Clinician Perspectives on Dashboards at OHSU: A Qualitative Analysis

By

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CERTIFICATE OF APPROVAL

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T. Brady Wright, MD

Abstract

With the rising prevalence of healthcare information systems, enormous volumes of clinical data are readily available. As financial incentives for healthcare quality become a new reality, informaticians are facing increased pressure to discover new methods to use the electronic health record and accompanying data to improve clinical outcomes. A Dashboard- a unified display summarizing key information- can yield novel insights into data and aid in complex decision making. However, little is known about effective dashboard use in a clinical setting or at the point of care. To better understand the qualities of clinical dashboards that might facilitate adoption and effectiveness, we interviewed primary care clinicians at our institution. Data analysis using qualitative methods revealed common themes. We found that usability, accuracy, and relevance of data are critical. In addition, dashboard information should guide workflows and facilitate communication between developers and clinicians. We also identified system barriers and needed system facilitators at our institution. This knowledge might help guide future dashboard implementations targeting quality measures for population health.

Introduction

Thanks to the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009, Electronic Health Record (EHR) use is now commonplace (1). Through use of an EHR, a tremendous variety and amount of clinical and healthcare operational data can be collected, aggregated, and stored by healthcare organizations and affiliates(2). Using this data to improve the practice of medicine has long been touted as a key benefit of EHR technology(3). More recently, the evolving paradigm of payment for medical services has led to the concept of linking care quality to reimbursement and is highly dependent on EHR data(4). For a variety of reasons, using EHR technology and related data to improve clinical outcomes and healthcare quality is highly desired. However, the means to accomplish these goals is yet to be convincingly demonstrated in practice(5, 6).

A clinical dashboard presents one possible method for using EHR data to improve healthcare quality. In the literature, the definition of a dashboard varies widely(7-9). The term, borrowed from the main information display in a typical automobile, generally describes a visualization tool that succinctly summarizes key information to inform decision making(10). Dashboards may also track metrics over time, make predictions or projections, or even infer relationships between measures. The technical capabilities of published dashboards are also higly variable- ranging from a manually constructed spreadsheet to a fully-automated graphical visualization suite with drill-down and predictive capabilities(11-14).

As dashboards have the potential to leverage information technology to improve healthcare delivery, it is the task of clinical informaticians to evaluate the use of dashboards in the clinical space. In this manuscript, we will review what is known about dashboard adoption and effectiveness both in healthcare and in other service industries to formulate a research question. We will then review methods and results of our original research in an attempt to answer that question. Finally, we will discuss the implications of our research, how it adds to the current body of knowledge with regards to clinical dashboards, and considerations for future research opportunities.

Background

In service industries outside of healthcare, such as marketing, banking, or online services, dashboard use is common. Though dashboard development in these sectors is largely driven by the need for practical applications and marketing from software providers, there is quality research available that attempts to better understand dashboard adoption and use in these fields. While the context of use may be entirely different, the sociotechnical aspects of dashboard use in other service industries might provide useful insights into the development of dashboards for use in a clinical environment.

In 2009, Pauwels, et. al. published a thorough review examining the "marketing dashboard" (10). Though the review is now nearly ten years old, many of the challenges at the time appear to be highly relevant to the healthcare industry's exploration of dashboards today. This work reviews the purposes of marketing dashboards, how to develop effective dashboards, adoption and success of dashboards, and discusses a

research agenda to increase the value of dashboards for the service industry. The following section will discuss aspects of this work that may have relevance to dashboards in healthcare.

The Marketing Dashboard

Per Pauwels et. al., drivers for marketing dashboard development include data complexity, increasing accountability, individual bias in decision making, and the need to standardize performance reporting. In healthcare, many of these same drivers exist today. Thanks in part to the EHR, healthcare data is abundant and highly complex. The increased cognitive burden this causes clinicians is noted as one of the many unintended consequences of healthcare information technology(15). Increasing accountability has been a major goal for the healthcare industry ever since the Institute of Medicine's 2001 landmark publication called for fundamental changes to improve healthcare quality(16), and is even more true today with rising healthcare costs(17), in addition to the increasing need to balance costs, quality, and the patient experience(18).

Pauwels et. al. discusses how the marketing dashboard is able to fill its industry's needs by integrating data, processes, and viewpoints. Data is integrated and organized from disparate sources across the organization. Comparisons, such as between expenditures and performance measures, allow the integration and understanding of processes. Finally, by providing synchronized, standardized information, the viewpoints of stakeholders such as the executive leadership are integrated as well. The purpose of a marketing dashboard, then, is to enforce measure consistency, monitor performance, plan and strategize, and communicate values to stakeholders.

The purpose of a clinical dashboard might share many of these characteristics. Thanks to the EHR and accompanying technologies, the technical capability of integrating disparate data systems is currently achievable. Though interoperability between institutions is an ongoing conundrum, many healthcare organizations internally operate a centralized data warehouse that can used to provide information for applications such as dashboards(19). Yet, even with a central data repository, clinical quality measure standardization is a difficult challenge in healthcare(20). Without high quality standardized measures, performance monitoring, benchmarking, and strategic planning will be difficult to achieve.

A framework for the adoption and success of marketing dashboards is also proposed by Pauwels et. al. Their six-step framework is adopted from various prior models, such as the Technology Acceptance Model (21). It begins with supply and demand and, perhaps more importantly, the fit between these two constructs. Demand is determined by factors such as dashboard users or the decision style of the organization. Supply is more of a technical construct with consideration of factors such as drill-down capability and the visual display. Factors of supply and demand must complement each other for a dashboard to be successful. For example, if users demand detailed tables with quick drill-down capabilities to make certain decisions but are supplied highly visual, summarized graphical interfaces with no drill-down capability, the dashboard might not be successful.

