A Pragmatic Guide to Establishing Clinical Decision Support Governance and Addressing Decision Support Fatigue: a Case Study

Kensaku Kawamoto, MD, PhD, MHS[1], Michael C. Flynn, MD[2,3], Polina Kukhareva, PhD, MPH[1], David ElHalta, RPh, MS[4], Rachel Hess, MD, MS[2,5], Travis Gregory[6], Chris Walls, MS[6], Angela M. Wigren[6], Damian Borbolla, MD, MS[1], Bruce E. Bray, MD[1,2], Mary H. Parsons, MD[2], Brett L. Clayson, PA-C[7], Melissa S. Briley, MS, PA-C[7], Carole H. Stipelman, MD, MPH[3], Dean Taylor, RN, MS[6], Carrie S. King[6], Guilherme Del Fiol, MD, PhD[1], Thomas J Reese, PharmD[1], Charlene R Weir, PhD, RN[1], Teresa Taft, PhD[1], Michael B. Strong, MD[2]

Departments of [1]Biomedical Informatics, [2]Medicine, [3]Pediatrics, [4]Pharmacy Services, [5]Population Health Sciences, [6]Information Technology Services, and [7]Family Medicine, University of Utah, Salt Lake City, Utah

Abstract

There is limited guidance available in the literature for establishing clinical decision support (CDS) governance and improving CDS effectiveness in a pragmatic, resource-efficient manner. Here, we describe how University of Utah Health established enterprise CDS governance in 2015 leveraging existing resources. Key components of the governance include a multi-stakeholder CDS Committee that vets new requests and reviews existing content; a requirement that proposed CDS is actually desired by intended recipients; coordination with other governance bodies; basic data analytics to identify high-frequency, low-value CDS and monitor progress; active solicitation of user issues; the transition of alert and reminder content to other, more appropriate areas in the electronic health record; and the judicious use of experimental designs to guide decision-making regarding CDS effectiveness. In the three years since establishing this governance, new CDS has been continuously added while the overall burden of clinician-facing alerts and reminders has been reduced by 53.8%.

Introduction

Clinical decision support (CDS) entails providing clinicians, staff, patients, or other clinical stakeholders with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care.[1] CDS can encompass a broad array of workflow tools, including alerts, reminders, order sets, documentation templates, and intelligent information displays. When provided to clinicians within their workflows as actionable, patient-specific recommendations at the time and location of decision making, computer-based CDS has been shown to significantly improve clinical practice in over 90% of randomized controlled trials.[2]

Despite the promise of CDS for improving health and health care, a critical challenge that affects many healthcare systems is CDS fatigue. CDS fatigue can be defined as a systemic lack of response to alerts and reminders and indicates a design failure to support clinicians' workflow and decision-making. CDS fatigue encompasses both alert fatigue and fatigue towards clinical reminders. The reasons for the over-rides are many, ranging from desensitization to lack of relevancy and mismatch with clinicians' workflow.[3] If the right solution is not implemented, a vicious cycle may ensue where new CDS – however accurate and valuable as it may be – leads to further CDS fatigue, reduced overall CDS effectiveness, and provider dissatisfaction.

Given the need for appropriate governance to optimize CDS, Wright *et al.* conducted site visits and surveys at five institutions considered to have effective CDS in order to identify best practices in governance.[4] This 2011 study identified six recommended practices for CDS governance: (i) prioritize the order of development of new CDS and delegate content development to specialized working groups; (ii) consider the potential impact of new CDS on existing clinical information systems; (iii) develop tools to monitor CDS inventory, facilitate updates, and ensure continuity; (iv) implement procedures for assessing the impact of changes and additions to CDS on the system's own functionality; (v) provide multiple robust channels for user feedback and the dissemination of systems-related information to end users; and (vi) develop tools for ongoing monitoring for CDS interventions.[4] As noted in the study, however, many of these governance practices were identified from organizations that had invested significant resources and many years to developing "large and multifaceted governance structures", such as Partners HealthCare,

Vanderbilt Medical Group, and the Veterans Health Administration. Moreover, this study was conducted when many of these organizations developed and maintained their own EHR and CDS systems, whereas almost all U.S. healthcare systems today – including the organizations where this original study was conducted – are now either using commercial EHR systems or are in the process of transitioning to such systems. Therefore, there is a gap in the literature for pragmatic guidance on how an organization that uses a commercial EHR system, and is not in a position to allocate significant new resources, should go about establishing CDS governance.

In 2014, University of Utah Health was faced with this exact issue. We had completed an enterprise-wide go-live of the Epic® EHR system in May 2014, and there was increasing feedback from clinical users that excessive CDS, in particular in the form of "pop-up" alerts, was becoming a significant problem. At the same time, given all of the other ongoing information technology (IT) priorities, including system stabilization, Meaningful Use requirements, and the impending transition to ICD-10 for billing, there were no significant new resources available to address this issue. Thus, known best practices were adapted to a pragmatic approach to CDS governance that could be implemented with existing resources. Three years after establishing this governance in January 2015, we have gathered empirical data suggesting that the governance implemented was successful in reducing CDS fatigue and improving CDS effectiveness. The goal of this manuscript is to provide practical guidance based on our experience, so that other healthcare organizations looking to establish pragmatic yet effective CDS governance can do so with available resources.

