Using qualitative studies to improve the usability of an EMR

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Abstract

The adoption of electronic medical records (EMRs) and user satisfaction are closely associated with the system’s usability. To improve the usability of a results management module of a widely deployed web-based EMR, we conducted two qualitative studies that included multiple focus group and field study sessions. Qualitative research can help focus attention on user tasks and goals and identify patterns of care that can be visualized through task modeling exercises. Findings from both studies raised issues with the amount and organization of information in the display, interference with workflow patterns of primary care physicians, and the availability of visual cues and feedback. We used the findings of these studies to recommend design changes to the user interface of the results management module.

\section{1. Introduction}

The potential benefits of information technology (IT) and the Internet to medical care are well recognized. Reminder systems, online prescribing, and telemedicine applications are just a few areas where IT can have a significant impact on the quality and timeliness of health care delivery\cite{1}. However, medical professionals must first adopt and utilize this technology as part of their practices if these benefits are to be realized. One of the largest barriers to EMR adoption is resistance from physicians, who cite computer anxiety, increased time for orders, decreased interaction with patients, and lack of integration with physician workflow among their primary concerns\cite{2}. Usability is thus critical to successful IT implementation and adoption and its subsequent ability to improve health care quality.

As defined by the International Standards Organization\cite{3}, \textit{usability} represents the effectiveness, efficiency, and satisfaction with which specific users can achieve specific sets of tasks in a particular environment. A user’s experience with a system is also influenced by error frequency, learnability, and memorability\cite{4}. In order to support the healthcare process and reduce medical errors, EMRs must support clinical workflows and have “interfaces that are easy to understand and navigate”\cite{5}. Qualitative research methods, such as ethnographic observations and focus groups, can improve the design and usability of EMRs through interaction with real users. These studies seek to identify and prioritize user tasks in a clinical environment, as well as diagnose areas of existing systems where usable design is not present.

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We describe two separate qualitative studies that attempted to identify user task flows with an existing EMR, to better understand the environment in which these tasks are performed, and to determine how overall usability can be improved. The findings of these studies contain significant overlap with regard to certain user behaviors and expectations. In the following sections, we will define the task analysis and focus group methodologies used for the studies, present an analysis of the data collected with supporting cognitive research, and recommend design solutions to improve the overall usability of the EMR observed.

2. Research methods

Both qualitative studies focused on users of the Longitudinal Medical Record (LMR), a web-based application that facilitates the management of patient information, provides clinical messaging, and standardizes methods of data entry and retrieval. LMR is a well-liked and widely used system, but problems of usability and room for improvement have been informally observed. The test participants who volunteered their time are proponents of health care information technology and recognized our work as an opportunity to help LMR succeed.

There are many different functional components that comprise LMR, but our focus for this particular study is on Results Manager, a component that assists users with follow-up tasks for patient laboratory test results [6]. It collects test results ordered by a physician and presents them from one centralized location. The number of results letters generated using Results Manager has risen from 18 during its launch in November 2002, to nearly 4500 per month as of December 2003. However, to bring its adoption to universal levels within our organization, we sought to address usability factors in the application.

Our investigations were both formative and summative in nature, conducted to guide the formation of new user interface designs and to summarize the effectiveness of existing designs. IRB approval was requested and received when necessary.

2.1. Task analysis

The first qualitative study combined different forms of task analysis, a methodology that focuses attention on users and on their tasks and goals. Task analysis clarifies the objectives of each task, which tasks are most important to users, and which tasks depend on other tasks [7]. It also identifies the communication needs of users as they exchange information with others while performing tasks [4]. Other issues to consider are task difficulty and the knowledge and skills required by the task. We also incorporated ethnographic observations (or field studies) into our methodology to better analyze the environment and specific work settings in which user tasks were performed. The attention to detail in describing and explaining how work is organized provides a useful resource for system designers, helping them to understand the activities that should be supported in a new design and to identify processes that do not work well and need to be re-designed [8].