The framework continues with implementation, predispositions, and finally adoption and success. The implementation of a successful marketing dashboard depends on factors such as support from upper management, prototyping with end-users, and a cooperative

IT department. Predispositions of the dashboard users include factors such as trust and attitude. Users should trust the technology and have a positive attitude that the dashboard will be useful in helping them accomplish their goals. Finally, adoption and success of a marketing dashboard is measured by factors of dashboard use, increasing accountability, improved effectiveness and efficiency, and learning.

Though this framework proposed by Pauwels et. al. may not be designed for a clinical dashboard, it bears strong similarities to frameworks developed for use in healthcare technology in general such as the Effective Technology Use Model (22). Both of these models build upon prior work, such as the Technology Acceptance Model, and modify them via added variables to better fit the context of use. One major difference between these models lies within the dependent variable- the definition of adoption and success. While both models evaluate effectiveness, the model proposed by Pauwels et. al. includes a component of organizational learning. They propose that effective dashboard use should allow management to make better decisions from data, both explicitly through model development, and implicitly through intuition.

Finally, Pauwels et. al. discusses remaining research questions for the marketing dashboard. Issues perhaps most pertinent to healthcare discussed include identifying important metrics and how to limit the number of metrics, and how to identify causal relationships between metrics. As discussed above, development of standardized quality metrics in healthcare is a challenge. Whether these metrics will be useful in a clinical dashboard, or the best way to limit them in number, is indeed unknown(7). Some

research indicates a negative impact from the increasing focus on computer-based quality metrics in healthcare (23).

Technology in healthcare is often compared to other industries, such as aviation, perhaps to the point of being cliché. There is often much to learn from these pioneers in technology development. Dashboards are no exception. We can draw many comparisons from the marketing dashboard and perhaps apply these towards a better understanding of clinical dashboards. At a minimum, we can use the lessons learned to guide our own research questions.

Dashboards in Healthcare

In healthcare, as EHR use has grown, the technology and data to create clinical dashboards is readily available. As such, dashboards have naturally been introduced into both the healthcare administrative and clinical areas. Published examples of clinical dashboards generally aim to improve the quality of some aspect of care delivery, and a few studies do show promise(24, 25). Further publications exist that provide insight into specific dashboard implementations or proposed implementations(12, 26-29), as well as insights into the measures that might be most useful on a quality dashboard(30). Such dashboard implementations typically borrow common visualization designs, such as the traffic light, and often hypothesize that data provided will lead to improvement. Despite this available research, very little is known about the effectiveness of dashboard use at the point of care(7). Studies that focus on clinician perspectives regarding the general use of dashboards in a clinical setting to improve population health are lacking.

To facilitate effective decision support, it is suggested that the right information needs to be presented to the right person, in the right format, through the right medium, at the right time (31). A challenge, then, is to discover what qualities are important for each type of decision support system. For example, a system aiming to reduce adverse medication reactions might yield the most benefit by interrupting the ordering provider during order entry. For decisions dealing with population health or quality, determining the appropriate information system behavior may be less intuitive since managing a patient population or panel requires a different approach than managing patients on an individual basis. In such cases, a clinical dashboard could be used as an effective form of clinical decision support.

Though we may gain some insight into what a clinical dashboard should entail through evaluation of similar dashboards in other industries, simple emulation and provision of metrics to clinicians yields questionable effectiveness. The nuances of healthcare, particularly those involving the clinician and the complex adaptive systems they practice within, should be further explored.

The aim of this research is to explore clinician perspectives on dashboards in a clinical environment, with a focus on dashboard adoption and effectiveness. We wish to gain a better understanding of dashboard qualities that are important to clinicians and the systems they practice in. This information may be used to inform future dashboard implementation initiatives which may ultimately lead to improvements in overall population health, healthcare quality, and patient outcomes.

Methods

After formulation of our research question, a qualitative methodology was felt to best fit our needs. While we can learn much from dashboards used in other industries, we first need to understand what constructs are important in healthcare and how these constructs interact with each other. Qualitative methods allow researchers to better understand phenomena in its natural context and develop theories to explain relationships between entities (32). We decided to start from a clean slate and allow our constructs to be derived directly from gathered data by using a grounded theory research model (33).

Setting

This IRB-approved study was conducted at large academic medical center in the Pacific Northwest United States from January to March 2018. This institution implemented the Epic EHR system (Epic Systems Corporation, Verona, WI) in the inpatient and outpatient settings in 2006 and 2007, respectively. Various flavors of clinical dashboards and scorecards, either embedded within the EHR or distributed otherwise, have been in use during this time.

The most widely used dashboards by our target participants were those developed by the Family Medicine and the Internal Medicine departments. The Family Medicine dashboard was implemented shortly after introduction of the EHR system and has evolved over time. A sample of the clinical portion of this dashboard is displayed in Figure 1. Sometimes referred to as a scorecard, this report sources data from the institution's clinical data warehouse and presents aggregated as well as individual

provider-level metrics pertaining to both clinical and operational performance. The Family Medicine dashboard is distributed via email as a PDF on a monthly basis and is actively used to drive quality improvement activities. Data is segregated by clinic- each PDF contains all data for each individual provider as well as aggregate data for a particular clinic. This PDF, and thus each individual provider's quality metrics, is shared with all providers in each clinic.

