Usability Improvement of a Clinical Decision Support System

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Abstract. This paper focuses on improving the usability of an electronic health record (EHR) embedded clinical decision support system (CDSS) targeted to treat pain in elderly adults. CDSS have the potential to impact provider behavior. Optimizing CDSS-provider interaction and usability may enhance CDSS use. Five CDSS interventions were developed and deployed in test scenarios within a simulated EHR that mirrored typical Emergency Department (ED) workflow. Provider feedback was analyzed using a mixed methodology approach. The CDSS interventions were iteratively designed across three rounds of testing based upon this analysis. Iterative CDSS design led to improved provider usability and favorability scores.

Keywords: clinical decision support, CDS, clinical decision support system, CDSS, usability, emergency department, emergency medicine, human-computer-interaction, HCI, SUS, system usability scale, favorability score, mixed methodology, Healthcare IT & Predicting Adoption, Medical Error & Simulation, Patient Safety, Quality in Healthcare, , iterative design.

1 Introduction

As medical complexity and knowledge grow at a dizzying rate, medical providers rely increasingly on computer systems for support. The study of human-computer interaction in the context of healthcare delivery is essential to increase both provider satisfaction and efficiency as well as to improve patient safety and outcomes. Electronic health records (EHR) provide a mechanism to enable the delivery of healthcare; one aspect of the EHR which can impact this delivery is usability.

In the 2012 Institute of Medicine (IOM) report "Health IT and Patient Safety: Building Safer Systems for Better Care", usability of the EHR is identified as an important feature that may contribute to both improved patient safety as well as potential negative unintended consequences [1]. This report also notes that clinical decision

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support systems (CDSS) are an integral component of an EHR that provide suggestions to healthcare workers at the point of care. The IOM report identifies improved usability and design of CDSS as one way to maximize impact and error reduction as well as a way to limit alert fatigue [1,2,3].

In the United States, ambulatory EHR adoption has grown from 18% in 2001 to 78% in 2013 [4]. This growth can be partially attributed to various incentive ('carrot') and disincentive ('stick') programs favoring EHR adoption. The 2009 Health Information Technology for Economic and Clinical Health Act (HITECH) allowed up to US$63,750 in incentive (the 'carrot') payments per eligible provider for EHR adoption that meets certain requirements [5]. Healthcare providers who have not adopted a certified EHR by 2015 will face a 1% reduction in Medicare payments, increasing to a 3% reduction by 2018 (the 'stick'). Various other regulatory and quality improvement programs concurrently push for EHR adoption. These include Centers for Medicare and Medicaid Services' (CMS) Physician Quality Reporting System (PQRS) and Clinical Quality Measures (CQMs).

Hospital information technology (IT) and leadership such as Chief Medical Information Officers to date have largely been occupied with EHR deployment and maintenance as well as satisfaction of various regulations and metric reporting. Usability of the EHR is typically not a high priority among IT or hospital leadership given these competing factors. Further, to qualify for incentive payments under HITECH, various Meaningful Use requirements must be met, one of which is CDSS use. Usability analysis and design are not a requirement of any such regulations, and as such may receive a lower priority than deploying a non-optimized CDSS to satisfy regulations. A CDSS with poor usability may contribute to errors, rather than improve patient care and safety [1,2,3].

CDSS use is increasing as more EHRs are implemented and incentives for CDSS use are in place. CDSS are frequently utilized without regard to usability and provider feedback. Evaluation of CDSS usability within the normal provider workflow is often overlooked in the development of informatics interventions. This evaluation may help refine CDSS to reduce alert fatigue and frustration, thereby making CDSS a more valuable tool in guiding clinical care. This study sought to refine and optimize a pain care CDSS by using an iterative usability design process utilizing a test EHR environment.

2 Methods

2.1 Physical Setup

The testing scenarios were conducted in a quiet office in the Department of Emergency Medicine at the Icahn School of Medicine at Mount Sinai in New York City during daytime hours over the course of 10 weeks.

