the data was carried out, focusing on the types of dashboards used in the included studies, the contexts in which they have been introduced, and the evidence for their impact on processes and outcomes. It was not appropriate to carry out a meta-analysis on the data due to the heterogeneity in interventions, processes measured and outcomes across the included studies.

2.5 Quality assessment

Quality of studies was assessed by different guidelines depending on their study design. The Cochrane Effective Practice and Organization of Care (EPOC) risk of bias guidelines for RCTs, non-randomised controlled trials and controlled before-after studies was used to evaluate studies with a separate control group [29]. The EPOC guidelines for interrupted time series studies (ITS) was used to evaluate ITS studies and also used to assess risk of bias for studies monitoring changes over time. The quality of questionnaire studies was evaluated using an adapted checklist from Greenhalgh et al [30]. All three guidelines required a yes/no/unclear response on a set of questions, with the RCT guidelines having a potential score between 0 (high risk of bias) through to 9 (low risk of bias), the ITS guidelines a potential score of 0 (high risk of bias) through to 7 (low risk of bias) and the questionnaire studies a potential score of 0 (high risk of bias) through to 8 (low risk of bias). We considered studies to have high quality if all responses were yes, fair to good quality if at least half of the responses were yes and low quality if less than half the responses were yes. The quality of studies was independently assessed by two reviewers and the level of agreement was calculated using Cohen's kappa. The kappa score provides an evaluation of agreement taking into account the amount that would be expected by chance, with a kappa score of 0-0.20 representing poor agreement and 0.81-1.00 very good agreement [31].

For studies where there was disagreement the two reviewers had a discussion and reached consensus.

3. Results

3.1. Study Selection

A total of 537 citations were identified through database searching and a further 11 through citation searching. After initial screening we identified 195 potentially relevant articles; of these 73 were excluded, 68 were conference abstracts with no full text available and 5 were inaccessible. 122 full text papers were retrieved for further screening of which 111 were excluded either because they were not about dashboards (n=76) or did not contain any empirical data (n=35), leaving 11 studies included in the final review (Figure 2).

