Usability Laboratory Testing to Define User Interface for Guideline Support in the Electronic Medical Record

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Abstract

Incorporation of "best practice" into clinical care has been inconsistent. Computer-based guidelines have been seen as one solution. The aim of this paper is to describe a process for developing an ideal user interface to support guidance-based clinical care and to identify the required features of the clinical information system to support this. The cognitive walkthrough method was used in the setting of a usability laboratory to understand necessary features of the ideal user interface to support guideline recommendations in clinical care. The method included identification of evaluators, determination of sample tasks, and development of screen designs. This was followed by convening the analysis sessions, recording the observations, developing solutions to problems identified, and revising the interface. We concluded that guideline support needs to be seamlessly integrated into the busy clinician's workflow. Tools such as alert reminders, flowsheets, medical calculators, screening questions and rationale for recommendations need to accommodate multiple users and workflows. User interfaces for additional guidelines need to be tested to see if these conclusions pertain to larger numbers of guidelines or guideline categories.

Keywords: Electronic Decision Support, Usability Interface, and guideline

Introduction

Although the pace of medical discovery and innovation has been rapid, the incorporation of the latest advances into clinical care has been inconsistent.[1] It is well accepted that evidence from systematic research should be incorporated into day to day clinical care, but this has proved to be a challenge.[2] Computer-based guidelines have been seen as one solution to the difficulty of integrating guidelines into clinical care, but there have been barriers to their implementations. One critical problem area is the user interface. Nuances of the user interface can mean the difference between success and failure.[3] To advance the use of common guidelines and overcome these barriers the National Institute of Standards and Technology funded a project in 2001 entitled "Standards Based Shareable Guideline Environment" (SAGE). This project proposed to develop a Standards-Based Interoperable Guideline (SIG) System. The SIG System consists of interoperable guideline model, workbench and deployment software. A key part of this project is to understand and define the required features of the clinical information system's user interface to support guideline-based care in a way acceptable to clinicians. Because the interaction between the clinician and the clinical information system during clinical care is very complex in itself, the interaction under the direction of a guideline or guidelines is even more challenging, and new concepts and principles of this interaction need to be developed.

One tool to understand the usability of a computer program in defined workflows is the usability lab. Jakob Nielsen has defined usability inspection as "the generic name for a set of methods based on having evaluators inspect or examine usability-related aspects of a user interface."[4] In the past we have used a comprehensive and rigid methodology to determine usability of a few features of the user interface on a large number of subjects. This is a successful but costly approach and best suited to

making refinements to software in which the workflow of the user is understood. We utilized the cognitive walkthrough method for our usability inspection to better understand broader issues of software requirements where we were unsure of the workflow.

The purpose of this paper is first to describe the process employed to understand computer-based guideline-assisted clinical care workflow, the human-computer interaction. Secondly, based on a sample of guidelines tested with this method we identified some features of a clinical information system needed to support guideline/clinical pathway supported care.

Methods

A large number of existing guidelines used in the Mayo Clinic inpatient and outpatient practices were examined to understand how they might be imbedded within the clinical information system to support their implementation. A representative subset of these guidelines and clinical pathways was selected for a more in-depth study of the computer interface with which a clinician would interact to perform guideline-supported care. The following three outpatient-based guidelines were chosen to represent preventive services, diagnosis, and chronic disease management: Adult and Pediatric Immunizations (Institute of Clinical System Improvement, ICSI), Community Acquired Pneumonia Diagnosis and Management (ICSI), and Diabetes Mellitus Management (ICSI).[5]
After the guidelines were chosen multiple specific clinical scenarios were developed to exercise the various aspects of the guideline logic. For example, the Adult and Pediatric Immunization Guideline were applied to seven scenarios:

- Neonatal, uncomplicated
- Routine pediatric, uncomplicated
- Pediatric with unknown/uncertain immunization history
- Pediatric with known, out-of-date immunization history
- Pediatric with permanent contraindications
- Adult with transitory contraindications
- Adult with permanent risk factors

These clinical scenarios or use cases were developed with input from physicians and the Mayo project team. The Mayo project team consisted of three general internists, a registered nurse, a medical informatics specialist, a laboratory medicine physician and three information services technical staff.

After the use case scenarios were developed screen designs for the clinical information system were developed. Standard Clinical Information System tools were simulated in the design of screens that would support various aspects of the workflow of each use case. These standard tools included flowsheets, pop-ups and reminders, inbox messages, and data capture screens. Hypertext Markup Language (HTML) was used to create the simulated screens for each of the scenarios. They were developed using Macromedia Dreamweaver MX and Microsoft Visio. These screens had the appearance of a current vendor-based electronic medical record familiar to the usability lab evaluators. The simulations required a standard sequence of choices with the buttons or tabs on the screens having hyperlinks to allow a basic simulation of screen flow. The simulations were run on a standard computer used for patient care in the Mayo Clinic Rochester clinical environment using Internet Explorer.

