A Usability Study of Physicians Interaction with a Paper-Based Patient Record System and a Graphical-Based Electronic Patient Record System

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ABSTRACT

The user interface of an electronic patient record system can significantly improve user acceptance and ease its adoption process. The design of a user interface should take into consideration the characteristics and the needs of the user incorporating usability engineering principles in the lifecycle of its development. In this paper we describe a study of physician interaction with a paper-based patient record system and a graphical-based electronic patient record system. The usability attributes of learnability, efficiency and satisfaction are evaluated on the whole spectrum of physicians' activities with patient record systems.

The results of the study did not reveal a significant difference in the overall time to complete typical physician tasks. However, on average physicians can perform *viewing* tasks faster, *documenting* tasks slower and *ordering* tasks at about the same speed on the graphical-based system than on the paper based system. Physicians were found to be significantly more satisfied with the graphical-based system than with the paper-based system. The results also revealed that physicians with higher levels of computer literacy and typing skills can complete typical tasks in significantly less time on a graphical-based system than physicians with lower levels of computer literacy and typing skills.

INTRODUCTION

There are many hurdles that need to be overcome in the adoption of an electronic patient record system. The most significant is the cost of acquiring or upgrading a system. Installing a new system requires a significant investment in human resources, personnel training, facilities, hardware and software [1]. The second most significant hurdle is ensuring that the personnel will use the system. If the users perceive the new system as difficult to use, not improving health care quality, and impediment to their productivity and waste of time, there is a good chance they will resist change. The consequences of resistance to change is documented in the literature. In [2] the authors describe the technical complexity of the transition from a paper-based ordering system to an electronic system. They mentioned how they had to deal with some physicians wanting to return to the paper-based system and how they avoided "user revolt" during the implementation process. There have also been discussions of strikes in the introduction of a physician order entry system at a major academic medical center [3,4].

The user interface of an electronic patient record system could significantly contribute to lowering the users hurdle. A user interface that is easy to use, easy to learn, and that allows users to achieve a high level of efficiency can significantly improve user acceptance and ease the system adoption process.

The design of a good user interface requires that the characteristics and needs of the users be taken into account. The design must be centered on the users. A user-centered design can be achieved by incorporating usability engineering principles in the lifecycle of the user interface development. Usability is associated with five attributes of a system: learnability, efficiency, memorability, errors, and satisfaction [5]. "Learnability" refers to the ease by which users learn to use a system and get some work done. "Efficiency" refers to the level of productivity that can be achieved with a system once the users have learned to use it. "Memorability" refers to the ease by which casual users can use the system without learning it again. "Errors" refers to the capacity of a system to reduce user errors. "Satisfaction" refers to the level of subjective satisfaction achieve by the users when using the system.

RELATED WORK

The relevance of usability engineering in the development of user interfaces for health care applications is recognized in the literature. An iterative usability testing process for evaluating usability problems on a clinical workstation is described in [6]. A cognitive-based usability testing approach for evaluating clinical information systems and user interfaces is described in [7]. However, there are only a handful of studies that report results of the evaluation of usability attributes of an electronic patient record systems. Most of these studies evaluate user satisfaction through questionnaires as is in [8-10]. A very small number of studies evaluate efficiency through user testing [11-12], and fewer evaluate learnability [12, 13].

Most of the usability studies found in the literature involving physicians dealt with order entry systems. Very few of them involved user testing [11, 12]. None of the studies involving physicians dealt with the whole spectrum of the physicians' interactions with patient records (*viewing, documenting* and *ordering*). In this paper we describe a study of physician interaction with a paper-based patient record system and a graphical-based electronic patient record system. The usability attributes of learnability, efficiency and satisfaction are evaluated on the whole spectrum of physicians' interactions with patient record systems.

METHODS

The Systems

The paper-based system consists of a collection of sheets. The sheets are typical patient record documents such as progress notes, nursing documentation forms, labs results, diagnostic studies results, and physician orders. Physicians' progress notes, primary care problems and SOAP documentation are written on hospital-made physician progress note forms. Physicians' orders are written in hospital-made orders form. Requests for consultations are written on a hospital-made consultation request form and must also be written on the physicians' orders form. The record used for the experiment was relatively small and did not include nursing documentation.

The graphical based-system is a research prototype of a computer-based record system for inpatients and outpatients. Physicians can lookup patient demographic information, medication, lab results, diagnostic studies results, primary care problems lists, physical exams, notes and summaries of previews patient visits. Physicians can also add new problems and notes, order medications, laboratories, and diagnostic studies, can request consultation with other physicians, and can discontinue medications.