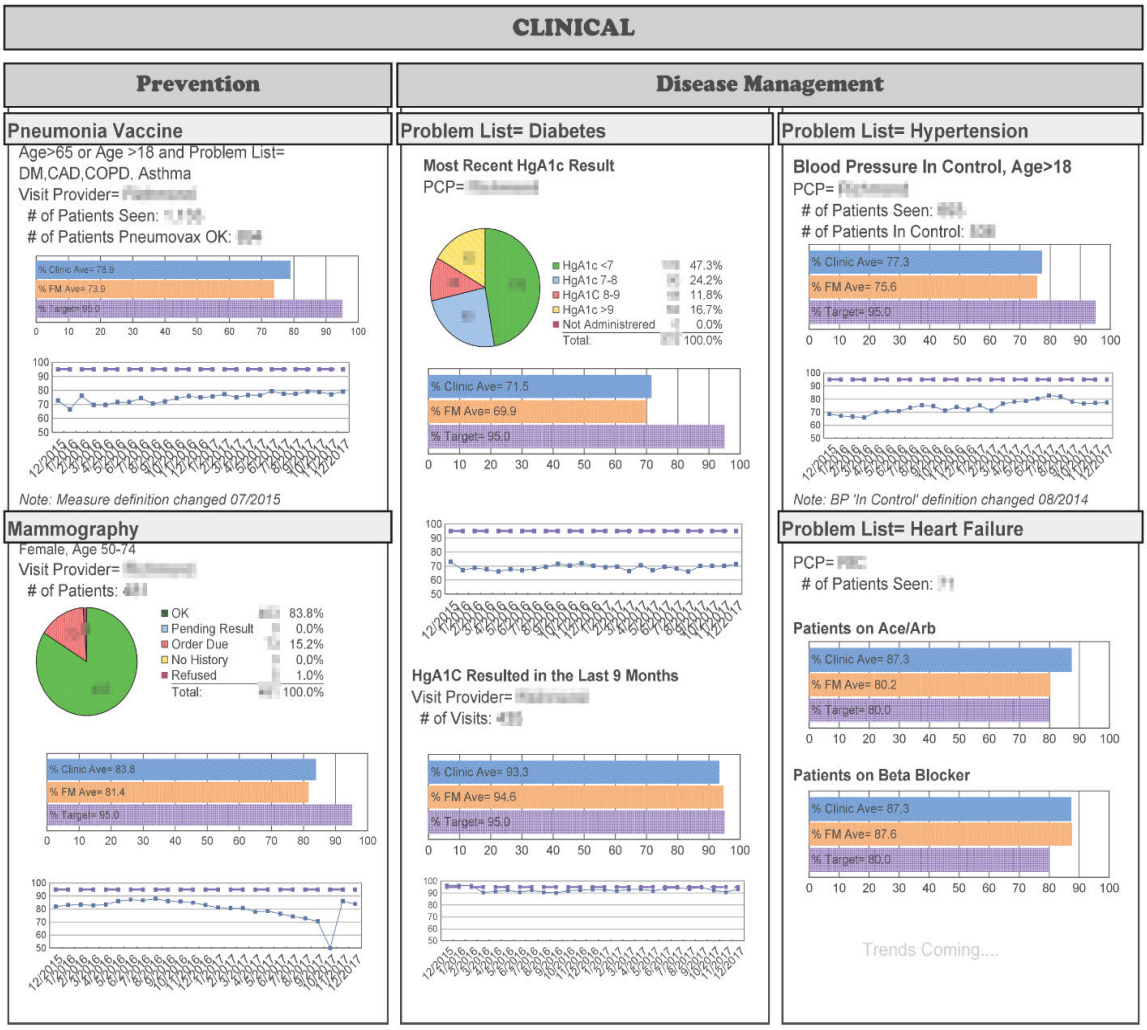

Figure 1: Family Medicine Dashboard - *Courtesy of The OHSU Family Medicine Data Team*

The Internal Medicine dashboard, on the other hand, is directly embedded within the EHR system. While all departments have a default widget-based landing page on log-in, the Internal Medicine department developed a widget that contains and embedded report that displays user-level clinical metrics in a graphical format. The underlying reporting software, much like the Family Medicine dashboard, also retrieves and aggregates data from the clinical data warehouse.

Interview Guide Development

A list of open-ended questions was developed to guide interviews and extract from participants constructs that may be pertinent to dashboard use in a clinical environment. Leveraging knowledge from background research, including the marketing dashboard review and our review of dashboards used in healthcare, an initial set of interview questions was developed. This list was reviewed by all members of the research team who then submitted feedback and suggestions. Our team includes members with expertise in clinical medicine, clinical informatics, executive leadership, project management, quality improvement, data analytics, clinical reporting, and qualitative research.

After some iteration, the interview guide received approval from all members of the research team. The guide focused around six broad categories including 1) general characteristics about the participant, 2) quality improvement and pay for performance, 3) dashboards use in general, 4) dashboard adoption, 5) dashboard effectiveness, and 6) accuracy and trust. The interview guide was additionally refined throughout the interview and analysis process. The final version of the interview guide is available for review in the supplementary materials.

Participants

To select participants for our study, we used a purposive sampling method(34) facilitated by a local quality improvement subject-matter expert. This individual has extensive experience working with clinicians on various quality improvement activities at this institution and was able to recommend clinicians who either had an active role in leadership or quality improvement, as well as clinicians who were felt to likely provide alternative viewpoints. To limit the impact of variables associated with clinical training, interviews were only offered to providers who, at the time of the study, participated in an active, independent clinical role in primary care.

Due to resource and time constraints, we set out to complete ten to fifteen interviews and limited the initial participant selection pool to twenty clinicians. Invites were distributed on a rolling basis. First, we invited at least one clinician in a leadership role and one non-leadership role from each target department. Effort was then made to include participants from as many individual clinics as possible. Further clinicians were invited as scheduling permitted. Through iterative analysis, saturation was felt to be achieved after eight completed interviews and invitations were halted. Ultimately, twelve clinicians were initially invited to participate. Six participants did not reply to the initial invitation- three of these were sent a second invitation, of which two responded and participated in the study.

Participants broadly represented both Internal Medicine and Family Medicine disciplines from various OHSU clinics around the area. All participants had extensive experience with the EHR system, either during their time at OHSU or during training. Please see

Table 1 for more detailed participant demographics. Please note some reported information is categorized broadly to protect participant confidentiality.