The setup of the computer and EHR reflected the setup in the clinical environment to which the test users were accustomed with the exception of the CDSS interventions being tested. The test EHR environment was Epic 2010 ASAP (Epic Systems Corp.) within XenApp (Citrix Corp.) running on a standard desktop PC platform with

Windows 7 Enterprise OS (Microsoft). User input was provided via standard 104-key keyboard and optical mouse with scroll wheel. The setup utilized a 17-inch LCD display atop which was mounted a camera for video/audio capture (Logitech Webcam Pro 9000, Logitech Corp.).

Data was recorded using screen capture and video/audio capture of participants with Morae Recorder version 3.3 software (TechSmith Corp). This allowed for later analysis of test sessions using Morae Manager as well as real-time observation of the screen/audio/video by study investigators in a nearby office using Morae Observer.

The study participant's face and audio was captured during the test sessions. A study facilitator was present in the room to direct the user to certain tasks and provide clinical context to the simulated cases. Audio of the facilitator was also captured.

2.2 Usability Testing

A group of five CDSS interventions was developed by an interdisciplinary team to address acute pain care throughout an ED visit (Table 1). Thirteen emergency physicians, all previously experienced in using the EHR, were recruited for participation.

Table 1. Description of Elderly Acute Abdominal Pain Care CDSS Interventions

CDSS Intervention	Description
Pain Score of 10 Alert	A visual pop-up graphic in the center of the EHR screen that interrupts workflow and alerts provider that patient has pain score of 10 that has not been addressed
Re-evaluate at 4 Hours Alert	A visual stimulus within the order entry screen of the EHR that alerts provider that patient has pain score of 10 that has not been re-evaluated or addressed after 4 hours
Order Set	A hyperlink that offers the provider a set of predefined analgesic treatment options for geriatric patients
HPI Reminder	A statement that appears in history of present illness documentation reminding the provider to address patient's pain
Alert at Discharge	A grayed out print button that prevents printing of discharge instructions for patients with an unaddressed pain score of 10

Users were given a $US100 incentive for their participation. Over a 10-week period, seventeen 1-hour usability sessions were conducted across three iterative rounds of testing. Users were given three patient scenarios and were asked to provide simulated clinical care using the EHR in a normal workflow.

The study facilitator provided guidance to the study participant so all tasks could be completed. The study facilitator was able to communicate real-time with the study investigators using iOS iMessage (Apple Corp.) to clarify clinically oriented questions posed by the participant. Users attention was not called to the CDSS interventions prior to the test sessions and users interacted with the CDSS interventions as they completed tasks associated with clinical care.

Patient scenarios consisted of elderly adults suffering from abdominal pain. These simulated patients were modeled as having diverticulitis, small bowel obstruction and constipation. Users utilized order entry, documentation and discharge workflows.

2.3 User Feedback

A System Usability Scale (SUS) survey (0-50 not acceptable, 50-70 marginal acceptability, 70-100 acceptable) was completed at the end of each testing session utilizing a survey function of Morae software. Following this survey, a study facilitator-led structured favorability questionnaire [scored negative (1), neutral (3), positive (5)], and open-ended narrative feedback of each CDSS intervention were completed after each session. Participants were shown pictures of each intervention as they appeared in the EHR and were asked if they would find the intervention useful or not useful and if they had any particular concerns or questions about the intervention. Users were also asked for areas of improvement for each intervention and had a time to provide open-ended feedback.

2.4 Analysis and Iterative Design

An interdisciplinary team consisting of four physicians with backgrounds in informatics, one PhD with a background in usability, one physician with a background in geriatric emergency care, one nurse/IT analyst, one IT EHR analyst and two research associates met to discuss the user provided feedback and study investigator observations. The team reviewed structured and unstructured feedback and favorability scores after each round of usability testing. The majority of this interdisciplinary team was active in the data acquisition phase of the usability studies, allowing informal real-time analysis and discussion among team members prior to formalized meetings. The team, informed by this information, triangulated discrete elements within each CDSS intervention that impacted usability, discussed which changes are feasible within the constraints of time and the EHR system, then incorporated changes to these elements in the next iteration of CDSS design.