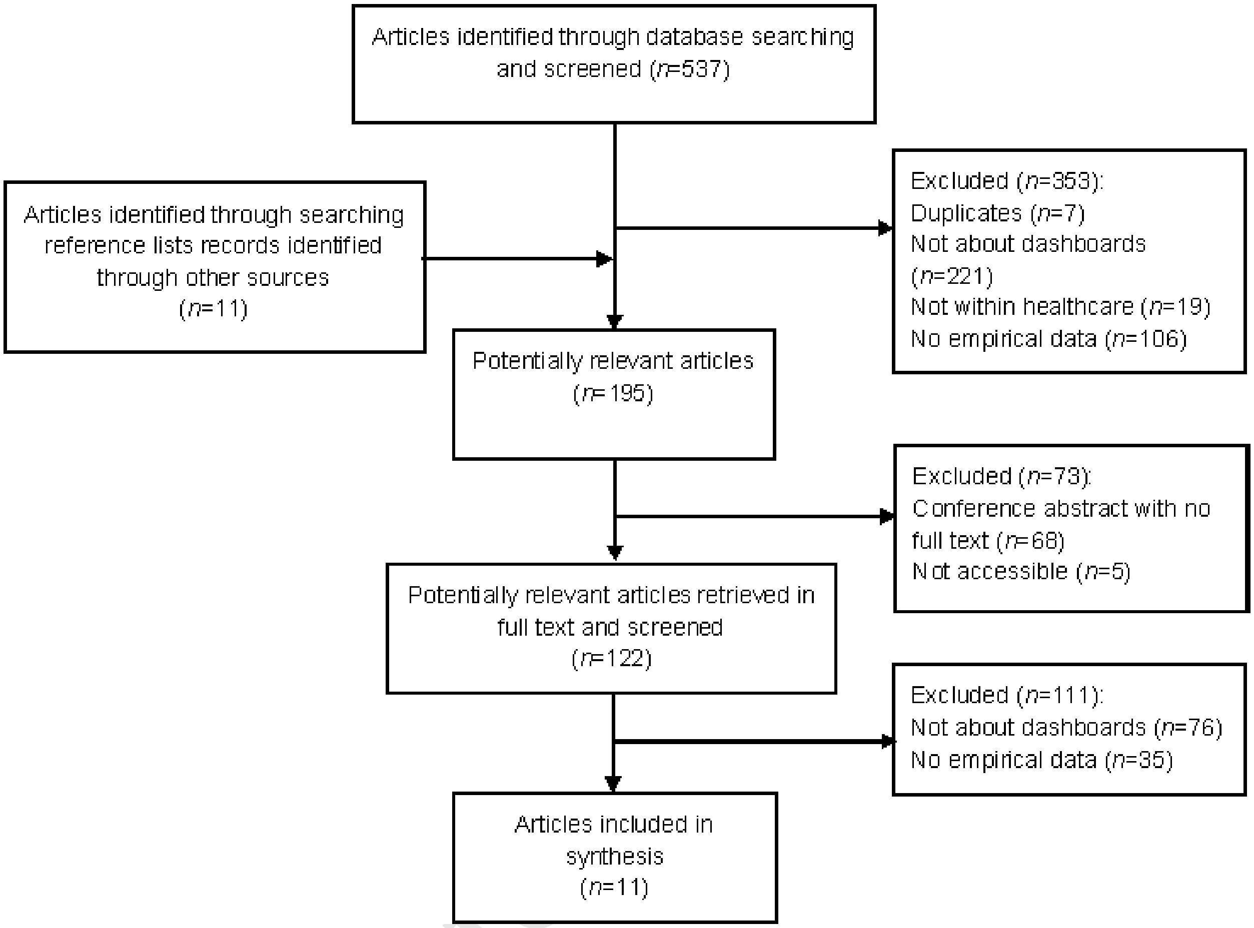

Figure 2: Flow diagram of included and excluded studies

3.2. Study Characteristics

Characteristics of the included studies are summarized in Table 2. One of the studies was a cluster randomized controlled trial, designed to evaluate the effect of introducing the dashboard on patient outcomes [28]. Two studies used an interrupted time series design to monitor the effect of introducing the dashboard on outcomes over time [32, 33]. Other study designs included before-after studies [34-36], non-comparative evaluations [37, 38], questionnaire surveys of users of dashboards [2, 39] and a usability study [40]. With two exceptions [28, 37], the dashboards were evaluated in one organization, where they had been developed and implemented.

3.3. Quality Assessment

Overall one study was rated as being of high quality [33], four as being fair-good quality [28, 32, 35, 40] and five as low quality [2, 34, 37-39]. The kappa coefficient between the two raters was 0.92 (95% CI 0.82-1.00) indicating very good agreement. The one cluster randomized trial was rated as fair-good quality [28], and of the two ITS study designs one was rated as high quality and the other as fair-good quality [32, 33].

Study	Design	Sample	Intervention	Control	Process/Outcome Measures	Key Design Features	Quality Assessment
Ahern et al (2012) [34] USA	Before-after study. By end of study all patients had access to navigator.	Patients with hypertension (n=20)	Patient navigators use clinical dashboard to monitor patients' Blood Pressure (BP) – used to flag communications to primary care team	All patients used internet portal to monitor blood pressure. One group also had access to navigator.	Patients receptive to the program and would recommend it to others. No data on effect on BP measures.	Dashboard used traffic light system to highlight BP measurements in or out of range. Patients required significant technical support.	*Low*
Batley et al (2011) [39] Lebanon	Questionnaire survey	Various clinical staff (n=175)	Emergency department (ED) clinical dashboard. Integrates information from laboratory and radiology results. Layout in form of ED cubicles.	None	Primary outcome – prescribing of antibiotics for Acute Respiratory Infection – no significant difference. Clinicians who used the dashboard less likely to prescribe antibiotics. 52% reported difficulties with access	Use of traffic light system to indicate whether results reviewed (red; new result, green; reviewed).	*Low*
Daley et al (2013) [2] UK	Questionnaire survey Undertaken 3 months after implementation	Mental health professionals (n=21)	Clinical/Quality dashboard tracking number of measures such as available beds, length of stay, % risk assessments, % falls, multidisciplinary team (MDT) assessments	None	Improved access to information (62%); increased communication and information-sharing (48%); increased staff awareness (43%); data quality (33%); difficulties accessing dashboard (52%); service disruption (19%); duplication of information (10%). Recorded MDT meetings increased from 54% at	Use of variety of different graphics (including bar chart, pie chart, tabulated data) to present information, with color coding	*Low*