The system features a graphical interface with separate windows for viewing the patient record and for entering physicians' orders. The top portion of the window for viewing records provides a photo of the patient and the patient's age, sex, weight, height, allergies and primary care physician. Below the top portion there are ten tabs (Profile, History, Complaints, Physical exam, Medication, Results, Nursing, Problems, Notes, Lookups). The user selects a tab by pointing and clicking on them. The information corresponding to a tab is displayed in the space below the tabs. In many cases the information is listed in rows and columns. Each row is an entry and each column an attribute of the entries. This information can be sorted according to an attribute by clicking on the attribute's name at the top of the tab.

The window for entering physicians' orders is similar to the window for viewing the record but without the photo and with six tabs (Medications, Laboratories, Exams, Consults, Misc, Summary). Some of the tabs provide options that can be selected by clicking an item from a list or by typing the item name followed by the return key.

Participants

The participants were selected from a group of physicians that responded to a call for participation. The selection was made based on their availability for the time slots scheduled for user testing following a first-come first-serve priority. Two groups of physicians participated in the study. The first group (Group A) consisted of seventeen internal medicine resident physicians from a teaching hospital in the San Juan metropolitan area. The group had an average of 2.2 years of experience as resident physicians. Only five participants from this group had some experience with electronic patient record systems. The group had an average of 7.9 years of experience using computers. The second group (Group B) consisted of nineteen internal medicine resident physicians from a teaching hospital in the Boston metropolitan area. The group had an average of 1.7 years of experience as resident physicians. All the participants in this group had experience using the hospital text-based electronic patient record system [14] which they used an average of two hours per day. The group had an average of 15.4 years of experience using computers.

Tasks and Procedure

Each participant was asked to perform the following tasks:

1. Indicate the age, weight and allergies of the patient.
2. Find out if the patient has been prescribed a specific medicine.
3. Look for the most recently dated result of a CHEST (PA & LAT).
4. Find out if the most recently dated X-ray results are abnormal.
5. Discontinue a specific medicine.
6. Enter a physical exam note including vital signs.
7. Add a new Primary Care Problem to the problem list and write a note describing it.
8. Enter a note to an existing Primary Care Problem.
9. Order a specific medicine.
10. Order a second medicine.
11. Order an x-ray of the thoracic spine.
12. Request a consultation with another physician.

After performing the tasks the users were asked to fill out a subjective user satisfaction questionnaire. The questionnaire asked the participants to rate a system on various activities using a 1-7 scale (1 being poor and 7 being excellent). The activities were classified in three categories: *viewing*, *documenting*, and *ordering*.

Experimental Design

The study involved the two experiments described below.

Experiment 1: Graphical-based vs. Paper-based

The participants of Group A were asked to perform the tasks described in the previous section on both the paper-based system and the graphical-based system. Nine of the participants performed first the tasks on the graphical-based system and then on the paper-based system. The other eight participants performed first the tasks on the paper–based system and then on the graphical-based system. After performing the tasks on both systems the participants filled a user satisfaction questionnaire.

Experiment 2: Group A vs. Group B

This experiment compares the time to complete the tasks described in the previous section and the user satisfaction of Group A and Group B using the graphical-based system. The scores of Group A with the graphical-based system in Experiment 1 and the scores of Group B with the graphical-based system in the study described in [15] were used for the statistical analysis. The study described in [15] compares physicians' interaction with a text-based electronic patient record system and the graphical-based system used in this study.

All the participants in both experiments were given a short tutorial session (about 12 minutes) on the graphical system before they performed the tasks on this system.

Statistical Analysis

The dependent variables of the study were time to complete the tasks and user satisfaction.

Experiment 1: Graphical-based vs. Paper-based

A dependent-samples t test was used to compare the time to complete all the tasks in the two systems. The tasks were grouped in three categories: *viewing* (tasks1-3), *documenting* (tasks 6-8) and *ordering* (tasks 9-12). A dependent-samples t test was used to compare the aggregated time of the tasks associated with each category in the two systems. Linear regression was used to evaluate the learning effect between the two systems.

A Wilcoxon sign-ranked test with an α level of .05 test was used to compare differences in overall user satisfaction between the paper-based and the graphical-based systems. A correlation analysis was used to determine relationships between overall satisfaction and each satisfaction category.

Experiment 2: Group A vs. Group B

An independent-samples t test was used to compare the time to complete all the tasks on the graphical based system between Group A and Group B. The tasks were grouped in same three categories as in Experiment 1. An independent-samples t test was used to compare both groups in terms of the aggregated time to complete the tasks of each category. A correlation analysis was used to determine relationships between the time to complete the tasks and the computer literacy and typing skills of the participants of both groups. The typing skill was measured by rating the typing speed of the participants on a 1-7 scale. A Mann-Whitney U test with an α level of .05 was used to compare differences in user satisfaction between both groups.