Methods

Clinical and Technology Context. This case study is focused on the experiences of University of Utah Health (UUH), which is a medium-sized academic health system based in Salt Lake City, Utah. Staffed by approximately 1,400 board-certified physicians and 5,000 health care professionals, UUH provides care across four hospitals and 12 community clinic centers. In calendar year 2017, UUH had approximately 39,000 inpatient discharges, 49,000 emergency department visits, and 2.5 million total patient visits.

UUH converted to the Epic EHR system enterprise-wide in May 2014. Prior to that time, Epic was used in the ambulatory setting, and the Cerner® EHR system was used in the inpatient setting. As of March 2018, UUH uses the latest available version of the Epic EHR system for both the inpatient and outpatient settings.

Prior to January 2015, all EHR issues – including CDS issues – were overseen by the combination of an EHR Physician Advisory Committee and an EHR Operations Committee. The Physician Advisory Committee met on a monthly basis and provided primary guidance for core CDS issues, but its primary focus was on other EHR-related issues. The primary decisions made by the Physician Advisory Committee prior to 2015 were to (i) set provider-level medication alert settings to a minimum yet safe level enterprise-wide to reduce alert fatigue and to (ii) set pharmacy-level medication alert settings to a higher level for an additional layer of safety checking. These settings were chosen after considering the recommendations of the medication knowledge vendor (Wolters Kluwer Health® Medi-Span®) and the settings used by peer organizations. The core settings have remained stable since that time, with incremental adjustments made to optimize effectiveness. Table 1 represents the UUH medication alert settings as of March 2018.

Table 1. Medication alert settings using Wolters Kluwer Health Medi-Span CDS content.

Alert Type	Clinician Setting	Pharmacist Setting
Drug-drug	Major: if at least probable Moderate: if at least probable Minor: all filtered 1 additional filtered interaction	Major: if at least suspected Moderate: if at least suspected Minor: if established 54 additional filtered interactions
Drug-allergy	On for active and inactive ingredients with cross-sensitive class match Off for selected inactive ingredients	Same
Duplicates	On for duplicate medications Off for duplicate therapy class	On for duplicate medications On for duplicate therapy class for inpatient setting
Dosing	% allowance for min dose: 10% % allowance for max dose: 100%	Same
Other	On for pregnancy, lactation, drug-disease, age/sex	Same

Study Period. This case study starts in January 2015, when formal CDS governance was instituted, and ends in January 2018, three years following initiation of the governance. The University of Utah Institutional Review Board (IRB) deemed this work to constitute quality improvement (QI) and exempted the study from IRB oversight.

Impetus for Establishing Formal CDS Governance. By late 2014, after the enterprise-wide EHR implementation had been in place for several months, there was growing institutional recognition of CDS fatigue as an important problem affecting users. In particular, interruptive pop-up alerts were a source of significant user frustration. Thus, it was decided to establish formal CDS governance to manage CDS fatigue and improve the usefulness of CDS in general.

Resource Considerations. Despite the recognition of the need for improved CDS governance, there were also many other critical IT priorities competing for resources. These competing demands included the need to stabilize the EHR system following go-live, the need to fulfill Meaningful Use requirements, and the need to prepare for the transition of billing from ICD-9 to ICD-10. Throughout the study period, budgeted resources for CDS and CDS governance consisted of approximately 2 full-time equivalent (FTE) effort from staff and managers distributed across the IT department, the department of pharmacy services, and the office of the Chief Medical Information Officer. In addition, various clinicians contributed their expertise and insights on a voluntary basis.

Enterprise CDS Committee. The core of the new CDS governance was the establishment of an enterprise CDS Committee. Chaired by an Associate Chief Medical Information Officer with expertise in CDS (KK), the committee was designed to be clinician-driven with support from key stakeholder groups including the quality department, IT, and informatics. The membership of the CDS Committee as of March 2018 is provided in Table 2. Of the 36 members, 27 are physicians, physician assistants, nurses, or pharmacists.

Table 2. CDS Committee members.

Category	Members
Clinicians	Chief Medical Information Officer
	Associate Chief Medical Information Officer
	Medical directors
	Director of Health System Innovation and Research
	Other clinician leaders, including physician assistants
Quality leaders	Chief Medical Quality Officer
	Associate Chief Medical Quality Officer
	Director of Quality Department
IT and informatics professionals	Director of clinical information systems
	Directors of inpatient and ambulatory clinical information systems
	IT professionals responsible for CDS development
	Nursing informaticists, pharmacy informaticists, and clinical informaticists

The charge of the CDS Committee was to oversee CDS strategy and execution for the institution, with a specific goal to reduce CDS fatigue while enabling the judicious introduction of new, high-value CDS content. The scope of the committee's responsibility entailed medication alerts, custom EHR alerts and reminders known as Best Practice Advisories (BPAs), and the Health Maintenance section of the EHR, which provides a list of patient-specific care recommendations for issues such as cancer screening, immunizations, and chronic disease management (e.g., laboratory testing for diabetes monitoring). The scope of providers included in the committee's purview were clinicians (defined here as physicians and advanced practice clinicians [APCs]), pharmacists, and medical assistants. An explicit decision was made to keep the scope of the CDS Committee focused in order to enable more rapid progress.