Seven test participants from primary care practices associated with Brigham & Women’s Hospital (BWH) and Massachusetts General Hospital (MGH), including five physicians and two nurses, were observed individually in their clinical workplace using Results Manager (Fig. 1). One author—an experienced usability engineer—was present at all sessions to record data as each participant worked for 30–40 min with various patient records. Test participants also used the “think aloud” method to describe their thought processes and offer feedback while interacting with the system. A microcassette recorder was used to capture and review these comments. Due to the somewhat intrusive nature of the task analysis methodology and the limited availability of our clinical users, our only requirements for these sessions were that each participant had at least some experience using Results Manager and was willing to be observed.

Following the qualitative data collection process, relationships among the various user tasks were established and task modeling exercises [9] were performed using Microsoft Visio to diagram the workflows of each clinician (Fig. 2). Each diagram represents the collective set of actions that were performed by a clinician while he or she worked with the system. This exercise allowed us to visualize the complex processes inherent in outpatient medicine, compare and contrast user interactions, and identify where similarities in workflow occur. The diagrams and supporting test participant comments were then used to suggest possible design solutions.

The data collected in this study required approximately 6 h of analysis, with an additional 14 h devoted to task modeling.

2.2. Focus group

Generally used for market research, focus groups can be an excellent source for collecting usability data and are a reliable instrument for measuring the quality of health care [10]. Focus groups are an informal and relatively unstructured exercise that can help assess user needs and feelings both before and after system design [4]. Moderators can also ask participants to discuss how they perform certain activities, making this methodology an excellent complement to a task analysis study.

Our second qualitative study included five separate focus group sessions that were open to any attending physicians or internal medicine residents who worked
in a primary care practice at BWH or MGH. There were no other exclusion criteria. Email invitation letters and reminders attracted a total of 26 physicians (2 interns, 11 residents, and 13 attendings) with varying degrees of computer and EMR experience. Participants in this study were compensated with $50 gift certificates to a national bookstore. One physician who participated in the task analysis study also took part in a focus group session.

The recorded sessions were co-facilitated by two co-authors—one an internist, the other a psychologist. Each session lasted 90 min and was recorded and reviewed to ensure complete analysis of all content domains. The five groups took a total of 7.5 h to conduct, plus 15 additional hours of analysis. Focus group questions were primarily open-ended and addressed details of clinical workflows such as visit preparation, patient encounters, order entry, visit documentation, and follow up. More focused questions were used to ascertain when (during their workflow) clinicians would be most able to respond to decision support, their receptiveness to case management interventions, and their opinions of LMR-based support. For the purposes of this study, we present our findings on usability issues related to Results Manager and follow-up of test results.

2.3. Collaboration

The task analysis and focus group studies were conducted independently of each other, but with an agreement between their respective administrators to collaborate and identify common themes during the data analysis phase. This resulted in a joint effort to systematically compare the results of our inspection and propose solutions for enhancing LMR’s usability.

3. Results: similarities between studies

In this section, we discuss related findings in the two qualitative studies that address certain usability deficiencies of LMR and, specifically, the process of using Results Manager to follow up on patient test results.

3.1. Navigation and system context

The navigation in LMR was described as “awkward” by participants from both qualitative studies who also indicated “too many clicks and screen flips” were required to complete the task of acknowledging and informing patients of laboratory results. This particular workflow required frequent access to other modules of the LMR, most notably Patient Summary, Medications, and Notes. If the information required to support this workflow was not immediately present in the Results Manager screen, it became necessary for users to temporarily shift their focus to other parts of LMR, making it harder to maintain system context. “The navigation is unclear, so I go back to a common point I’m familiar with,” expressed one observed participant.

All participants observed during the task analysis study, as well as many from the focus group, expressed the need for quicker access to LMR’s Notes module.

Fig. 1. Screen shot of existing Results Manager user interface.
(where previous outpatient visit notes are kept) from within the Results Manager. Currently, this can be done using the “Popup” menu feature on LMR’s main navigation bar (Fig. 1), which launches a new “child” window on top of the active browser window to view other LMR modules. However, even experienced users found continued frustration with this indirect approach as Notes is not listed as a selection under the Popup menu. Another sub-menu item, such as Health Maintenance, must be selected first, and then the user can navigate to Notes. Another alternative is to stay within the main browser window and leave the Results Manager module, which adds the additional tasks of temporarily saving data and moving to another screen. Two users from the task analysis study described themselves as “single-window users.” One was unsure what the “Popup” menu actually did and the other avoided using it because she sometimes had the tendency to close the wrong window when working with multiple overlapping windows.