Study ID	*Gender*	*Department*	*Clinical Experience (post-training)*
101	F	Internal Medicine	5+ years
103	M	Family Medicine	5+ years
104	M	Family Medicine	5+ years
107	F	Family Medicine	5+ years
112	F	Family Medicine	1 - 5 years
115	F	Internal Medicine	5+ years
116	M	Internal Medicine	1 - 5 years
117	M	Internal Medicine	1 - 5 years

Table 1: Participant Demographics

Interviews

Selected participants were individually invited to participate in an interview via email using an IRB-approved template. If the participant agreed to interview, they were forwarded the study information sheet for review and were scheduled a one-hour time slot at a semi-private conference room on the University's campus. All interviews were performed by the same researcher in a one-to-one fashion. Interviews were audio

recorded using a laptop with a USB condenser microphone and the Audacity audio recording software (https://www.audacityteam.org/), as well as a handheld backup device. The laptop failed during one interview but the backup device was successfully used to recover all data.

Interviews began with introductions and verbal consent and then proceeded in a semi-structured fashion following the interview guide. All who were scheduled to interview fully consented and completed the interview within the allotted time frame. At the end of the interview, each participant received a piece of chocolate as a small token of appreciation.

Analysis

Audio recordings were manually transcribed verbatim using Microsoft Word (Microsoft Corporation, Redmond, WA). The transcripts were anonymized by either omitting personally identifiable details or replacing them with the internal study identification number during the transcription process. Transcripts and any compiled results were then tracked using only this study identification number. Final transcripts totaled 73 pages with 41,401 words.

Transcripts were analyzed using an open-coding strategy (32, 35). Initial codes were derived from highlighting and summarizing content directly on the transcripts. These codes were coalesced into primary descriptions of ideas which were extracted from the transcripts and compiled into a separate word processing document. The coalesced codes

were then printed out and cut into individual cards. Cards were then pile-sorted into categories to develop initial sub-themes, themes, and organization.

Finally, coalesced codes from each theme were used to identify exemplary quotes from the transcripts. In an iterative fashion, themes and sub-themes were reorganized, consolidated, and re-phrased to better express the underlying data. The final themes were validated through discussions with clinician and non-clinician subject-matter expert members of the research team.

Results

While interviews revealed much about clinician perspectives on dashboards, they also revealed a wealth of information regarding the complex adaptive system within which such dashboards would reside. To better distinguish these ideas, themes were organized into three main categories: characteristics of the dashboard itself, identified system barriers to dashboard success, and needed system facilitators. Table 2 summarizes the main themes and subthemes in each category. The following sections outline each theme and subtheme and present exemplary quotes.

	Theme	Subtheme
Key Dashboard Factors	**Usability**	Information clutter and a high number of clicks Customization can add value
	Accuracy	Clinicians are naturally suspicious of data Accurate information is actionable
	Relevance	Information should directly support clinical workflows
	Guidance	Data used for prediction, not just review Providing focus and communicating values Enable benchmarking
	Communication	Facilitate feedback and conversation with developers
Identified System Barriers	**Inflexible Metrics**	Misrepresentation of the care quality spectrum Not accounting for shared patient and clinician values Unintended consequences
	Variability in Clinician Attitudes	Clinician disengagement Transparency-related anxiety
	Misaligned Tools and Processes	Panel management Data entry tasks
Needed System Facilitators	**Alignment with Clinician Values**	Clinicians value good patient care Compensation methods
	System Support	Populations management Synergistic interventions Support staff and panel managers Dedicated time and structure
	Champions	Visible system and leadership support

Table 2: Themes and Subthemes by Category

Key Dashboard Characteristics

The first group of themes describe characteristics of the dashboard itself that were noted to be relevant to dashboard adoption and success.

Theme 1: Usability

Various aspects of usability were frequently cited as important for dashboard adoption. Clinicians desire tools that make effective use of visual cues and are generally quick and easy to use.

> *[117] So like, a diabetic, like, it's very clear, like, they've had, like, you know, I know the- whatever 5 or 6 things that they need to have every so often.* ***And I would just like that to be… easy to, you know- it would just work.***

Too much information, clutter, and a high number of clicks are detrimental to the user experience and will be prohibitive to adoption and use.

> *[115] So again,* ***too much information****… And honestly [laughs],* ***having to click too many times is always the thing that kills it.*** *Like, if you have to click twenty-five times to see the one thing you're looking for,* ***no one's going to go looking for it****. So, I would say that. I mean it's pretty basic.*

Some noted that enabling customization may alleviate these issues and add value by enabling them to emphasize their individual interests.

> *[116] I think it does need to be customizable because people- and in our clinic there's… there's women's health providers, there's geriatricians, there's sports med-type people.* ***There's all sorts of different niche interests****, and so... I would hope that we can…* ***emphasize our clinical interest in the dashboard****.*

Theme 2: Accuracy

Accuracy is critical for a successful clinical dashboard. Clinicians rely on available information to make medical decisions. Yet, clinicians have grown suspicious of EHR data and data presented does not always make sense because numbers either do not align with expectations or are clearly erroneous.

> *[112] And some of them- I still fight with our data team about some of them, because* ***I'm like 'these don't make any sense'*** *- I still don't know what any of these mean…*

Thus, clinicians hesitate to act on data that they do not understand. In a dashboard, clinicians want to understand the measures and how they are calculated.

> *[115] I think if you're gonna tie it to my reimbursement, or you know incentives in that way then* ***it's really important for me to understand … if it's something you want people to pay attention to, they should feel comfortable that they know what it's measuring and how it works***

Trustworthy, accurate information enables dashboards to be actionable.