CDS Committee Logistics. The CDS Committee meets once a month at a time convenient for practicing clinicians. Guests are invited on an as-needed basis. The agenda is primarily composed of reviews of requests for new CDS, as well as review of existing CDS that needs to be optimized or retired.

For CDS requests that are likely to be non-controversial, an online vote can be taken wherein committee members vote to approve, disapprove, abstain, or request in-person discussion at the meeting. If any members disapprove or request in-person discussion, the request is taken to the next meeting for discussion.

To ensure that the CDS Committee does not become an unnecessary bottleneck, the Committee has pre-authorized the IT team to make any changes that can be considered to be bug fixes without further review. Immediate safety issues may also be addressed without prior review by the full committee.

CDS Working Group. The CDS Working Group is a subset of the CDS Committee which includes the committee chair, director of clinical information systems, and clinical and pharmacy informaticists responsible for CDS implementation within Epic. This Working Group meets once a week to review and coordinate on the CDS work queue. All CDS work orders are tracked and managed within the IT department's Jira® issue management system.

Core Principles. The CDS Committee operates under several commonly agreed upon core principles with a goal of implementing CDS that is desired, integrated, and valuable. The first principle is that, with rare exception, *new CDS should be added only if it is actually desired by intended recipients*. The rationale is that if the intended recipients see no usefulness in the CDS, they would ignore it anyway, which would lead to both the proposed CDS being ineffective and reducing the overall perceived value of CDS in general, contributing to increased CDS fatigue. Thus, when there is a question of whether the CDS is desired by intended recipients – which is particularly important when the CDS is to be an interruptive pop-up alert – review and consent is requested from leaders of target recipients of the CDS. Such leaders may include medical directors and practice managers of affected clinics or ambulatory and inpatient clinical leaders from each specialty known as Chief Value Officers.

The second principle is to *use the most appropriate and least disruptive workflow integration approach*. For example, if a desired clinical goal could be achieved through education or the addition of explanatory text provided along with an EHR orderable item, the committee may recommend that such alternate approaches be pursued instead of alerts or reminders.

The third principle stipulates that *the benefits achieved from the CDS should outweigh the costs*. This principle acknowledges that there is often a real cost to certain CDS modalities in terms of CDS fatigue and workflow interruption. This principle generally drives the deepest discussions in the committee, as the answer is often a judgment call that requires weighing benefits against costs. To inform this discussion, the committee may request further data review, for example by turning on a proposed alert in "silent mode" as a background process in the EHR to assess how often the alert would fire, and for whom, if turned on for users in the production system. The committee may also approve CDS for pilot use in a limited clinical area, with a decision to expand the implementation contingent on the findings from the pilot. The CDS committee may also consult with other governance bodies, as described next.

***Coordinate with Other Governance Bodies*.** When the CDS Committee feels other governance bodies should weigh in on a decision, it reaches out to these groups for consultation. For example, for a medication related issue the Pharmacy and Therapeutics Committee may be consulted. The EHR Physician Advisory Committee was initially an important source of consultation on general clinical issues. UUH later retired the EHR Physician Advisory Committee due to functional redundancy with the Chief Value Officer governance structure; as such, this type of consultation is currently conducted with the Chief Value Officers. While the specific governance structures will differ from institution to institution, the general approach is to leverage other governance bodies, especially for controversial topics. As an example, when the U.S. Preventive Services Task Force updated its screening recommendations for breast cancer in 2016,[5] the CDS Committee ultimately consulted with a wide variety of groups including affected specialties (primary care, breast radiology), the EHR Physician Advisory Committee, the ambulatory Chief Value Officers, and the Chief Medical Officer.

Communicate Change. Without proper communication, a CDS change may have a potential for negative impact, for example if providers have come to rely on alerts that are being retired. Similarly, there may be cases where there is a potential for positive impact from communicating a CDS update, such as the availability of a new Health Maintenance "modifier" that allows a clinician to tailor how frequently a given patient should be monitored for colorectal cancer screening. In such cases where communication can reduce the potential for harm or improve the potential for benefit, an appropriate communication is provided to users, for example through email and Web-based notices sent to all users regarding notable system changes in scheduled EHR updates. In other cases, more directed approaches are taken, such as targeted emails to specific users who are affected by a change.

Typical Lifecycle of a New CDS Request. A request for new CDS content is typically received through an IT department help ticket or through direct communication with end users. The request is logged in a Jira issue management system, and requestors for BPAs are asked to provide more information using a structured request

document adapted from a form provided by colleagues from Stanford University. This request form seeks information on the goal, baseline data on current performance, the primary sponsor, prior efforts, why those prior efforts were insufficient, alternative potential approaches for meeting the need, possible unintended consequences, and technical details on the desired system behavior.

The CDS Working Group reviews every request for new CDS to conduct a preliminary assessment. If additional information is needed, the requestor is contacted to obtain the required information. If an alternate approach seems to be a better solution to the identified need, discussions are held with the requestor to explore these alternative options. Also requested at this time is confirmation that the target users support the CDS. The request is then generally scheduled for discussion at an upcoming CDS Committee meeting, with the requestor asked to attend if the request is anticipated to be controversial. If a request is considered to be straightforward and likely to encounter no concerns, the request may be sent out to committee members for an online vote.