Fig. 2. Sample task flow diagram of Results Manager workflow.
A physician participant in the task analysis study (who also participated in the focus groups) demonstrated a different workaround to address the LMR navigation issues—he kept multiple browser windows open and switched back and forth between different patient records and LMR modules. While waiting for the system to process one patient record, he created his own navigation system to be more productive. However, while this may seem like a clever solution, it can undermine patient safety [5]. When asked if he ever got confused during multiple window switching, this physician responded, “Yes, all the time.”

3.2. Information design

One of the greatest identified challenges of EMR user interface design was balancing the clinician’s information needs with the limited amount of available screen real estate. Our test participants wanted immediate access to information: “If it’s not on the screen, it better not be more than one click away,” as summarized by one observed user during our task analysis research. However, physicians also complained when too much information was on a screen, making it “too busy” and problematic when trying to perform tasks quickly.

During their observed usage of Results Manager, all seven participants in the task analysis study accessed LMR’s Patient Summary feature at least once. The Patient Summary screen serves as a clinical portal that displays customizable components similar in form and layout to those found in My Yahoo! Users of this feature can quickly glance at a selected patient’s results, medications, visits, notes, family history, and allergies. Despite the convenience of Patient Summary, however, many participants were quick to point out that its layout feels cluttered in the 800 × 600 display and the Notes, Visits, and Medications components require horizontal as well as vertical scrolling.

Screen contrast is also an important consideration for user interface designers. Test participants noted the Results Manager’s liberal usage of color and low contrast with data objects that are in their “selected” state. For example, the list of laboratory results that require action are displayed in bright blue “hyperlink” text. When selected, a blue-gray bar appears behind the laboratory result text and it becomes hard to read (Fig. 1). Secondly, although the Alerts and Guidelines box is displayed with bright red borders, the task analysis test participants paid little attention to it, suggesting that it used color ineffectively, or may require more prominent placement on the screen.

3.3. Customization

Comments regarding customization were targeted primarily toward the letter-writing feature in Results Manager. Many physicians often used their own letters and found the pre-defined letter templates of Results Manager to be inadequate for all their workflow needs. Three test participants cited bigger default font sizes for letters to elderly patients and the ability to import prior test results as desirable features. The additional steps of having to copy and paste from previous notes and to continuously adjust fonts add to the user’s time on task.

3.4. Workflow patterns

The majority of participants in both studies used Results Manager during specific blocks of time they reserved during the week, typically 30 min to an hour. It was often the case that these users only had a single block of time each week to spend acknowledging laboratory results and printing patient letters. However, there were some users who attempted to complete these tasks in between their patient encounters and other daily responsibilities, using either Results Manager, or a manual method such as hardcopies of laboratory slips. The task analysis participants typically had anywhere from 10 to 40 patient records waiting in their queue, but one participant said she could have as many as 100 pending records upon returning from a week out of the office. One observed participant checked for updates throughout the day and wrote preliminary notes as separate results came in. Batch printing of patient letters was also common across test participant workflows, as not every user was within close proximity to a printer.

As mentioned earlier in the report, Medications, Notes, and Patient Summary were among the most frequently accessed LMR modules while working with Results Manager. However, most of the task analysis participants said they would not need to invoke Popup to access the Medications module if they could edit the patient’s medication list directly from Results Manager. Currently, they can only add a new medication from within the Results Manager screen.

Sometimes workflow patterns seemingly unrelated to following up on test results had an impact on the use of Results Manager. For example, one physician in the focus groups had her secretary copy her last visit note into the current note immediately prior to the visit. Because Results Manager creates its own note, the physician was afraid that her secretary would get confused and copy that instead of the last visit note. The result was that they physician did not use Results Manager at all.