RESULTS

Experiment 1: Graphical-based vs. Paper-based

Dependent-samples *t* test did not reveal a significant difference on the average time it took the participants to complete all the tasks and the *ordering* tasks on the paper-based system and the graphical-based system. Dependent-samples *t* tests revealed a significant difference in the time it took the participants to complete the *viewing* and *documenting* tasks on the two systems. The participants completed the *viewing* tasks in significantly less time in the graphical-based system (M=75.94, SD=36.93) than in the paper-based system (M=194.23, SD=69.00). However, the participants completed the *documenting* tasks in significantly less time in the paper-based system (M=344.00, SD=36.93) than in the graphical-based system (M=267.82, SD=92.03). A linear regression indicated that there was no significant learning effect carried by the participants from one system to the other.

A Wilcoxon test revealed a significant difference in overall users' satisfaction. The participants were more satisfied with the graphical-based system (M=6.32) than with the paper-based system (M=4.22). Overall satisfaction was significantly correlated with the three satisfaction categories (*viewing*, *documenting* and *ordering*).

Experiment 2: Group A vs. Group B

An independent-samples *t* test revealed significant differences between the participants of Group A and Group B in the time to complete all the tasks categories. The participants of Group B completed the combination of all the tasks in significantly less time than the participants of Group A. The participants of Group B also completed the *viewing*, *documenting* and *ordering* tasks in significantly less time than the participants of Group A (see table 2).

Task Category	Group A		Group B	
	M	*SD*	*M*	*SD*
all	590.94	127.07	351.58	73.66
viewing	65.94	36.93	46.63	17.65
documenting	344.00	87.51	195.00	44.89
ordering	131.94	25.19	90.16	19.03

Table 2. Means and Standard deviations of Independent-Samples *t* Tests

The overall time to complete the tasks, and the time to complete the *documenting* and *ordering* tasks were significantly correlated with typing skills, general computer experience and the experience with electronic patient record systems of the participants. The time to complete the *viewing* tasks were significantly correlated with typing skills and general computer experience of the participants but not with the experience with electronic patient record systems.

A Mann-Whitney test did not reveal a significant difference in overall users' satisfaction between the participants of Group A and Group B.

DISCUSSION

The results of Experiment 1 revealed that on average physicians can perform *viewing* tasks faster, *documenting* tasks slower and *ordering* tasks at about the same speed on the graphical-based system than on the paper based system. However, the difference in performance between *viewing* task and *ordering* tasks counterbalanced resulting in similar overall average completion times of all the tasks in both systems. Since the participants of Experiment 1 had no prior experience with the graphical-based system (only a 12 minutes tutorial) it is reasonable to expected that their performance will improve as they acquire experience with the system. As a result, the time to complete tasks on the graphical-based system will decrease. With more experience and or improved computer literacy and typing skills physicians could perform all the three tasks categories in less time in a graphical-based system than on a paper-based system. The results of Experiment 2 support this conclusion. The physicians of group B completed the task of the three task categories in less time than it took the physicians of Group A to complete them on the paper-based system.

The results of Experiment 1 also revealed that physicians can be significantly more satisfied with a graphical-based system than a paper-based system even when they are novice users of the graphical-based system and expert users of the paper-based system. It was surprising to us that they were significantly more satisfied with all typical activities (*viewing*, *documenting* and *ordering*). The case of satisfaction with the *documenting* activities was particularly surprising because the physicians performed *documenting* tasks faster on the paper-based system.

In Experiment 2 the physicians of Group B were able to perform all the task categories in significantly less time than the physicians of group A. The physicians of group B had on average more years of general computer experience (15.6 vs. 7.9); had on average more years of experience with electronic patient

record systems (1.9 vs. 0.6); and on average had better typing skills (5.5 vs. 4.1). Since these factors were correlated with tasks completion times, it is very likely that the differences in performance between the two groups are due to these factors.

Tasks completion times were more strongly correlated with typing skills. This is something that should be seriously considered by health care institutions and medicine schools because physicians with better typing skills will spend less time interacting with a graphical-based electronic patient record system and thus, will have more time for interacting with the patients.

CONCLUSION

Physicians make the transition from a paper-based patient record system to a graphical-based electronic patient record system with minimal training, without increasing the overall time to complete typical tasks and with significantly more satisfaction with the new system.

Computer literacy and typing skills are factors that significantly affect physicians' performance with a graphical-based electronic patient record system. Physicians with more years of computer experience, with greater experience with electronic patient record systems and with advanced typing skills can achieve higher levels of performance interacting with a graphical-based electronic patient record system. However, these factors don't seem to have a significant effect on the physicians' satisfaction with graphical-based electronic patient record systems.

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