[101] And I'd love to have stuff when the patient comes in or the patient calls in, to have it be accurate enough so that you can, it can be ***acted on*** *then…* ***The more accurate it can be, and to the level of detail that you need to be actionable at the patient level- the more useful it's going to be to the clinician.***

Theme 3: Relevance

Dashboard information should be relevant to provider workflows and scope of practice. Relevant information conveys meaning and can aid in the decision-making process, leading to actionable processes and workflows.

[116] I think, so, the ways it wouldn't work, is that it... it doesn't help, it's ***not pertinent information****. It just takes up space but doesn't actually like, it doesn't really help you in like, either the population management or the individual patient management. It just sort of- it is. Because I think that [the EHR] does this a lot,* ***just puts things in places so that they like look good, but it doesn't really do much.*** *And our clinic has built some things that like, look like graphs and charts, you know, a lot of line graphs about something-* ***but it doesn't really mean anything to the provider.***

Theme 4: Guidance

Dashboards should provide guidance to users. It is not enough to inform clinicians about the past- dashboards should be used for prediction & proactive actions.

> *[101] And I think that's the one thing we're missing- cause that's- the dashboard would go to them first.* ***With people who are approaching overdue, as opposed to waiting until they are overdue.***

Dashboards can provide focus across the organization and communicate values to clinicians, but this is likely limited in number and such messaging can grow stale if not updated regularly.

> *[115] I think the purpose of that is more to****… to serve as like a tickler or reminder*** *like, '****oh yeah, we're working on this right now'****, you know, 'have you done your', you know, I don't know chart review that was supposed to be a part of this yet, or whatever-* ***it's just like a reminder…***

Dashboards can also provide benchmarking at various levels. Peer benchmarking was mentioned frequently, however its usefulness was controversial. Broader benchmarking, such as at the clinic, organizational, or national level, was generally viewed as a positive.

> *[112] …what is the goal… level?' then, there's* ***'what are my peers doing'*** *and then* ***'where am I in relation to that'?*** *Like 'am I behind my peers and behind the goal? Am I with my peers, but still below the goal?' I guess that- that kind of matters to me.*

Theme 5: Communication

Dashboards should facilitate feedback and open communication between clinicians and developers. This aids in trust and can alleviate frustrations with usability and accuracy.

> *[101] Knowing whether the- if there's a big dip, there should be a note saying not to worry about it. Someone letting you know that. But if they don't do that and if it dips it becomes-* ***you don't know what to trust and what not to trust****… - I mean, it's not that they're hiding anything it's just, it's not obvious to the person. …It's* ***communication****. And when there's a problem with a metric you just, like, highlight it or something.*

System Barriers

We found that factors at play within the complex adaptive system of healthcare delivery play just as important a role as the dashboard itself. Significant barriers to effective dashboard use for improving care quality exist are brought to light in interview data.

Theme 6: Inflexible Metrics

Inflexible, standardized metrics were frequently cited by clinicians as problematic and counterproductive to the delivery of high-quality patient care. For example, clinicians feel quality metrics do not represent the whole spectrum of care quality.

> *[101] The question is,* ***do they measure the quality of care I'm providing****? … sometimes they do, and sometimes they don't. … It's just these checkbox quality stuff, and a lot of what we do can't be measured that way… [it]* ***doesn't reflect on the whole of the quality of the care.***

Standardized metrics also do not allow enough flexibility to enable shared decision making that accurately reflects patient and clinician values. A strong focus on such

metrics, in many instances, can undermine their validity as clinicians are forced to choose between satisfying patient values or satisfying metrics. The need for more flexible exclusion criteria, particularly involving patient autonomy and end-of-life care, is often cited.

> *[104] …but when they're 95 and, you know… the plan of care is comfort care and they're hospice… that should be somehow accounted for. And so that aspect of care could be,* ***could make you feel a lot better about doing this****- and so you feel the system is working with you, and not against you or making your life more difficult…*

This mismatch of values between the care delivery system and shared patient/clinician values will inevitably result in unintended consequences.

> *[103] …Otherwise, it will create the* ***danger*** *of- clinicians either of start to firing this patient, right- that's the easiest way [chuckles] to get your score better- or increasing the polypharmacy.*
>
> *[117] … I think it's stupid. I* ***mean I think my focus should be on taking good care of my patients*** *and… I can think of lots of things to incentivize that could really help patients but I, I don't choose the quality metrics…*

Theme 7: Variability in Clinician Attitudes

Clinician may not always be excited about new technology and change. Though interviewed participants personally exhibited excitement about the possibility of a new

quality dashboard, many cited colleagues who might be less than willing to participate, often due to disengagement and apathy.

> *[115] …I think the challenge is to get, maybe, busy faculty who have done the things they've done the way they've done them for a long time to re-engage in quality improvement work… I know* ***some people who just turned theirs [dashboard] off, or like don't, you know, they just like have chosen not to look at it.*** *[TW] Why do you think they do that? [115] I think because of a sense of 'this doesn't apply to me' or 'these measures are imperfect' because they can't exclude patients who are not appropriate for this and 'all these numbers are wrong anyway'. So, I think it's… And maybe* ***just disengagement*** *with the process.*

Multiple clinicians also expressed a component of anxiety related to the transparency of quality data, though since this had been the norm at our institution for many years the effect was often downplayed.

> *[112] I think that there's evidence that shaming, public [laughter] … you know, a little bit of public auditing-* ***you don't want to say shaming- but I think it is****… And I'd been working on [a metric]-* ***because I know it's publicly out there - people can see it- it's posted on a wall in our clinic- and I know it's bad for medical care- my colleagues may see it.***

This anxiety, combined with disdain and perceived unfairness of standardized quality measures, can elicit negative emotions.