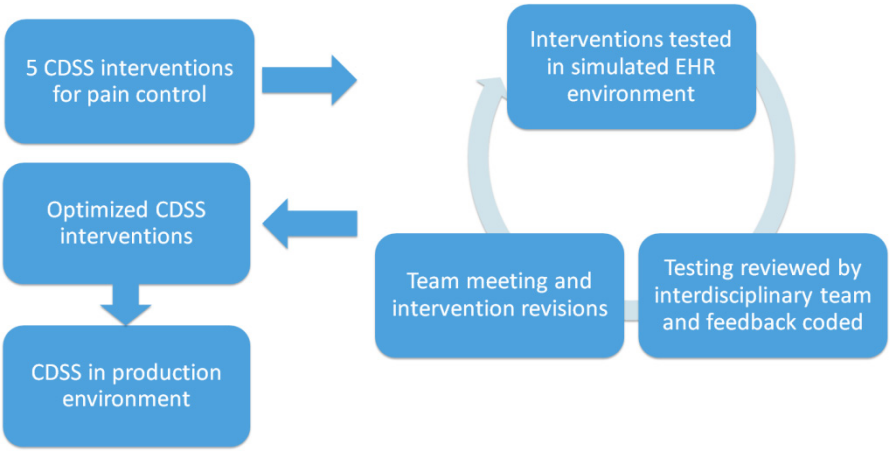

Fig. 1. Iterative design process

3 Results

Twenty-six discrete elements within the CDSS interventions were identified as impacting CDSS usability based upon expert review and testing feedback. Of these 26 elements, 21 were prioritized and addressed in future iterations.

See Figures 1 and 2 for a representative example of the changes that occurred (e.g., reduced text, fewer required fields, and direct links to actionable items) with the intervention for managing patient-reported pain scores of 10.

Over the three testing rounds and redesigns, mean SUS scores improved from 75 to 89. Mean favorability scores improved from 3.4 to 4.5 [scale 1 (worsened care) to 5 (improved care)].