					baseline to 94% at 6 months; recorded falls assessments increased from 0% at baseline to 82% at 6 months.		
Koopman et al (2011) [40] USA	Usability study	Primary care doctors (n=10)	Diabetes dashboard providing view of Electronic Medical Record (EMR) data	EMR	Total time on task, finding 10 data elements: 1.9 minutes (SD = 0.6) with dashboard vs 6.3 minutes (SD = 2.2) with EMR (*P* <.001); mean actual time on task (total time minus writing time): 1.3 minutes (SD = 0.6) with dashboard vs 5.5 minutes (SD = 2.1) with EMR (*P* <.001); number of mouse clicks: 3 clicks (SD = 4) with dashboard vs 60 clicks (SD = 16) with EMR (*P* <.001); accuracy: 100% with dashboard vs 94% with EHR (*P* <.01).	Use of spark-lines or word size graphics – most data presented in tabular form – use of traffic light system to highlight status of patient on quality performance measures	*Fair to Good*
Linder et al (2010) [28] USA	Cluster randomized controlled trial 9 month intervention (November 2006 - August 2007), monthly	Primary care practices (n=27). 258 clinicians in intervention group.	Acute respiratory infection (ARI) dashboard, displaying clinician's performance against peers and national benchmarks, accessed from EMR reports central area. Can drill	Usual care	No significant difference in antibiotic prescribing for all ARIs (primary outcome), antibiotic-appropriate ARIs, non-antibiotic-	Dashboard used data summarized as bar graphs – comparison of individual with peers and national benchmarks. 28% of clinicians in intervention	*Fair to Good*

	email reminders		down to patient records.		appropriate ARIs, or any individual ARI. Clinicians who used the dashboard were less likely to prescribe antibiotics for all ARIs (*P* = .02) and non-antibiotic-appropriate ARIs (*P* = .004).	group used the dashboard (no incentive to use it).	
McMenamin et al (2011) [37] New Zealand	Non-comparative study 15 months, other interventions related to smoking, alcohol, and breast screening happened at same time.	Primary care practices (n=35)	Patient dashboard linked to EMR – provided clinician with color coded indicators for agreed patient health targets (e.g. recording of smoking status)	None	Recording of smoking status increased from 74% to 82% and of alcohol use from 15% to 47%. Screening for diabetes increased from 62% to 74%, cardiovascular risk assessment from 20% to 43%, cervical screening from 71% to 79%, and breast screening from 60% to 80%.	Display listed various health indicators with use of traffic light color coding to indicate if met or not. Each indicator link to tool that supported patient management.	*Low*
Morgan et al (2008) [35] USA	Before and after study and questionnaire study 3 study periods, each 10 months: no dashboard, unintegrated dashboard (not integrated with signing tool),	Radiologists (n=47 in before/after study, n=72 questionnaire study)	Radiology dashboard integrated into Picture Archiving and Communications System and pulling data from the radiology information system, with color coded alerts at the individual, division, and department/hospital level. Individual alerts	None	Significant difference in turnaround time for signing reports between 'no dashboard' and 'integrated dashboard' and 'unintegrated dashboard' and 'integrated dashboard', no significant	Use of 'traffic light' color coded alerts. System was always visible and provided link to unsigned reports.	*Fair to Good*