*[104] I, you know**, I think people got pretty upset and defensive** the first couple of times it came out. That was at, you know a group who got angry- 'well it's not my fault my patient's A1c's are', you know, 'they're not taking their medicine' - the usual kind of**… anger, denial, and all that***

Theme 8: Misaligned tools and processes

Current tools and workflows are a poor fit for population health management. Clinician time is classically aligned to the fee-for-service model, and these priorities do not often overlap. For example, accurate data entry is crucial for dashboard functionality and tracking population health outcomes. Yet, clinicians do not have time for data entry tasks, which are viewed as menial and burdensome, and must balance this with other priorities such as work-life balance.

*[116] … I'm spending ten minutes poking through outside records to look for a pathology report, it's just **a really inefficient use of clinician time**. So, if they're gonna- so telling us we need to **do these like menial tasks, in order to make our numbers better**… **You're basically incentivizing us to do data entry.** And, so, why incentivize us to do data entry? You know, take the money that you're gonna pay us and like hire someone to do it.*

These competing priorities likely result in low quality, inaccurate EHR data, which dominoes into reported poor quality measures.

[115] Yes, they realize they have memory problems but they're coding it as 'memory problem' instead of 'Alzheimer's dementia without behavioral

disturbance' which, is a very different… ICD code that triggers that CPC-plus recognition of, 'yes, this is a complex patient'… in just looking at 6 months of data, [the] ***vast majority were inappropriate codes or non-specific codes****. So, at least I think the number was like sixty-something percent.*

Systems should provide more support for clinicians in these tasks with better data entry tools, improved interoperability, and more support staff.

*[116] So, there is the sense that like the qual- all of these metrics lie on the clinician****, but that's very different than the idea of… managing a panel****. And I shouldn't have to manage my entire panel's colonoscopy, you know, records. Like, that doesn't need to- in an individual visit I can address it, but outside of a visit that's not something that's ever gonna cross my mind.* ***So, there's some weird disconnect between, you know, we wanna pay for these things but we're not gonna give you any support, but we're not gonna like automate it or make it more efficient to get this stuff done.***

Needed System Facilitators

In addition to system barriers, we identified a number of facilitators that would enhance clinical dashboard effectiveness and adoption

Theme 9: Alignment with Clinician Values

Clinicians firmly voiced that delivery of good patient care was among their primary driving values and shifting focus away from these values can create friction. For

example, individual compensation for quality measures, while not yet initiated at our institution, is viewed as complex and often in a negative light.

> *[103] Whenever you compensate, you really want to compensate for good work that they do, right?* ***And not to punish the good work they do as well…***
>
> *[117] I'm not sure that I believe that pay-for-performance, which we're not doing right now but we're moving towards, I'm just not sure that that…* ***I'm not sure I, I totally buy it as a good- good for patients necessarily.***

Some directly note that, for successful quality improvement projects, messaging from leadership should reflect that the underlying goals aligns with these values.

> *[107] I think we have to also help physicians look beyond the numbers too, and be, and I think the important message is that* ***…we wanna do things for patients because it's the right thing- not to really drive the numbers****. So, I do think* ***we have to keep that in mind****.*

Theme 10: System Support

Clinicians frequently discussed the need for more support from the healthcare system in order to engage in population management tasks and fully utilize tools such as clinical dashboards.

> *[101] I mean* ***I think just giving people dashboards isn't going to be effective****. You have to say, 'OK these, we've picked this to work on…* ***and I actually think it makes a whole lot of sense to work on it as a whole clinic***

> ***team**, because otherwise you may decide to do something **but then you don't have the team support to make it happen.***

System interventions should be developed that synergize with dashboard information and workflows and processes should be integrated.

> *[116] So, I see it a lot and I don't exactly know how to. Other than doing a panel review, **there's no real way to turn it from the data that I see into like an action step…***

Support staff and panel managers should be used to offload out-of-scope tasks for clinicians.

> *[103] If I were able to start from scratch I would tell the system say, 'you want us to really engage in this quality metric? Yes, no? **If it's yes- you need to, you need to invest in panel management.** ' And this is, you know, I can give them a number. Per 10,000 probably need one FTE minimum. From the beginning, they have it, then great.*

Clinicians need dedicated time and structure to perform population health tasks and panel management.

> *[101] I just don't know that the dashboard- it's interesting because I don't know that the dashboard… if you're not doing… the quality. If you're not in charge of the quality improvement work, and you're seeing patients all these half-days. **Then, right now the way it's structured there's no reason for***

anyone to look at it. So, you need to create that time and that energy- space for that time and energy that's gonna be actually used well.

Finally, compounding the issues mentioned above, clinicians are already very busy. Adding tasks or responsibilities to their packed day will compete with and likely negatively impact other priorities, such as good patient care.

[103] You know what? [sips coffee] ***Clinician already busy****… We have not really, honestly engaged in our conversation - what is the cost to do population management? …cost to the clinician's competitiveness and ethical view of care? …* ***asking the clinician to improve is the last place I usually go right now.***

Theme 11: Champions

Clinical champions are identified as a major system facilitator that clinicians noted can ensure visible system, team, and leadership support.

[112] …another thing is I have ***leadership*** *who is a data quality person, and so he thinks about, and* ***cares about these things****- and is engaging us in projects. And, I think that's really important. And I think that would be the biggest thing, too, about a scorecard- is having a person,* ***having some champions****- like, having somebody who is the go-to in this site who can like 'this is being rolled out-* ***I'm who you go to for questions, I'm who you go to for issues with this, I'm a face you recognize*** *as a... and I'm a face who can bring your question to the right people" …so I think, you know, if you want people to use*

what you're doing- ***providing some level of 'face to face' about it will be useful. Especially for a dashboard that you're wanting people to use.***

Discussion

Key Findings

Our findings highlight that usability, accuracy, and relevance of information are absolutely necessary for an effective and successful clinical quality dashboard. Poor usability is often cited as a major criticism of healthcare information technologies, with implications ranging from patient safety, user frustration, and total implementation failure(36). Any clinical dashboard development should, at a minimum, follow principles of user-centered design and consider formal usability evaluations. In addition, many excellent resources exist that review best practices for data visualization(37-40), and these should be implemented when possible. Accuracy and relevance of information may be equally as important- accurate, relevant information allows clinicians to take action based on dashboards and develop workflows around dashboard use. If information is either inaccurate or irrelevant it has no use to the clinician.