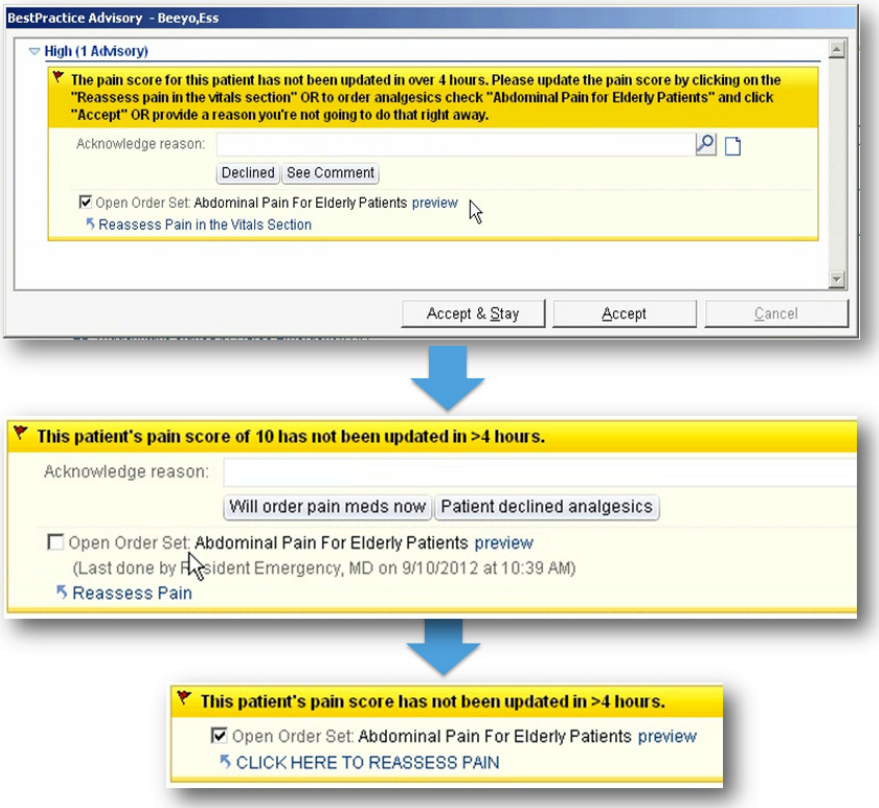

Fig. 2. Iterative usability design of one CDSS intervention over three rounds. There has been streamlining of text, clearer buttons and direct links to order sets or pain re-evaluation dialogs. A representative comment on round 1, "[this intervention] is too complex; I assumed it was an error and I ignored it", and on round 3, "[this intervention] is great, straightforward. I would want to do something about a pain score of 10".

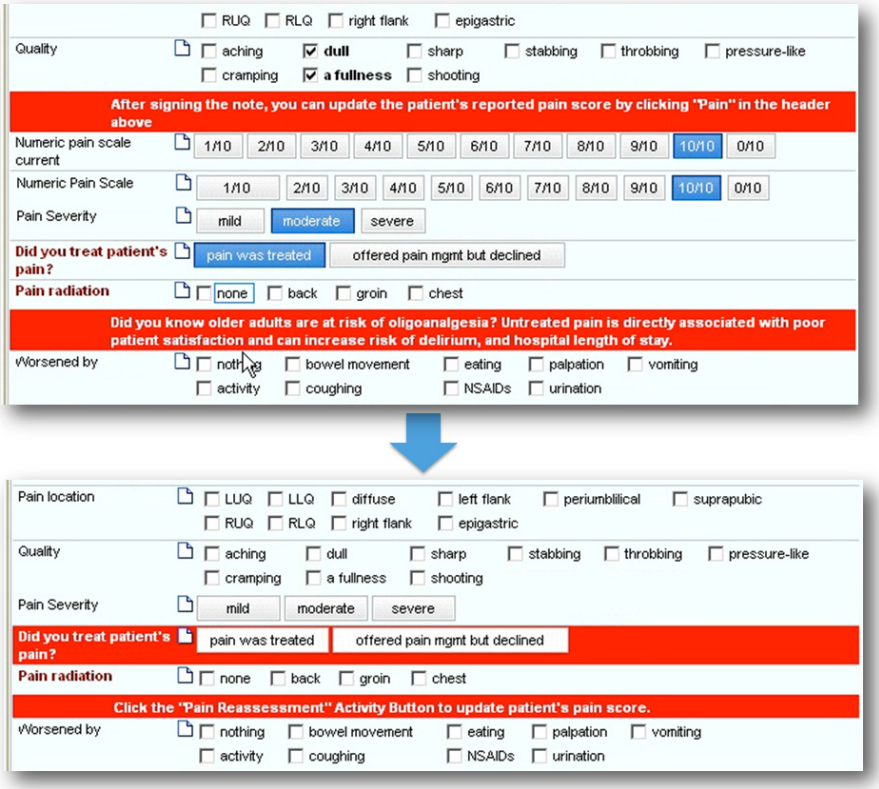

Fig. 3. Iterative usability design over two rounds of testing. Redundant pain scale buttons have been eliminated, and text prompting treatment of pain has been simplified.

4 Conclusions

This study demonstrates how an iterative design process conducted by an interdisciplinary team improves the usability and favorability of a CDSS among providers.

A close working relationship among all key stakeholders in the CDSS development was essential to rapid turnaround of the CDSS interventions. IT was informed by clinicians observing the test users, and clinicians also learned the practical constraints that IT faces. As Health IT evolves past EHR deployment and satisfaction of regulatory requirements, iterative usability design of CDSS over a short period can result in meaningful improvement of the usability of CDSS.

Improved usability may result in greater patient safety, improved provider satisfaction and more efficient workflows. This process may be utilized in other institutions to improve provider satisfaction and enhance the use of CDSS. Usability redesign prior to CDSS deployment in a production EHR environment may result in financial

rewards as IT staff become less burdened with answering users questions and revising a CDSS that is already in production.

Future studies will include real-world testing of the interventions to determine provider efficiency and clinical impact.

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