	dashboard		indicated unsigned reports.		difference between 'no dashboard' and 'unintegrated dashboard'. 42% agreed or strongly agreed with 'The dashboard helps to guide what I do next', 76% agreed or strongly agreed with 'I sign reports more often with the dashboard in place.'		
Pablate (2009) [32] USA	Time series analysis Phase 1 control 20 weeks, Phase 2 dashboard 16 weeks, Phase 3 dashboard and text message 6 weeks	Anesthetists (n=29)	Screensaver dashboard providing feedback on timeliness of anesthetists' preoperative antibiotic administration	None	Percentage of documented on time antibiotics: Phase 1: 66.7%, Phase 2: 79.2%, Phase 3: 84.2%, p = <.001	No detail on visual display for screensaver	*Fair to Good*
Starmer et al (2008)* [36] USA	Before and after study	Not clear (presumably nursing staff)	Ventilator management dashboard, presented as a screensaver and accessible from EMR with indicators for each patient for each element of ventilator management bundle	None	Increased compliance with bundle elements (RASS score, weaning, Head of Bed elevation, OB, oral care). Nurse Managers and Charge Nurses note that dashboard allows them to more quickly see when a nurse is becoming overloaded with patient and can divert resources.	Each indicator has traffic light status (green done, yellow imminent, red overdue/not done). Indicators not always up to date as reliant on timely documentation – problematic if workflow uses 'batch' documentation	*Not assessed as preliminary overview of same system reported by Zayfudin et al [33]*

					Reports of more frequent collaboration among members of healthcare team.		
Waitman et al (2011) [38] USA	Non-comparative study 183 day study period	Pharmacists (n=51; 28929 patient admissions)	Potential Adverse Drug Event (ADE) dashboard that integrates data from multiple clinical systems to highlight potentially high-risk medication scenarios, and allows user to drill down for information on particular patient	None	Warfarin cases requiring detailed review were reviewed an average of 4 times. All patients receiving aminoglycosides were reviewed at least once with the detailed patient page, with an average of 8 reviews per case. Detailed review of patients receiving heparin/enoxaparin occurred in fewer than 5% of cases. Generation of pharmacy comments varied from 100% of aminoglycoside cases (more than 3 comments per case), 50% of warfarin cases, and only 3% of heparin/enoxaparin cases.	Use of color coded alerts (red/green) with ability to see inter pharmacy communications by hovering over summary record page. Lower utilization possibly explained by monitoring of heparin/enoxaparin being a new requirement.	*Low*
Zayfudin et al (2009)* [33] USA	Interrupted time series analysis Pre-intervention period January	Nursing and medical staff	Ventilator management dashboard, presented as a screensaver with indicators for each patient for each	None	Average compliance with ventilator bundle improved from 39% in August 2007 to 89% in July 2008 (P < .001).	Use of color coding for indicators; green = in compliance, red = out of compliance, yellow = soon due	*High*

	2005 - June 2007 (30 months), implementation in July 2007, post-intervention period August 2007 - July 2008 (12 months)		element of ventilator management bundle		Rates of ventilator-associated pneumonia (VAP) decreased from a mean (SD) of 15.2 (7.0) to 9.3 (4.9) events per 1000 ventilator days after introduction of the dashboard (*P* = .01). Quarterly VAP rates were significantly reduced in the November 2007 through January 2008 and February through April 2008 periods (*P* < .05). For the August through October 2007 and May through July 2008 quarters, the observed rate reduction was not statistically significant.	Managers received daily reports on compliance levels	

*Evaluating the same dashboard

Table 2: Characteristics of Included Studies

3.1.1. Context of use

Four of the studies were carried out in primary care settings [28, 34, 37, 40], with the users of dashboards being primary care physicians (n=3) and patient navigators (n=1). Two of the studies appeared to be evaluating the same dashboard for ventilator management introduced into an intensive care unit (ICU) [33, 36]. Other clinical areas included the Emergency Department [39] and mental health services [2]. Alternatively, dashboards were focused on specific users; anesthetists [32], radiologists [35] and pharmacists [38]. The predominant focus of the dashboards was providing information for clinicians to enable them to make decisions about the clinical management of patients. One study [2] fitted our definition of a quality dashboard, in that it provided data for unit managers regarding quality measures as a way of improving service delivery, but also provided data that was intended to support clinician decision making.

