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A Usability Evaluation of Electronic Medical Record Interface Design

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Abstract

Although benefits of electronic medical records (EMRs) have been studied extensively in the literature, there are concerns about safety issues that could lead to patient harm, illustrating the need for EMR interface usability. The objective of this study was to assess the usability and documentation accuracy of a proposed EMR interface design in comparison to an existing interface used for documentation of patient encounter notes in an ambulatory setting, including the review of systems (ROS), physical examination (PE), and diagnosis (Dx). Sixteen primary care providers participated in a between-subjects experiment. Results revealed a marginally significant physician preference toward the enhanced PE note design, which used multiple, cascading dialogs for data entry instead of a template-based presentation of findings. In addition, PE and Dx documentation accuracy was found to be slightly higher for the enhanced design. Non-significant results in ROS and Dx usability scores might be due to the novelty of manipulations in those notes as part of the enhanced design (ecological interface and color coding) for physicians accustomed to free text and/or checkbox data entry format. A follow-on study with greater sample size and training on the enhanced design will be conducted to further assess the effect of these manipulations.

Keywords

Electronic medical record, interface design, usability, safety, error

1. Introduction

With the introduction of healthcare information technology specifically electronic medical records (EMRs), there have been a number of changes in the industry particularly relating to provider-patient interactions, provider documentation, and provider workflows. From 2006 to 2012 the number of healthcare providers in the United States utilizing EMRs increased from 18% to 72%, as a result of government adoption requirements, with the numbers only increasing over the last few years [1]. In general, EMRs provide a methodology to gather, store, retrieve, and analyze medical information for a healthcare system. The stored medical information and the resulting analysis are utilized to provide information to healthcare providers in order to promote the best treatment and quality of care for a patient [2]. With the growing prevalence of these systems in healthcare domain, the usability of EMRs should be researched to ensure that healthcare providers are able to use the systems efficiently and that the technology actually promotes patient safety. Furthermore, there has been little research conducted on the role of EMR usability for processes directly related to patient condition misdiagnosis. One study found that 8 in 10 misdiagnoses were due, in part, to problems in the patient encounter, such as errors during the physical exam or medical history-taking [3]. The most commonly missed diagnoses in this study were common conditions seen in primary care including: pneumonia (6.7%), decompensated congestive heart failure (5.7%), acute renal failure (5.3%), cancer (primary) (5.3%), and urinary tract infection or pyelonephritis (4.8%) [3].

Several studies have identified usability issues in EMR interface designs. For example, a lack of consistency in the design of templates or data fields along with errors committed as a result of adjacency of features and fields have been observed [4]. User errors are created by a lack of function visibility, limited accessibility or time-consuming processes to select functions, illogical organization of information, inconsistent positioning of controls, and ample use of abbreviations [5]. A common complaint among users is excessive clicking to access functions [6]. Underlying causes of excessive clicking have been identified as high frequency features not being prominently located and related functions not being positioned adjacent to each other [7]. In addition, most of the information presented to users through EMRs is via text. It has been found that icons can be used to promote user readability and task efficiency [8].

Related to this, it was found that task completion time was significantly less when utilizing a graphics-based interface in comparison to a textual based interface [9]. Related to use of templates, issues arise during documentation when dialogs do not have desired user options leading to selection of similar but not precisely correct options in order to avoid leaving items blank. These similar option selections could lead to incorrect inferences about patient health [10].

The amount of information presented in an EMR and the task workflow often lead to information overload and "alert fatigue" for physicians [6]. It is believed that reduction in the overall information content and complexity of EMR interfaces will promote task efficiency and ease of use [11]. When the amount of information on a screen is increased, user attention is divided, as in multi-tasking, and the probability for detection errors increases [12]. It has also been hypothesized that a reduction in the number steps to complete a task with an EMR will reduce the cognitive load on the user [13].

As identified in the above literature review, there is a need to improve the usability of EMR interfaces to increase patient safety. Other important issues in the usability and safety of EMRs are the characteristics of the end users and the environment in which EMR systems are used. Healthcare facilities often present high workload and time pressure environments. Related to this, the accuracy of physician diagnosis of patient conditions is influenced by patient trust and fluidity of exchange with the physician. Physician EMR use may distract from patient presentation and compromise patient trust and information transfer. This situation may occur more commonly in clinics with high-patient volumes and for physicians less experienced in EMR use. EMR interfaces may pose changes in physician workflow (relative to manual processes) and create usability issues for new users. Since healthcare operations are often highly procedural, any change in physician workflow may increase diagnosis time. A lack of EMR usability and compromises in natural physician-patient interaction may also lead to errors in diagnosis and ultimately causes patient harm. On this basis, the objective of the present study was to assess the usability and documentation accuracy of a proposed EMR interface design in comparison to an existing interface used for documentation of patient encounter notes in an ambulatory setting.