At the CDS Committee meeting, straightforward requests are generally discussed and approved within five minutes, whereas other requests may require substantial discussion. For requests without a straightforward, ideal solution, committee members often suggest modifications to the requested approach to better meet the clinical need. Approved requests are assigned a priority for implementation.

Once approved, new CDS content is developed by the EHR team according to the designated priority. Brief training information is created if needed, and the CDS update along with any training materials are released with other EHR updates on a regular schedule. In cases where there is concern about low efficacy or CDS fatigue, requests are often approved on a pilot basis in a subset of clinical areas, with a requirement to return to the committee with data on the results from the pilot prior to widespread dissemination.

Approach to Reviewing and Optimizing Existing CDS Content. The processes described thus far have focused on governance to vet requests for new CDS content. As an important complement to such efforts, the CDS Committee also oversees the review and optimization of existing CDS content. Because developing and implementing approved new CDS content consumes a substantial portion of available resources, the process of optimizing existing CDS content is conducted using pragmatic approaches focused on areas of greatest opportunity.

Active Solicitation of Feedback. Perhaps the most basic yet important method for optimizing existing content is to actively query clinical users on CDS content that needs to be improved or retired. Key sources of this feedback include clinician members of the CDS Committee as well as the Chief Value Officers. Our experience is that this type of direct solicitation for feedback is an efficient method for identifying significant contributors to CDS fatigue.

Data Analytics to Identify Low-Hanging Fruit and Monitor Progress. Relatively basic data analyses are conducted to identify the CDS that fires most frequently, as well as user responses to the CDS (e.g., over-ride vs. acceptance). For both medication alerts and BPAs, database queries are performed using log data provided by the EHR. For medication alerts, an Excel-based alert analysis tool provided by the EHR vendor is also used. The EHR vendor also provides an Excel-based BPA analysis tool that will be available for use at UUH in the near future.

For medication alerts, a pharmacy informaticist who is a member of the CDS Working Group convenes a quarterly meeting with approximately 30 pharmacists to review data analysis findings and make recommendations for optimizing the alerts. These recommendations are generally accepted with no reservation by the CDS Committee.

For the BPAs, the highest-volume alerts and reminders are reviewed periodically by physician informaticists and physicians on the CDS Committee. This review process has identified a number of opportunities for improvement, such as low-value BPAs that should be retired and BPAs that should have additional exclusion criteria added to improve specificity. These opportunities are then discussed and generally approved by the CDS Committee. For both medication alerts and BPAs, the data are monitored on a routine basis to ensure the system is performing as expected.

Transition of Alert and Reminder Content to Other, More Appropriate Areas in the EHR. Because care providers deliberately and voluntarily check the Health Maintenance module of the EHR as a part of their routine workflow, they are welcoming of clinically relevant CDS provided in this context. Thus, wherever feasible and appropriate, new CDS content is added as Health Maintenance topics rather than as BPAs, and existing BPAs are retired and transitioned into Health Maintenance topics. Health Maintenance topics can also be made visible to patients in their personal health records, and the CDS Committee makes decisions on which topics should be made patient-facing.

Judicious Use of Experimental Trials to Resolve Uncertainty. In some cases, there may be significant uncertainty on the impact of a change in CDS. To help resolve this uncertainty, experimental designs such as cluster randomized controlled trials may be needed to properly evaluate the impact of a system change. As a result, the CDS Committee has approved using such experimental designs to resolve issues of uncertainty for operational purposes, and the IRB has agreed that such evaluations constitute QI and are exempt from IRB review. This approach has been particularly useful when removing an existing CDS capability. For example, many CDS Committee members felt that BPA reminders for breast cancer screening, colorectal cancer screening, and fall risk screening were unnecessary because they were redundant with the same information available in the EHR Health Maintenance module, which is where clinicians expect to find preventive care recommendations. However, there was substantial concern that removal of the BPAs could adversely impact patient care in clinical areas where the Health Maintenance module may not be routinely used. To resolve this issue, the CDS Committee and the ambulatory Chief Value Officers approved a cluster-randomized controlled trial to evaluate the impact of removing these BPAs. This QI trial identified no clinically significant difference in the target preventive care performance rates between intervention and control clinics. After reviewing these results, the CDS Committee approved removing these BPAs enterprise-wide to reduce CDS fatigue.

Primary Evaluation Metrics. Reported in the results are the primary metrics tracked at UUH for evaluating CDS burden (i.e., volume of CDS recommendations with which EHR users need to interact) and CDS effectiveness among clinicians (physicians and APCs). For CDS burden, the primary metrics are (i) the average number of clinician-facing medication alerts per patient visit; (ii) the average number of clinician-facing BPAs per visit; and (iii) the combined per-visit average of both CDS types. CDS burden metrics were computed on a per-visit basis in order to provide an intuitive understanding of the magnitude of alerts and reminders, as well as to adjust for the overall clinical visit volume. Intraoperative alerts for anesthesiologists are not included in the analysis, as they were added in the middle of the study period and are managed by a separate anesthesiology governance group. Secondary analyses were also conducted to assess the degree to which overall BPA volumes were impacted by pre-existing BPAs (those that existed on or before January 2015) versus BPAs introduced under the new CDS governance.