4. Design recommendations

When designing a system for diverse user groups such as those in a clinical setting, it is important to consider
the diversity of expectations, experiences, and prior knowledge that users will map to that system. More experienced users who are accustomed to media-rich interfaces may have a lower tolerance for systems that don’t immediately match their functional expectations or aesthetical preferences. Inexperienced users will most likely require a clean, simplified interface that explicitly maps to the tasks they are trying to perform. In either case, careful attention to usable design in clinical applications can impact the user’s perception of the application’s utility, and potentially patient safety and quality of care. Likewise, an aesthetic presentation adds personality and provides users with a sense of enjoyment, trust, and professionalism [11]. This section demonstrates how we have attempted to solve some of the usability issues discussed throughout the report.

With task flow diagrams (Fig. 2) and supporting qualitative feedback as a guide, designers can generate wireframes (Fig. 3) and mature mock-ups (Fig. 4) to test potential solutions. Minor changes in screen designs can have major impact on user actions [12] and we have attempted to balance the basic structure of the Results Manager user interface with principles of good information architecture and usable design. It is our hope that the proposed modifications have resulted in a cleaner, more user-friendly design. Future usability assessment will be necessary to determine if these design changes are more accommodating to user needs.

4.1. Screen resolution

A recent report showed that nearly half of all World Wide Web users have their monitors set at 1024 × 768 pixels and an additional 18% are using even larger screen resolutions, while only 34% use 800 × 600 or lower [13]. Throughout our health care network, shared workstation builds are currently set by default to 800 × 600 pixels. Private office builds are also set to this resolution, but clinical users with their own systems are free to adjust the settings. One of the first noticeable differences in the updated Results Manager design (Fig. 4) is the optimization for the higher screen resolution of 1024 × 768. With additional screen real estate, the data has room to breathe and the overall presentation is cleaner, allowing users to more easily scan the page.

4.2. Alignment of data objects

The task analysis data suggested the need for displaying the Alerts and Guidelines box in a more prominent position on the screen. Our proposed solution involved moving this component to the top of the page and toning down the amount of bright red so that the box is more easily noticeable, yet not distracting when users are scanning other parts of the page. We also added a recognizable alert icon that should be familiar to users of the Microsoft Windows operating system.

![Fig. 3. Wireframe of proposed Results Manager user interface.](image-url)
In the current Results Manager interface, the data fields and action buttons in the left-hand portion of the screen appear bunched together and it is difficult to tell which objects are related. Using a soft colored box, we have visually grouped the list of laboratory results with the action buttons related to acknowledging the results. The free text box for entering comments has been grouped with the “Close Current Visit” checkbox and the “Back to Results List” button—actions typically performed before leaving this screen.

When composing a letter, users will now notice the “Add address & salutation” and “Add ending & signature” buttons are now visually grouped with the other formatting tools.

4.3. Navigation

To reduce the number of clicks required for accessing Notes and other relevant data, we’ve taken advantage of the higher screen resolution and have added some additional components at the bottom of the screen. Notes and Visits data are now grouped together in a tabbed component, allowing users to view existing notes and add new notes. Medications and Problems data are still present, but have also been grouped together using the tab metaphor. Together, these changes also allow for better integration of Results Manager tasks into the workflow patterns of the physician users.

4.4. Aesthetics and color

Our redesign uses color sparingly and favors a softer color palette over the abundant and heavier blues in the original design. When a web page is saturated with color, it is hard for any one color to stand out. With a quick glance, it is now much easier to spot information that is intended to stand out, such as the icons, red text, and highlighted tabs. Contrast between foreground text and background has also been improved in both the laboratory selection list and with the tab labels.

4.5. Customization

We are currently planning to deploy more context sensitive templates that give users the option to import test results with the patient letter. These enhancements are not reflected in the design mock-up.

5. Discussion

Usability testing has not been a routine part of designing clinical computing systems [12] and there has been a dearth of human factors-related research in the field of informatics. However, recent studies have identified system speed to be the primary determinant of user
satisfaction in the clinical setting [12] and a test participant from our task analysis study commented that she would gladly give up many features to make the system faster. Other informatics research has reinforced that the application of usability principles, and not just the technology itself, holds the key to successful EMR implementation and adoption [5].