An interesting finding in this work is that clinicians interviewed expressed a desire to be more directly involved in the processes relating to dashboard use, rather than just a consumer of dashboard information. Clinicians desire facilitation of feedback and other ways to communication with developers as a key component of a useful clinical dashboard. They felt that more collaboration between clinicians and data analysts in the validation process would improve data validity and trust. Clinicians who worked directly

with panel managers and data providers were more comfortable in their quality measures and clinicians voiced examples where they were happy when the system worked together to improve outcomes. Involving clinicians, particularly clinician champions, in the development and application of a clinical dashboard appears to be critical for success.

> *[101] … **you don't know what to trust and what not to trust**… I mean, it's not that they're hiding anything it's just, it's not obvious to the person. …It's **communication.***

However, clinicians also advise caution with certain aspects of dashboard use such as individual financial incentives or too strongly focusing on specific measures. The most vocal concerns involve unintended consequences, either directly, such as with polypharmacy or patient selection bias, or indirectly, by shifting resources and clinician time away from where it may be more beneficial. Unintended consequences from use of healthcare information systems is a well-documented phenomenon and implementations should be vigilant to avoid them(41). The implementation of a quality improvement dashboard is no exception.

Interviewed clinicians felt that standardized measures poorly represent the true quality of care provided. Caring for some certain patient populations, such as the poor or elderly, can lead to unfair representation due to patients' lack of resources and competing values-constructs with which the clinician may have no control over. The strict definitions of metrics leave little room to allow clinicians and patients to focus on their shared personal values or priorities and these competing priorities can cause tensions. Standard measures and benchmarks are more valid when benchmarking populations or in composite (42),

and interviewed clinicians note individual scores to be less meaningful for the above reasons.

Further, many clinicians are naturally competitive and take their personal 'scores' very seriously- so much so that emotions are at play.

> *[107] I think,* ***there are people that are just competitive in nature*** *and see that [dashboard] and want to do something about it…*

Even with no financial incentives involved, clinicians expressed anxiety over public display of personal measures due to the perception of peer shaming as a form of punishment. Along with the unintended consequences described above, some clinicians have dealt with this through apathy and disengagement with quality improvement initiatives.

To provide more relevant information to clinicians in a dashboard and facilitate engagement, it might be better to separate measures reported for reimbursement purposes from those shown to clinicians. For example, allowing clinicians to exclude patients at will from personal dashboard measures could alleviate anxiety and prevent some unintended consequences associated with 'unfair' formal measures while also allowing clinicians the flexibility to practice the art of medicine and identify and focus system resources on patients who will benefit the most.

> *[116] So, my quality measures aren't great. And I don't know,* ***does that mean I'm a bad primary care doctor?*** *I don't know… So, it's helpful for patient*

population management, but I'm not sure how… what it means in terms of reflecting back on the doc.

However such separate reports may simply open another avenue for 'gaming the system', and some would argue this approach compromises the integrity of the formal reporting infrastructure for comparative purposes(20). Another issue one might have with this solution is how to handle financial incentives. However, multiple clinicians interviewed felt that individual financial incentives for quality improvement is not the "right locus of control" and that such funds would be better targeted toward system resources such as panel managers. Additionally, physicians expressed with great sincerity that they highly value provision of "good patient care". Regardless of the mechanism, alignment of tools like clinical dashboards with such clinician values will greatly improve chances of implementation success.

Interestingly, a number of our findings correlate to constructs discussed in the marketing dashboard implementation framework by Pauwels et. al. For example, Pauwels et. al. posits that the predispositions of users, mostly influenced by trust and attitude, heavily influence adoption. We demonstrate that trust and data accuracy, as well as variable clinician attitudes, are identified by clinicians as important for clinical dashboard success. We also see that the importance of champions and leadership support are identified in both contexts. These findings may yield credence to adoption of similar healthcare-specific models, such as the Effective Technology Use Model, for clinical dashboard implementations.

Perhaps the most prominent message from our clinicians is that they are not in a position to manage population health alone. System support is necessary to have a meaningful impact on quality metrics and by extension patient outcomes. Current tools and processes available to clinicians are not well-suited to improve population health.

> *[104] …you know, we can't get discouraged… data's only a tool- and it's only as good as it is…* ***it's not very helpful if you don't have a way to actualize it****. If you can't actualize it, writing all kinds of reports and data isn't very helpful. So, you need to find systems of care, and I think it really does come down to team-based care.*

Busy clinicians must balance performing menial data entry tasks and burdensome documentation with patient values and personal quality of life. Data entry tasks should be offloaded, and more staff are needed to assist with outreach, panel management, and to overcome issues with poor EHR interoperability. Clinicians need dedicated time and structured processes to facilitate and guide the work required to improve. The current system is still largely focused on patient throughput. Changes to the classical practice structure may need to be explored.

Limitations

While interview data obtained in this research were high-quality and demonstrated high congruence, the results and applicability are limited by many factors. As saturation was felt to be achieved we believe the total number of clinicians interviewed was adequate to elucidate the experiences of the targeted group. However, clinicians interviewed only

represent the disciplines of Internal Medicine and Family Medicine at a single academic medical institution. Factors unique to this institution, such as the EHR system and clinician's prior experiences with various dashboards may bias results. Even like-minded clinicians in private practice or in other areas of the country may have differing values and other forces acting to guide their needs. Further, this study was targeted to highlight factors most relevant to dashboards focused on adult primary care quality measures. Fields such as surgery, radiology, pediatrics, or oncology may have additional or differing requirements for a useful clinical dashboard.