For medication alert effectiveness, the primary metric is the proportion of clinician-facing drug alerts for which the drug is discontinued within the next hour, excluding discontinuation due to hospital discharge. For BPA effectiveness, the primary metric is the proportion of BPAs that lead to an "effective user interaction," defined as the user selecting "accept," pursuing a recommended clinical action such as order placement through the BPA user interface, or selecting an "acknowledgment reason" other than to note that the BPA fired in error. A given alert or BPA can be triggered multiple times for the same user, as when a user navigates past a reminder or in-line medication allergy warning multiple times. To avoid over-weighting for such cases, CDS effectiveness metrics are calculated at the level of the unique alert or BPA rather than users' potential multiple interactions with that CDS during the same visit.

Due to their important contribution to CDS fatigue, BPA pop-up alerts were evaluated in a subset analysis. An illustrative case study on CDS for hepatitis C screening is also reported.

Results

Impact on CDS burden. From January 2015 to January 2018, the volume of clinician-facing medication alerts started at an average of 0.47 alerts/visit in January 2015 and decreased steadily until May 2017, when there was an increase in alert volume due to the expansion of inpatient duplicate medication alerts to consider medications given in outpatient settings including the emergency department (Figure 1). In January 2018, the medication alert volume was 0.38 alerts/visit (19.8% reduction vs. January 2015).

From January 2015 to January 2018, the volume of clinician-facing BPAs decreased from 1.24 BPAs/visit to 0.41 BPAs/visit (66.9% reduction) (Figure 2). During this timeframe, the volume of clinician-facing BPAs that had existed on or before January 2015 decreased from 1.24 BPAs/visit to 0.21 BPAs/visit (83.4% reduction) (Figure 3).

A total of 178 new BPAs were introduced during this timeframe, some of which were variants of one another (e.g., sepsis alerts based on different thresholds of Modified Early Warning System scores). These new BPAs accounted for 50.0% of the total BPA volume in January 2018 (Figure 3). Examples of new BPAs introduced during this timeframe include BPAs providing clinical prediction rules for the management of acute pharyngitis and community-acquired pneumonia (as part of a multi-site, cluster-randomized trial); pharmacogenetic CDS provided as a part of the Displaying and Integrating Genetic Information Through the EHR (DIGITizE) initiative;[6] and early

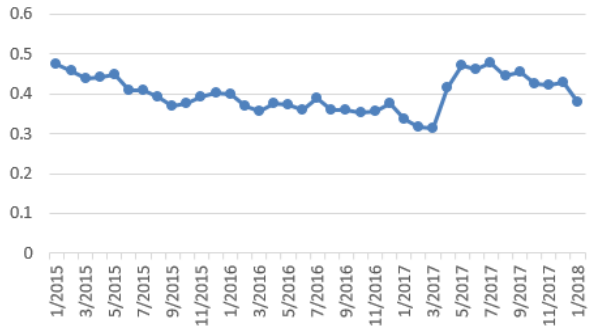

Figure 1. Clinician-facing medication alerts/visit.

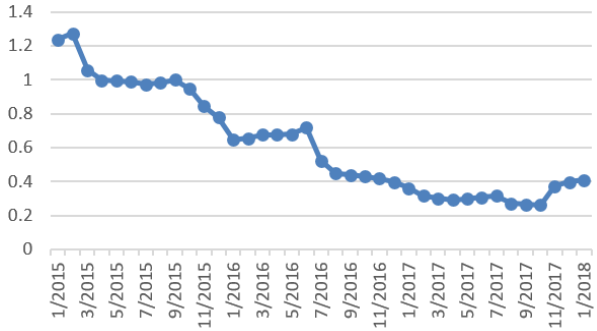

Figure 2. Clinician-facing BPAs/visit.

warning BPAs for detecting sepsis and physiological decompensation. The sepsis early warning BPAs were part of a multi-faceted intervention that led to significant improvements in time to antibiotic administration and overall hospitalization costs.[7]

The overall volume of alerts and reminders (i.e., medication alerts + BPAs) decreased from 1.71 to 0.79/visit (53.8% reduction). The volume of pop-up BPA alerts decreased from 0.29 to 0.14/visit (52.3% reduction) (Figure 4).

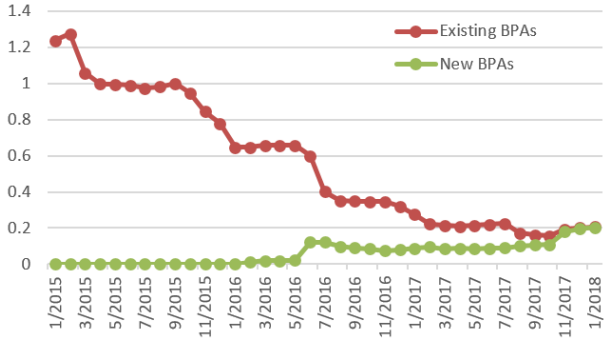

Figure 3. Clinician-facing BPAs/visit stratified by introduction before or after CDS governance initiation.