As the screens and scenarios were being developed questions arose among the experimenters with regards to the ideal workflow and screen design to manifest the requirements and suggestions of the guidelines. It was these questions that were tested in the usability lab scenarios. In other words, a guideline use case was developed, but a subset or modification of the use case was chosen to test hypothetical concerns about the optimal screen tools necessary for the clinical scenario. Before proceeding to the laboratory aims were articulated. From November 2002 through July 2003, four usability sessions were performed. Three guidelines to date have been tested: Community Acquired Pneumonia Diagnosis and Management (Institute of Clinical System Improvement, ICSI), Diabetes Mellitus Management (ICSI), and Adult and Pediatric Immunizations (ICSI).

Sample tasks for evaluation were determined for each of the usability laboratory sessions. Sample tasks that were evaluated included enrolling patients into guideline, reviewing patient specific data, alerting clinicians with guideline recommendations, entering patient data required by the guideline and communication of the rationale for a recommendation.

The testing of the clinical information system screens took place in the Mayo Clinic Usability Laboratory. There were 2 to 5 experimenters observing per individual evaluator session. The lab consists of two

rooms connected by a corridor. The testing room consisted of a computer and telephone on a desk. Experimenters observed from the second room which was adjacent to the first and separated by a two-way mirror. The testing sessions were recorded. The experimenters had no contact with the evaluators before or during the testing session. During each of the four-usability test sessions there were 5 to 10 evaluators who were individually observed by the experimenters. The evaluators were registered nurses, license practical nurses, family medicine physicians, general internists, pulmonologists, and an endocrinologist. The Usability Lab Facilitator sat with the evaluators during each session prompting the evaluator for comments and providing assistance with moving from scenario to scenario.

Each session tested 2-4 scenarios with the corresponding electronic medical record screens. An average of eight evaluators per session were individually observed going through each scenario. During each session each experimenter kept notes on the evaluator's actions and comments. In particular, areas where an evaluator faltered, had trouble with understanding the screens or navigation, desired additional information, or wished to move faster without impediment were noted. At the end of each session there was a debrief run by the lab facilitator which captured, documented, and categorized all of the observations. Every attempt was made not to begin problem solving during the debriefing sessions.

After all of the evaluators had completed their sessions all of the observations were reviewed and solutions to the identified problems were proposed and discussed. Discussions were prioritized by the frequency in which a particular problem was identified. Deductions about the requirements of the clinical information system as well as the interaction between the clinical sytem, the expert engine, and the guideline engine were made. These deductions and conclusions were organized in a specification document that described the necessary features of the clinical information system and its interaction with the guideline engine.

At the completion of the usability laboratory testing, the screens were modified based on the observations and proposed solution. In the case of unclear scenarios or obvious design issues, screens were modified immediately after the issue was identified during the test of an individual subject. This rapid screen design and turn around allowed subsequent evaluators in a particular session to avoid distracting issues and allowed the experimenter team to progress faster through questions that needed to be studied.

After an optimal set of screens was agreed to the lab scenarios and modified screens were documented using Unified Modeling Language (UML) use cases and activity diagrams. The UML diagrams served as a communication tool to the joint partners on the project and influenced both the model development and ultimate electronic medical record design for successful execution.

Results

General Observations

Many evaluators did not understand the term "guideline". In specific, the nurses who participated in the usability lab did not seem to understand that the software was triggering the alerts. This confusion was clarified by avoiding the terms guideline and clinical pathway but instead referring to them as "care support". Instead of using the term guideline reminders, we started using the term "care support reminders".

Multiple current workflows for immunization assessment and documentation were observed. Workflow varied based on the intent of the visit and the specialty and site of the caregivers.

Enrollment

The concept of enrolling a patient into a guideline was foreign and cumbersome to the evaluators. This became evident when testing the Community Acquired Pneumonia Guideline. It is impossible for an electronic guideline to assist the clinician in making a diagnosis if the clinician does not know to call it or the software does not know the signs or symptoms the patient is experiencing so it can offer suggestions. Current clinician workflow consists of evaluating the patient by taking a history and performing a physical examination. Typically, these assessments are not documented until the end of a visit when it is too late for prompting by the software. Therefore some knowledge on the part of the physician about what support is available is probably necessary. Therefore, instead of trying to enroll patients in diagnostic guidelines based on signs or symptoms we found having order sets or medical calculators with pre-filled patient specific data to be potentially more effective aids. The challenge will be to make the medical calculators contained in the EMR to be more convenient then other available tools such as a hand held personal digital assistant (PDA).

Enrollment of patients into the immunization guideline and diabetes guideline was less of a problem. We found that it worked the best to automatically enroll all patients in the immunization guideline at birth or with registration at the hospital or clinic. For chronic disease guidelines, such as diabetes mellitus, enrollment would occur automatically when the diagnosis was entered on the problem list. Any patients felt to be exceptions to the guidelines would need to be actively dis-enrolled by the clinician or office staff. Thus, guidelines vary in how enrollment can be triggered.