3.1.2. Focus of decisions

The focus of the decisions that dashboards had been designed to support also varied across studies. These included providing feedback to help improve blood pressure management [34]; provision of information to reduce inappropriate prescribing of antibiotics [28, 39] or ensure appropriate prescribing of antibiotics [32]; monitoring of adherence to best practices for managing chronic conditions [37, 40] or adherence to the ventilator bundle in ICU [33, 36]; improvements in the timeliness of radiology reporting [35]; improving monitoring of potential medication adverse events [38] and for improving information about provision of mental health services [2].

3.2. Effect on Outcomes and Care Processes

Dashboards designed to provide information to clinicians regarding prescription of antibiotics for respiratory infections were found to have no overall effect on prescribing rates [28, 39]. However, both of these studies reported that those clinicians who actually used the dashboard were less likely to prescribe antibiotics (and therefore may have been more likely to be prescribing antibiotics appropriately). The majority of other studies reported generally favorable impacts of the implementation of dashboards; their introduction has been associated with a significant increase in the prescription of on-time antibiotics by anesthetists [32], increased compliance with the ventilator bundle and a possible associated decrease in ventilator associated pneumonia in ICU settings [33, 36], increased recording of smoking status and health screening for diabetes, cardiovascular risk, cervical and breast cancer [37], and improvements in the time taken for radiology reporting [35]. Two studies highlighted that using a dashboard appears to improve clinicians' ability to find information effectively [2, 40] and one study showed that using a dashboard may assist pharmacists to monitor adverse events associated with certain drugs [38]. Patients liked the dashboard system in the study by Ahern et al [34]; in the study by Daley et al [2] staff reported that their use of the dashboard led to improvements in communication and information sharing.

Overall therefore, in some contexts the use of dashboards appears to be associated with improved care processes and outcomes for patients. One of the key elements in the studies was whether or not clinicians actually used the dashboards available to them. This is particularly notable in the studies by Batley et al [39] and Linder et al [28], both of which reported that clinicians who used the dashboard were more likely to reduce inappropriate prescribing rates for antibiotics; however overall the results of these two studies indicated no difference with dashboard use, because of the proportion of individuals who opted not to use them. None of the studies explored how clinicians use and integrate the information provided by the dashboards into their decision making, and so provide few insights into why some clinicians opted not to use the dashboard information.

3.3. Dashboard Characteristics

Nine of the studies described using color coding to impart information to users, in the format of a 'traffic light' approach where green indicates that there is no action to be taken by the individual and red indicates that an action is required [2, 33-40]. The majority of the dashboards used lists of indicators in a table form, with color coding [33, 35-38, 40]. However, three studies also reported using other visual representations to impart information, such as bar graphs and pie charts [2, 34, 39]. One study provided no detail on the way in which information was presented to users [32].

There was variation in the ways in which users could access the information presented in the dashboard. In three studies, the dashboard was used as a screen saver for computer terminals in the unit [32, 33, 36] or was continually visible [35], meaning that clinicians had access to the information constantly. These studies also indicated positive outcomes (decreased VAP rates, increase in on time prescription of antibiotics, increase in turnaround time for signing reports) associated with the implementation of the dashboard. In the study by Linder et al [28], clinicians had to proactively access the dashboard from the EMR; in this instance there was variability in whether or not clinicians used the information. In other studies it was unclear how clinicians accessed the dashboard and used the information to assist with their decision making.

4. DISCUSSION

The aim of this review was to assess the current state of evidence for the use of clinical and quality dashboards in health care environments. As highlighted in the introduction, the use of clinical and quality dashboards, which aggregate metrics (such as performance or quality indicators) into a visualized format to provide feedback to clinicians and managers is increasing (7 of the 11 studies in this review have been published in the last 3 years). There has been much discussion of dashboards in the literature, with 106 articles identified in our search that provided overviews, opinion pieces, and accounts of the introduction of this technology. However, this review identified only 11 available full-text articles that reported an empirical *evaluation* of dashboards, considering either their impact on desired outcomes (either patient or professional behavioral) or clinician perceptions of the utility of such dashboards in clinical practice. Other studies were identified where the dashboard was one part of an intervention and it was not possible from the results to distinguish between the impact of the dashboard and the impact of other intervention components [41-45]. In our search, we also identified 68 potentially relevant conference abstracts for which no full text paper could be located, suggesting that research is being undertaken in this area but that it is in the early stages. This may also be due to the relative newness of this technology in health systems.