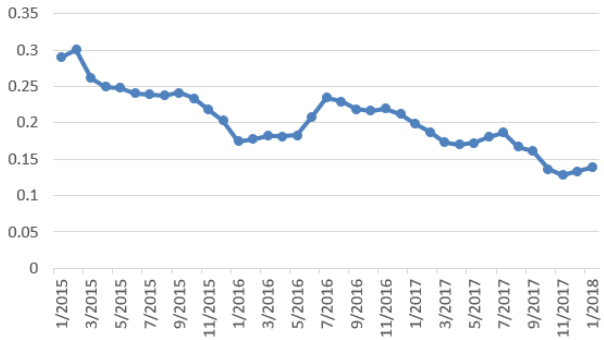

Figure 4. Clinician-facing pop-up BPA alerts/visit.

Impact on CDS fatigue. For medication alerts, the proportion of alerts leading to a discontinuation of the triggering medication within one hour increased from 12.2% to 14.3% (16.9% relative increase) (Figure 5). For BPAs, the proportion of BPAs with an effective user interaction increased from 11.3% to 25.3% (2.2-fold increase). This increase was driven largely by an increase in effective interactions with pop-up BPA alerts, from 25.6% to 56.6%.

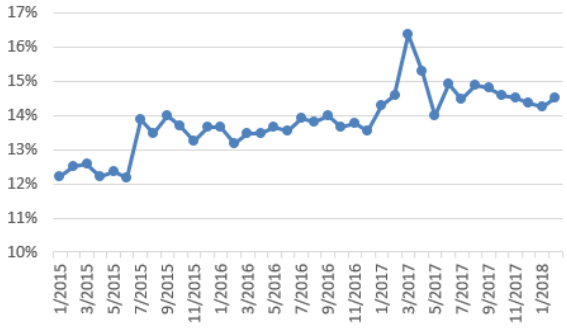

Figure 5. Proportion of medication alerts followed by discontinuation of triggering drug within one hour.

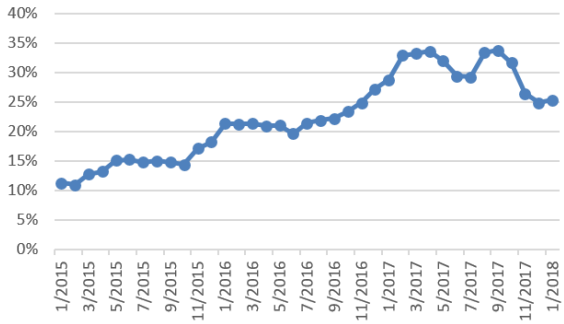

Figure 6. Proportion of clinician-facing BPAs with effective user interaction.

Case study: Hepatitis C screening. When the CDS Committee was first constituted, a BPA reminder for hepatitis C screening among individuals born between 1945 and 1965 accounted for 9% of all BPAs by volume. Data analysis identified, however, that the recommended screening was completed within 30 days of the reminder in less than 3% of cases, and there was abnormal confirmatory test results less than 0.05% of the time following the BPA reminder.

The hepatitis C testing rate and the proportion of eligible patients whose hepatitis C status was known had increased initially when the BPA was introduced in July 2013 (Figure 7). However, there had been a steady decline in hepatitis C testing rates by the end of 2014. After the BPA was turned off in early 2015, there was no clinically significant change in the screening rate. In early 2016, hepatitis C screening was added to the EHR Health Maintenance module. The Health Maintenance module also allows care reminders to be made visible to patients in their personal health records, and this feature was also turned on at the same time. Following this implementation in the EHR Health Maintenance module, there was an immediate and sustained increase in testing rates. This case study shows how changing a CDS modality to match clinicians' desires of where preventive care recommendations should be displayed not only reduced a significant source of CDS burden but also resulted in improved achievement of the clinical goal of improved hepatitis C screening.