The usability issues discovered in our collaborative research can be improved through a stronger awareness of the health care practitioner’s workflow in busy clinics and their ongoing need to provide chronic disease management and quality care.

5.1. Summary of findings

The usability issues identified through our research have been noted in other studies [5,12,14] and can be associated with various theories of human cognition and visual sensory perception.

5.1.1. Navigation and system context

The context and navigation issues discovered during our studies can be linked back to the notion of speed being the essential attribute for a successful EMR [12] and to the importance of efficiency in our earlier definition of usability [3]. This is also consistent with other studies in which physicians register a loss of overview when they are required to go to “many different fields on many different screens to enter many details” [5]. The inventiveness of user workarounds are clues to these types of design problems.

Supported tasks should be time-neutral, if not time-saving, by making it easy to perform common tasks such as printing patient letters and instructions. The software must also take into account the user’s entire workflow, including a variety of practice styles, and not just the workflow relating to the task at hand [5].

5.1.2. Information design

A user-friendly EMR will effectively balance information needs with screen real estate, or risk adding unnecessary burdens to clinician workflows. Cognitive load theory is defined as the amount of “mental energy” required to process a given amount of information [15]. As the amount of information increases, so does the cognitive load on our mental resources. A user’s attention becomes divided when faced with multiple complex tasks and items in working memory begin to deteriorate as they compete for precedence. In addition, anxiety and frustration can reduce the size of the available memory when a person’s attention is partially absorbed in concerns that are beyond the problem-solving task. This increases the potential for errors. If users rely less on cognitive resources, they have more attentional resources to place on the task at hand and the likelihood of errors is reduced.

When screen elements are too close together, users are forced to engage in slower serial processing of the information, which requires more time and attentional cognitive resources [16]—both lacking in the clinical user’s multi-tasking workflow and interrupt-driven environment. Close proximity of user interface items may also lead to users inadvertently clicking the wrong options—this is of particular concern given LMR’s current 800 × 600 screen resolution requirements.

The concept of a “visual hierarchy” is an arrangement of visual elements in which related items are physically grouped together [17]. The physical structure of the layout guides the user to the information they need. Building on this idea, designers should organize visual elements into logical groups defined by space (proximity) and alignment, giving important elements prominence through contrast [18].

To simplify the amount of displayed information in future releases of LMR, a knowledge-centric organization of relevant content could be a possible solution. For instance, rather than display all notes, it might be useful to show only those notes that have mentioned a specific test or problem.

5.2. Implications for software design

Our findings have other implications for software design that extend beyond the specifics of LMR and Results Manager.

5.2.1. Global and personal focus

A task-centric approach allows designers to quickly funnel a diverse user base into specific action-oriented areas of a web site or application. System designers should be able to anticipate some of the most important user needs and present task-based action items to meet those needs [19].

However, physicians also want customizability, and the lack of personalization features can be an impediment to EMR usage. The desire to customize system options such as letter templates and alerts and reminders could be reflective of the fear many physicians have of losing the “human element” of medicine—in this case, having a system make decisions for them. Regardless of the extent to which future EMR templates and alert systems are user-defined or more intuitively standardized, they should be contextually relevant and should match user expectations [5].

5.2.2. Usability and user-centered design

Task analysis data and usability research in general are critical components in the system development process and should be given equal consideration with functional requirements and standard user interface conventions to help produce usable solutions. However, it is not always possible to conduct extensive usability
studies during a product life cycle, due to time constraints, lack of financial resources, or insufficient expertise. In these situations, there are “discount inspection methods” that can be applied such as simplified thinking aloud and heuristic evaluation [20]. Both exercises strengthen comprehension of user workflows, require little to no formal usability training, and can be conducted regularly throughout the system design phase by any member of a product team. Frequent iterations of prototype design and testing help promote a user-centric focus throughout a development organization and give clinicians the opportunity to become more involved in the production of software they may potentially use.