Overall the results of the 11 studies highlight a mixed picture; for example the introduction of a clinical dashboard to assist with ventilator management in ICU may be associated with a reduction in the number of ventilator associated pneumonias (presumably through the mechanism of improving clinician adherence to the ventilator bundle, a set of interventions that together have been shown to reduce VAP rates) [33, 36] but was not associated with an improvement in antibiotic prescribing for Acute Respiratory Infections [28, 39]. These variations in outcome are likely to be due to a complex pattern of reasons, including the availability of the dashboard itself, the types of information that it displays and the ease with which clinicians can act on the information provided by the dashboard. For instance, those studies in the review where the dashboard was constantly in sight (via a screen saver or other means) reported more positive outcomes than those studies where clinicians had to choose to access the dashboard information. This reflects the wider literature on CDSS where it has been shown that CDSS that provide information to clinicians at the point of decision making are more likely to be associated with positive outcomes [46].

Clinical and quality dashboards are a specific kind of HIT which although distinct from systems such as CPOE may have similar characteristics in terms of their effect when implemented in health care organizations. A number of studies have highlighted how factors inherent in HIT systems or changes in an individual clinician's behavior (as a result of HIT implementation) may in turn lead to consequences of the technology which were unintended when it was introduced, or produce 'workarounds' to ensure that the technology 'fits' with existing work processes. Unintended consequences have been defined as "outcomes of actions that are not originally intended in a particular situation (e.g. HIT implementation)" [17] and are normally considered to be outcomes that are undesirable and are rarely anticipated [13-15, 17, 18]. What is apparent is that the introduction of HIT such as CPOE, rather than resulting in more effective, efficient and safer care, may result in a greater workload burden for clinicians, and different types of threats to patient safety [14, 15, 18]. As HIT systems are used in practice they have an impact on clinician workflow, communication patterns and the broader health care team, all of which may lead to outcomes that were not anticipated when those systems were introduced. What is not apparent from the studies in this review is the potential impact of dashboard introduction on clinical workflow and patterns of communication with the broader health care team. These insights are important to explore given the existing literature on the effects that using quality measurement indicators at an organizational level may have on individual behaviors, such as tunnel vision or measurement fixation [20-22].

The way in which information is presented to individuals may also affect the decisions they make [23, 24]. Nine of the eleven studies in this review presented information to clinicians using color coding based on a 'traffic light' alerting system, where red indicates a measure that requires action and green indicates that at present the indicator is 'normal' or that no action needs to be taken. This corresponds to the literature on presentation of risk information more generally, where it is acknowledged that the system of red/yellow/green is a universally understood and simple method for communicating risk information [47]. However, within the dashboards there was variation in the visual representations utilized to provide information to clinicians, from a predominant very simple table format (where buttons or lists are color coded) to pie charts and bar graphs. Further work needs to be conducted to explore how clinicians understand and interpret such information, and how this then impacts their decision making and behavior.

Although overall the majority of studies in this review indicated that the introduction of dashboards had a positive effect on outcomes and care processes (such as documentation of care processes, improved communication and access to information), there are a number of limitations with the study designs utilized to evaluate dashboards. With the exception of one study in the review which was rated as high quality [33], the majority of studies had some element of potential bias, with 5 studies being of low quality, meaning that any significant results should be treated with caution.

4.1. Future Research

There are a number of outstanding issues in the existing evidence base for the design and effectiveness of dashboards relating to data presentation, effect on decision making and purpose. Future studies of the introduction of quality and clinical dashboards could consider evaluating the effectiveness of providing information in the form of screen savers or other formats that are constantly available compared to dashboards that individuals have to actively seek to utilize. Additionally, research is needed on the impact of the introduction of quality and clinical dashboards on clinicians' decision making behavior and both the intended and unintended consequences of such technology. Further work also needs to be conducted to identify areas of practice where dashboards could be most appropriately introduced to target specific initiatives to improve the quality of care received by patients.