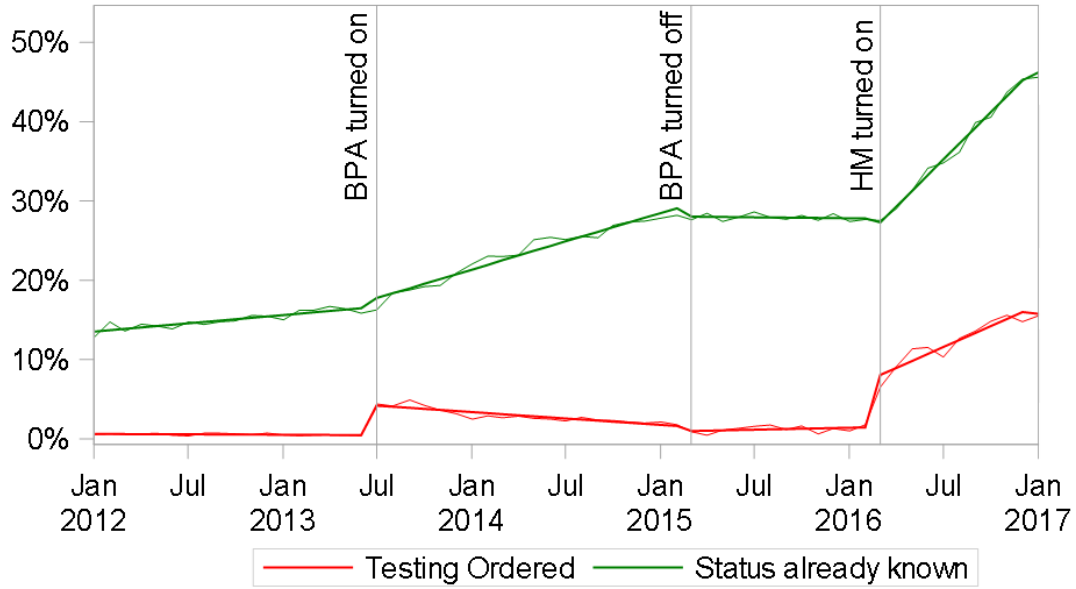

Figure 7. Hepatitis C screening and screening status for patients born in 1945-1965. HM = Health Maintenance.

Discussion

Summary of Findings. In January 2015, the University of Utah initiated formal CDS governance using existing resources. A core component of the governance was the establishment of a clinician-driven, multi-stakeholder enterprise CDS Committee which operates under the principles to (i) add new CDS only if it is actually desired by intended recipients; (ii) use the most appropriate and least disruptive workflow integration approach; and (iii) seek to ensure that the benefits achieved from CDS outweigh the costs. The CDS Committee coordinates with other governance bodies to leverage their expertise, and a subset of the CDS Committee known as the CDS Working Group meets regularly to manage the CDS work queue and implement the direction of the CDS Committee. Changes are communicated to end-users when such communication could help prevent harm or enhance CDS effectiveness. New CDS requests are scrutinized to ensure they provide sufficient benefit to outweigh concerns regarding CDS burden. Existing CDS content is reviewed and optimized through active solicitation of feedback, data analytics to identify low-hanging fruit and monitor progress, and the transition of alert and reminder content to other, more appropriate areas in the EHR. Furthermore, experimental trials are judiciously used to resolve uncertainty.

In the three years following the implementation of this pragmatic approach to CDS governance, the overall alert and reminder volume was reduced by 53.8%, with medication alerts being reduced by 19.8% and BPAs being reduced by 66.9%. Since reduced volume was likely caused by discontinuing CDS thought to be ineffective (some confirmed experimentally) and increasing the specificity of other CDS, these results suggest that the reduced volume was

achieved through elimination of undesirable CDS. For medication alerts, the proportion of alerts leading to a discontinuation of the triggering medication within one hour increased by 16.9%. For BPAs, the proportion of BPAs with an effective user interaction increased by a factor of 2.2.

In summary, this study found that pragmatic CDS governance can be implemented in a resource-efficient manner to reduce CDS burden and improve CDS effectiveness in the context of a commercial EHR system. Moreover, this study provides detailed guidance on establishing and operating such governance. Given the gap in the literature for such pragmatic guidance, this study will hopefully serve as a useful guide for the many healthcare organizations that use commercial EHR systems and are seeking to leverage existing resources to reduce CDS fatigue.

Difference in Impact of Governance on Medication Alerts versus BPAs. The reduction in volume for BPAs was significantly greater than for medication alerts (-66.9% vs. -19.8%). For medication alerts, the base alert settings used for clinicians were conservative, and these general settings were largely left unchanged. The reductions in medication alerts came primarily from targeted changes rather than sweeping changes to foundational configuration settings such as the required severity or evidence level for drug-drug interactions (Table 1). Also, medication alerts are supplied by a knowledge vendor, which limits the degree to which the decision logic can be customized. For BPAs, the overall reduction of 66.9% was driven by an 83.4% reduction in the volume of BPAs that had existed before the CDS governance was instituted. Many new BPAs have been added; by January 2018, half of the clinician-directed BPA volume came from new BPAs that had been introduced after the CDS governance was implemented.

Strengths and Limitations. A key strength of this study is that it describes a pragmatic approach to CDS governance that reduced clinician CDS burden and fatigue while requiring no major investment of new resources. A second strength compared to prior work in this area is that this study provides much greater practical detail on establishing CDS governance. As such, this study provides not only guiding principles but also detailed information on specific steps that can be taken for implementing and operating CDS governance. Third, the approach should be applicable to organizations that use EHR systems with commonly available features such as vendor-supplied medication alerts and customizable alerts and reminders. Finally, our approach was implemented at a setting that is much more similar to the typical U.S. academic medical center. Thus, the approach is potentially more generalizable. Although UUH has a strong Biomedical Informatics department and training program, most CDS Committee members are practicing end-users rather than formally trained informaticists.