5.2.3. Ergonomic considerations

It is worth noting that all seven test participants observed during the task analysis study were using washed out CRT monitors that were very dark, even at the highest brightness and contrast settings, making the interface difficult to read. This could be an indication that the monitors are continuously left on, which shortens their life spans considerably. The bright lights of the offices and exams rooms reflecting off the monitors further impeded discernability of the user interface. Liquid crystal displays (LCDs) would provide a more vivid presentation of the data and, whenever possible, soft ambient light is recommended to reduce the screen glare that can be caused by direct and overhead lighting [16]. While this could be a potential limitation of the study, we feel that the LMR user interface could still benefit from enhanced contrast, which would help mitigate the adverse effects of poor monitor quality and lighting conditions. Ensuring an appropriate level of contrast between interface elements becomes that much more important when considering environmental factors such as these.

5.2.4. Training issues

Users approach new products with preconceived ideas based on their prior experiences [21]. They interpret what they see in an interface and draw their own conclusions about how it works and act on those conclusions—which may differ from the designer’s intentions. Mental models are formed through experience, instruction, and training and are used to make associations between information users are learning and information they already know [22].

During the training of a new application, it is important to explore with users its impact on their workflow. Novice and expert users alike often need to re-engineer their workflow as they try to use a new application to improve quality and efficiency. Training should therefore go beyond just the mere functionality of the application and explicitly discuss different ways to use the new application in the environment of the user. Single training sessions where a lot of material is covered is often ineffective because many users simply cannot remember every detail presented to them. From a training perspective, this emphasizes the need for ongoing training and incorporating sufficient visual cues on the screen to create a more intuitive design.

5.2.5. Portable devices

We are currently in the process of conducting studies to assess the usability of Tablet PCs running LMR and their impact on clinical workflows. These portable devices still lack applications that are truly tailored for the health care environment [23] and many of the same usability issues apply to a Tablet as with their larger desktop counterparts. The ability to retrieve and manipulate data effectively and efficiently using a clear navigation system is still a requirement, but becomes more challenging when considering touch screens and styluses and the efforts needed to calibrate them properly.

5.3. Limitations and next steps

A major obstacle when conducting our qualitative studies was user availability. Due to the small number of observed users, we may have not captured every type of workflow pattern, but this was a tradeoff in the sense that there was richness in the data we did collect. Results Manager users have a tendency to designate certain blocks of time during the week to acknowledge laboratory results, so observation sessions took place in the absence of patients. Other LMR modules in the system may require a different approach, as many physicians may not be as receptive to sessions being observed during patient encounters.

Observations for our task analysis study took place in four clinics within one large care network using a homegrown EMR, so issues may vary at other organizations using different systems. Another limitation of both qualitative studies is that they focused primarily on physicians, with only two nurses included in the task analysis sessions and none in the focus groups study. However, some of the focus group discussion addressed physicians’ impressions of a proposed case management system, so it would not have been appropriate to query nurses on topics such as these.

In the future, we would like to observe more nurses, physician assistants, and other relevant office staff members while they work and construct additional focus group studies that specifically address their work flows. It may also be useful to include quantitative measures such as task frequency and time on task.

Overall, we are very satisfied with the amount and quality of data we received using these qualitative assessment methodologies and the relative ease involved in their setup. The task analysis participants were simply performing their normal tasks, but simultaneously contributing to the usability efforts that will enhance the de-
design of an important tool they have come to depend on. Recruitment efforts for the focus groups were also fairly easy given the nominal incentive to participate.

The next phase in the usability life cycle of LMR is to conduct summative evaluations of our design recommendations to validate their effectiveness in addressing the issues outlined here. We have a number of user group meetings and other clinical forums through which we can collect rapid feedback on initial design proposals, while prototyping and other implementation efforts will allow for more thorough assessment.

6. Conclusions

Usability engineering can play a valuable role in assisting product design teams as they support the growing relationship between health care providers, patients, and information technology. We have identified a method of combining task models with qualitative feedback to improve the usability of an EMR. Cognitive research extends the value of collected test data by offering explanations as to why users respond to interfaces the way they do, and offers insight on design improvements. The findings of these studies are being used to improve LMR’s user interface and provide reference data for the creation of visual style guides, which will help ensure usability and design consistency across other clinical applications.

References