Another significant source of bias in this research must be considered in context of any discussion of the results. The primary researcher, author, and sole-interviewer in this work is a clinician with experience in primary care. This author may have strong biases on certain aspects of clinical care such as poor EHR usability or difficulties with interoperability. Some aspects of dashboard use, such as the unintended consequences of stringent quality metrics, could be misrepresented. In addition, the non-clinical aspects of dashboard use in healthcare, such as for operational or efficiency measures, were likely under-represented in this research.

Finally, purely qualitative research brings inherent limitations as well. Qualitative research is exploratory in nature rather than explanatory. Though a great wealth of information can be gained with proper utilization of qualitative methods, further work is required before this information can be generalized to the development of clinical dashboards.

Conclusions and Implications for Future Work

How to best use the EHR and related data to improve outcomes remains elusive, but financial incentives for care quality encourage healthcare organizations to explore new ways to improve. Outside service industries have shown that dashboards can effectively facilitate decisions and drive improvements, and early evidence suggests that such dashboards may be effective in healthcare. Our research expands the current knowledge of clinical dashboards and explores aspects of dashboards, from the perspective of the primary care clinician, that may facilitate effective use and adoption in healthcare.

We identified eleven key themes important for clinical dashboard adoption and effective use. Clinical dashboards should present highly accurate, relevant information that can be used for prediction and to guide clinical practices, all in an easy to use format. The dashboard itself should also facilitate communication with the development team. Leadership should facilitate dashboard use through messaging that aligns with clinician values, provision of system support, and sponsoring champions. System barriers to address involve the inflexible nature of standardized metrics, variability in clinician attitudes towards quality improvement related activities, and misaligned clinical processes.

Further qualitative work should be pursued to validate and build upon the constructs we have identified here. Other specialties such as radiology or surgery may have differing views and needs and would provide valuable insights. Additional research should also

evaluate if these themes are generalizable to other organizations and geographical areas. Similar methods to those used here could accomplish these goals.

After validation, such constructs could be used to inform the development of an implementation and evaluation framework for clinical dashboards. Many of our findings resonate with existing informatics and decision support literature, such as the importance of usability, or the dangers of unintended consequences. Some findings also agree with literature on dashboards used in other industries, such as the importance of executive sponsorship and alignment of user values. Due to these similarities, it may be possible to leverage existing implementation frameworks for clinical dashboards. However, current healthcare technology implementation frameworks, such as the Effective Technology Use Model, should be evaluated for use with clinical dashboards specifically.

Finally, after expansion and validation, research with a focus on the development and implementation of clinical dashboards should be performed with a quantitative evaluation for efficacy. Due to the complexity of research directly involving healthcare information systems, this would require a very different approach than the qualitative methods described here. As demonstrated by currently available research on clinical dashboard implementations, this type of study may be difficult to design. A Group-Randomized Trial may be able to bypass some of the inherent issues by randomizing and clustering separate clinics or even entire healthcare systems(43). Another, likely much easier approach, may be to use simulations to first determine dashboard factors that have a favorable effect on clinical decision making at the point of care(44).

The successful widespread EHR adoption over the past decade was in part due to a tremendous effort by the informatics community. Most healthcare systems now enjoy a wealth of easily-accessible data, but the true fruits of these efforts are yet to be seen. Our task is now to discover novel uses for healthcare technology and data to support clinicians, patients, and healthcare administrators and actually improve the delivery of healthcare. This research on clinical dashboards is one step towards that goal, as future clinical quality dashboard implementations will hopefully lead to improved care quality.

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Supplementary Materials

I. Final Interview Guide

Dashboards Study Interview Guide

[Interviewer] Interviewing [Participant] - [Location] [date and time]

Turn on recorder

Today is [Date] and this is [Interviewer] interviewing [Participant] at [Location]. As mentioned in the Information Sheet, we would like to record this interview and need your verbal consent —**do you agree to recording?**

1. **About you**
   - First, we'd like to learn a little about you. Could you give us a few words about your **background**?
   - What is your primary specialty and how long have you been practicing clinical medicine?
   - How do you define **your patient population**? Who are you responsible for? What is your **patient panel**?

2. **Quality Improvement & Pay for performance**
   - **We are interested in population health…**
   - Do you participate in any **clinical** quality improvement activities?
   - If yes:
     - What kinds of measures do you look at?
     - How do you track measures?
     - How do you know what to try and improve?
     - How do figure out what to do to actually improve?
   - If no: (Why not?)
     - Do you look at quality reports?
     - How do you feel your practice performs with regards to quality?
     - How would you know if your performance was very poor or very high in certain areas?
   - How would you feel about **peers viewing** your personal performance? Would you want to view the performance of your peers?
   - How do you feel **about incentives for quality**?

3. **Dashboards in General**
    - How long have you been using an Electronic Health Record system?
    - In your own words, could you please describe what a “dashboard” means to you?
    - What would be the ideal purpose of a **clinical quality dashboard**?
    - Do you use dashboards in your clinical practice? Describe them…
    - Do you know if others use dashboards? Are they used in staff meetings or for administrative purposes? Culture of dashboards in your department?

4. **Dashboard Adoption**
    - What might make you more likely to use dashboards in practice?
        i. Or use them more than you do now?
    - What are some barriers to using dashboards in your current workflow?

5. **Dashboard Effectiveness**
    - Do you feel dashboards can/could help you care for patients? How?
    - What would your ideal clinical dashboard do for you?
    - What kinds of measures would you like to see on your clinical dashboard?
        - How many measures is “best”?
    - **How do you know the measures are fair?**
    - **How would you know your goals are appropriate?**

6. **Accuracy and Trust**
    - Do you trust the accuracy of dashboards? When would you believe or not believe the data?
    - How important is it to you to understand the underlying methods of how data is collected and reported?
    - Do you feel the attribution of metrics is fair?