One limitation of this study is that clinician review of CDS content in the Health Maintenance section of the EHR is not counted towards CDS volume metrics. However, since end users access the Health Maintenance section on-demand, it is unlikely to contribute to CDS fatigue, whereas intrusive pop-up, "hard-stop" medication alerts and BPAs are likely to be the main contributors to CDS fatigue. This distinction may come from the fact that the Health Maintenance section of the EHR is accessed voluntarily and willingly, when doing so fits best with the user's clinical workflow. Related to this first limitation, a second limitation is that one important tactic used – the delivery of CDS recommendations in a voluntarily accessed section of the EHR that does not contribute to perceived CDS fatigue – may not be possible if an EHR does not offer such a functionality. However, the higher-level principle – to place CDS content in the most appropriate section of the EHR – should be applicable in any EHR as a means of optimizing CDS. Indeed, this principle is closely aligned with Osheroff's CDS 5 Rights, which calls for providing the right information, to the right people, in the right intervention formats, through the right channels, at the right points in workflow.[8] A third limitation is that this study focused on clinicians, whereas other healthcare stakeholders – including pharmacists, nurses, and medical assistants – have similar compelling needs for reducing CDS burden and fatigue. A fourth limitation is that this study does not evaluate the contribution of patient engagement in driving clinical decisions, in particular with regard to Health Maintenance topics which are visible to patients through their personal health records. A fifth limitation is that this study does not include a comprehensive evaluation of the impact of the CDS governance on clinical outcomes. A final limitation of this study is that the approach used has not been formally adopted and evaluated at other institutions. We hope that such external evaluation of the approach can be reported and shared by colleagues in the future.

Implications. An important implication of this study is that a significant infusion of new resources is not a pre-requisite for implementing formal CDS governance and achieving meaningful reductions in CDS burden at typical, average-sized U.S. academic medical centers. Moreover, we believe the approach should also translate well to average-sized community-based health systems. Thus, while additional resourcing could enable optimal governance and effectiveness, healthcare organizations without access to such resources should still be able to move forward in a meaningful manner for instituting effective CDS governance. In particular, as EHR vendors increasingly recognize

the importance of CDS fatigue and provide their customers with analytical tools to support CDS management, tackling CDS fatigue should only become easier.

***Future Directions*.** In addition to the operational CDS governance approaches described in this manuscript, clinical informatics researchers at our organization have been conducting in-depth sociotechnical mixed-method analyses of how clinicians interact with the EHR, with a particular emphasis on CDS and alert fatigue. While the findings from these studies are just getting synthesized and have not yet been used to guide CDS governance at our healthcare system, we are exploring ways in which we can further optimize CDS using the insights from these research endeavors. Furthermore, we have started to interface external CDS Web services into the EHR using the CDS Hooks interoperability framework[9] and the open-source OpenCDS Web service platform.[10] Using this approach, we are exploring further opportunities for optimizing CDS, such as through the shared development and use of optimized CDS content across multiple organizations and the tailoring of CDS content to individual users. For example, using these technical approaches, we could potentially disable a non-critical alert when the user's past behavior indicates that the alert will almost certainly be ignored given the current patient and workflow context.

While we have had some tangible success in reducing CDS burden and improving CDS effectiveness, we feel there is clearly much more opportunity left for addressing this problem. As such, we will continue our CDS optimization efforts with a goal of improving patient care and enhancing the provider experience.

Conclusion

Even without significant new resource investment, pragmatic CDS governance can be implemented to achieve meaningful reductions in CDS volume and CDS fatigue.

Acknowledgements

In the past year, KK has been a consultant on sponsored researcher on clinical decision support for McKesson InterQual, Hitachi, and the Office of the National Coordinator for Health IT (via ESAC, A+ Government Solutions, and Hausam Consulting). The other authors have no potential competing interests to declare.

References

1. Osheroff JA, Teich JM, Middleton B, Steen EB, Wright A, Detmer DE. A roadmap for national action on clinical decision support. Journal of the American Medical Informatics Association : JAMIA. 2007 Mar-Apr;14(2):141-5.
2. Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. BMJ. 2005 Apr 2;330(7494):765.
3. McCoy AB, Thomas EJ, Krousel-Wood M, Sittig DF. Clinical decision support alert appropriateness: a review and proposal for improvement. The Ochsner journal. 2014 Summer;14(2):195-202.
4. Wright A, Sittig DF, Ash JS, Bates DW, Feblowitz J, Fraser G, et al. Governance for clinical decision support: case studies and recommended practices from leading institutions. Journal of the American Medical Informatics Association : JAMIA. 2011 Mar-Apr;18(2):187-94.
5. Breast Cancer Screening. Available from: https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/breast-cancer-screening1.
6. DIGITizE: Displaying and Integrating Genetic Information Through the EHR. Available from: http://www.nationalacademies.org/hmd/Activities/Research/GenomicBasedResearch/Innovation-Collaboratives/DIGITizE.aspx.
7. Lee VS, Kawamoto K, Hess R, Park C, Young J, Hunter C, et al. Implementation of a Value-Driven Outcomes Program to Identify High Variability in Clinical Costs and Outcomes and Association With Reduced Cost and Improved Quality. Jama. 2016 Sep 13;316(10):1061-72.
8. Osheroff JA, Teich JM, Levick D, Sittig DF, Rogers KM, Jenders RA. Improving outcomes with clinical decision support: an implementer's guide, second edition. Chicago, IL: Health Information Management and Systems Society; 2011.
9. CDS Hooks overview. Available from: http://cds-hooks.org/.
10. OpenCDS home page. Available from: http://www.opencds.org/.