4.2. Review Limitations

As a rapid review, the methods applied utilized a streamlined approach to searching and evaluating papers for inclusion in the final review. Although we conducted a search of a number of electronic databases, we chose not to search the ‘grey’ literature or consider studies in all languages, which may have limited the findings. Similarly, we accelerated the process of assessing papers for inclusion in the review, by having a second reviewer only consider those papers that had been excluded by a first reviewer (rather than having two reviewers independently assess all potential articles). Our search strategy highlighted the difficulties involved in identifying potential articles for inclusion in the final review, with 76 articles (out of 122) rejected at the full text stage as it was apparent they were not about dashboards. This lack of search specificity is due to a variety of issues; firstly there is a lack of consistency in the use of keywords for studies that evaluate clinical or quality dashboards, and secondly often the dashboards are categorized as a quality improvement intervention, rather than a form of health information technology. Our search was necessarily broad, in order to ensure that we did not inadvertently miss any relevant studies, and it was often unclear from the study abstracts what the nature of the quality improvement intervention actually consisted of (and whether it met our definition of a dashboard) without evaluating the full text article.

4.3. Conclusion

This review was carried out to assess the current state of evidence related to the implementation and use of clinical and/or quality dashboards in health care settings. It identified 11 studies that carried out some form of evaluation of dashboards, across a variety of contexts. What was evident from the studies included in the review was the considerable heterogeneity in settings where dashboards have been used, the design of dashboards (e.g. use of text or graphs, use of colors, how information is presented to users) and the types of users who have been targeted by dashboard technology. The results of the review suggest that there is some evidence that implementing clinical and/or quality dashboards which provide constant access to information for clinicians (e.g. in the form of a screensaver) can improve adherence to quality guidelines and may help improve patient outcomes. However, it remains unclear exactly what characteristics of dashboards are related to improved outcomes.

AUTHOR'S CONTRIBUTIONS

All authors contributed to the conception of the review. RR led the design of the review, with input from all authors. EB, PD, GF, JF, SH, and ZWM reviewed the retrieved references, with RR acting as second reviewer. Papers were retrieved by RR, with assistance from EB, PD, and LC. RR reviewed the full text papers, with assistance from LC and GF for papers in French and German, with PG and DD acting as second reviewers. Data extraction and quality assessment was undertaken by RR and DD. DD led the writing of the manuscript, with all authors contributing or providing feedback and approving the final version of the manuscript.

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STATEMENT ON CONFLICTS OF INTEREST

The authors have no competing interests.

Summary Table

What is already known on the topic?

- Quality and clinical dashboards provide summary data on performance measured against metrics (often related to quality of care or productivity) using data visualization techniques (such as graphs) to provide feedback to leaders or individual clinicians to inform care decisions at organizational, unit or individual patient level.
- Introducing Health Information Technology such as dashboards can lead to unintended consequences.
- There is a lack of information on the impact of introducing visualized information in the form of clinical and quality dashboards on care outcomes and processes.

What has this study added to our knowledge?

- There is considerable heterogeneity in the settings where dashboards have been used, the design of dashboards and the targeted users of dashboard technology.
- There is some evidence that introducing clinical and quality dashboards can have a positive effect on care outcomes and processes of care.
- It is unclear what dashboard characteristics (such as type of graphical display, method of presentation to users) are related to improved outcomes, nor how clinicians incorporate use of dashboards into their everyday practice.

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APPENDIX 1: RAPID REVIEW SEARCH STRATEGY (WEB ONLY)

Medline (1996 – November week 3 2012) (OvidSP)

1. dashboard*.ti,ab.
2. score?card*.ti,ab.
3. Benchmarking/
4. quality assurance, health care/
5. Physician's Practice Patterns/sn [Statistics & Numerical Data]
6. Electronic Health Records/sn [Statistics & Numerical Data]
7. Decision Support Systems, Clinical/sn [Statistics & Numerical Data]
8. Medical Records Systems, Computerized/
9. 3 or 4 or 5 or 6 or 7 or 8
10. 2 and 9
11. 1 or 10
12. limit 12 to (abstracts and (english or french or german or spanish))