Alerts/Reminders

When guideline recommendations are due an alert/reminder may be needed to prompt the clinician. We tested two types of alerts/reminders, a screen pop-up and a message sent to an in-box. The pop-up displayed whenever a user in the appropriate role selected a patient for whom a guideline element was due or indicated. The in-box was displayed on a chart summary view screen of the clinical information system. The chart summary screen is the first, patient specific screen, which contains the patient's medication list, allergies, vital signs, future appointments and an in-box. We also tested varying amounts of information contained within the alert/reminder. Finally, we tested presenting the alert/reminder at the beginning and the end of the patient encounter.

There was divided preference to the type of reminder. Half of those tested preferred a pop-up reminder and half preferred an in-box reminder. The majority of evaluators wanted to be alerted at the beginning of the patient encounter, in order to plan and pace the visit time accordingly. This avoided any of those "oh, by the way" type surprises at the end of a patient encounter.

There was a strong desire to include patient specific information in the alert/reminder. For example, an alert/reminder that just states "immunizations due" was more satisfying when it had mouse roll-over capabilities and displayed the specific immunizations (eg. Influenza, Pneumococcal) due. If several different guideline alerts were triggered, the evaluators did not want a separate pop-up alert for each guideline. Evaluators wanted to be alerted efficiently, unobtrusively and with information rich alerts.

Flowsheet

When a particular guideline-associated documentation element is due or an order is suggested, our usability laboratory observations confirmed that the evaluators want an additional meaningful aggregate view of historical, physical examination and laboratory data for specific diagnosis or conditions. A care support flowsheet was tested and refined for this purpose. The care support flowsheet is a summary table for a particular guideline, set of guidelines or pathway. The flowsheet displays a guideline recommendation or important associated information element in each row.

Through the feedback obtained from the usability lab evaluators the care support flowsheet evolved into a multifunctional tool to assist the clinician in the care of his/her patients. For each guideline recommendation (row on the flowsheet) there is the desire to select the recommendation for documentation or ordering, to determine when the recommendation is due, to obtain focused additional guideline information, to see when the guideline recommendation was last administered (eg. immunizations) or measured (eg. glycosylated hemoglobin) and to see if a result is out of goal range. Administration of immunizations requires obtaining consent, assessing for contraindications and providing education. The concept of capturing screening questions in the flowsheet was tested. Supporting the collection of this information at a convenient time in the workflow assisted the clinician in their workflow and has the potential to ensure safe immunization administration by assuring any contraindication is collected.

Rationale for Recommendations

The evaluators wanted concise, information-dense references that they could call upon as needed. During the usability lab we tested hyperlinks to the full guideline text which consisted of at least 60 pages. This was not found to be useful during a patient encounter, when time is limited. Instead, information icons were placed on the flowsheet and were referenced by clinicians on an as-needed basis.

Discussion

The cognitive walkthrough method described in this paper provided a vast amount of information with regards to the optimal user interface for guideline support in the electronic medical record. The method

consisted of identification of evaluators, sample tasks and development of screen designs. This is followed by convening the analysis, recording the observations, developing solutions to problems identified and revising the interface. A usability lab, rapid design technique to provide software to users and strong understanding of guidelines and electronic record tools were important elements. The method allowed us to quickly understand high level workflow issues that could best be understood in the context of the electronic clinical information system that supports care. It allowed us to test hypotheses and quickly discover problems and issues. It did not require the numbers of evaluators to reach statistically significant conclusions but it did allow us to test widely different hypotheses quickly.

The cognitive walkthrough method has many limitations. In designing the scenarios we may not have considered all possible workflows for every type of user. The method also tends to reward interfaces that are easily learned rather than those that would support an expert user after education and experience. The method may not highlight features intended to enhance productivity. Lastly, the method is more expensive then other inspection methods since multiple actually users are tested.

There are several strengths of the cognitive walkthrough methods. Instead of asking usability experts to evaluate the interface we tested actual clinicians, which are the ultimate end users. The method is able to test minimal prototypes, even paper based prototypes if necessary. It is also a rapid way to determine appropriate menu titles and button labels.

In addition to testing the new usability method, we were able to make some general observations and conclusions about the user interface needed to support the three guidelines tested. Decision support during a patient encounter needs to be seamlessly integrated into a busy clinician's workflow. Tools such as alert reminders, flowsheets, medical calculators, screening questions and rationale for recommendations need to accommodate multiple users and multiple workflows. Even for a single category of users the varying clinical situations, user clinical expertise, and user computer skills make the design of a single user interface and workflow challenging.

Conclusion

The cognitive walkthrough method is an effective usability inspection method to test general concepts about the optimal computer interface to support guidelines. Based on the sample of guidelines tested, a number of observations and conclusions were made about the software used to manifest guidelines. Additional guidelines and categories of guidelines need to be tested to see if these conclusions pertain to larger number of guidelines or guideline categories.

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