2. Method

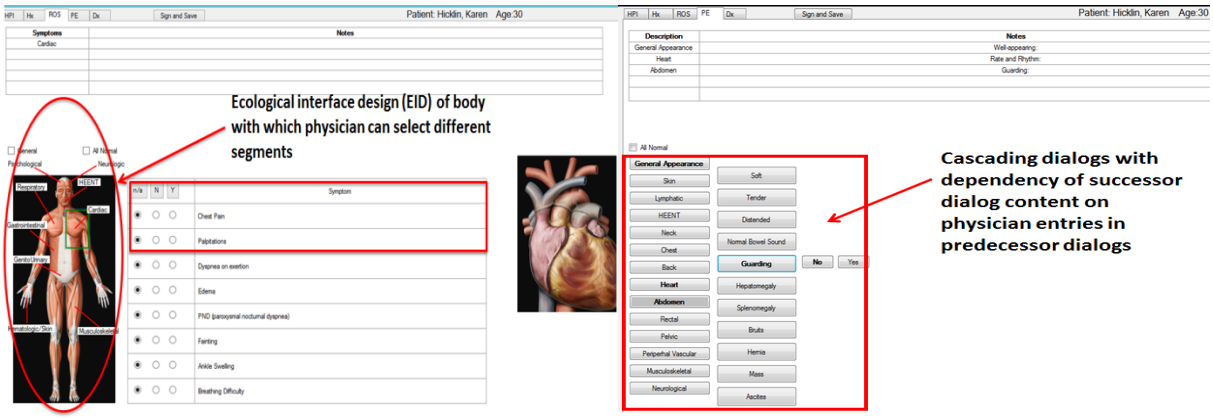
2.1. Participants

Sixteen primary care providers participated in this experiment (mean=10.3, SD= 6.6. years of experience using EMRs). Primary care providers were defined to be those persons specifically trained in comprehensive first contact and continuing care for patients, including health promotion, disease prevention, health maintenance, and diagnosis/treatment of acute and chronic illnesses in a variety of health care settings. Nurse practitioners, physician assistants, doctors of medicine, and doctors of osteopathy, working in a primary care setting, were all considered to be primary care providers.

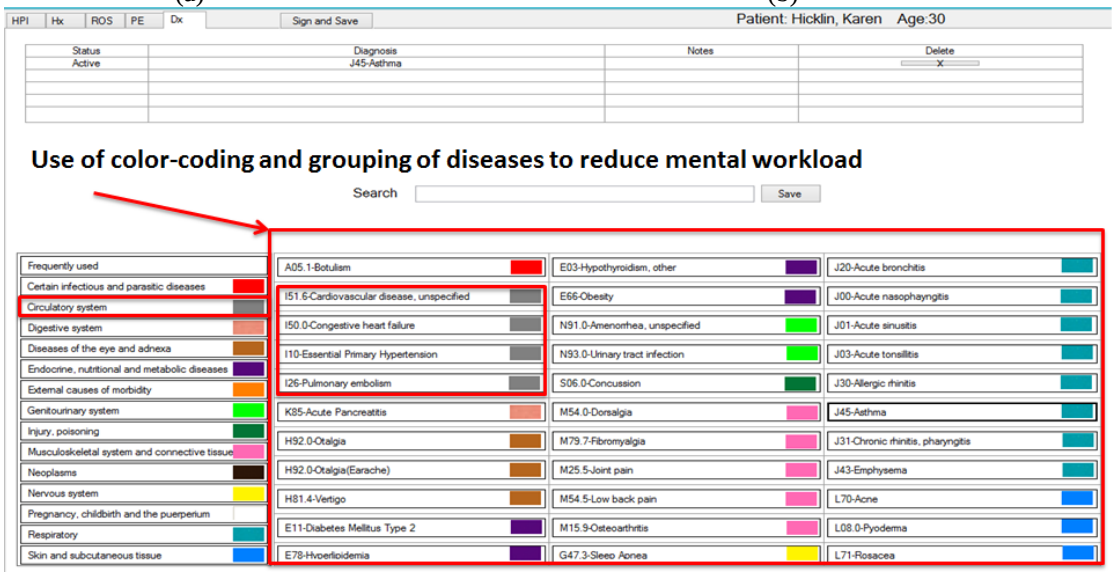
2.2. Independent Variables and Experiment Design

The primary independent variable investigated in this study was EMR interface design type, including two levels: baseline and enhanced interface. Within each interface design, three sections of the prototype were manipulated including: Review of Systems (ROS), Physical Exam (PE), and Diagnosis (Dx). The baseline prototype represented the current EMR interface in most healthcare settings with template-based presentation of data categories for all the three sections (including freeform text entry and checkboxes). The enhanced interface included: an ecological interface design (EID; graphical representation of the body) for system selection within the ROS note, cascading dialogs for data entry with dependency of successor dialog content on physician entries in predecessor dialogs as part of the PE note, and use of color-coding and grouping of diseases in the Dx note page (Figure 1). Each prototype was tested through three different patient cases including: asthma (A), diabetes (D), and heart disease (HD).

The experiment followed a split-plot design in which the whole-plot factor, interface design, had two levels (Baseline, Enhanced) and the split-plot factor, patient case, had three levels (A, D, and HD). Interface design was manipulated as a between-subject variable because of an anticipated learning effect that would occur with a within-subjects design. Case was manipulated as a within-subject variable. Interface design was randomly assigned to each participant as well as the order of the three cases. The latter procedure was intended to mitigate trial order effects. Although the such randomization might have yielded similar trial orders between subjects, it does not lead to within-subjects trial order effects.



(a) (b)



(c)

Figure 1: Enhanced EMR interface: (a) ROS note page, (b) PE note page, (C) Dx note page

2.3. Dependent Variables

Two dependent variables were collected as part of the study, including: documentation accuracy and perceived usability. Accuracy was calculated using Equation (1). Any missed symptom or inaccurately documented symptom was counted as an error. The diagnosis was treated as a binary result with the provider either determining a correct or incorrect diagnosis.

$$Accuracy = \frac{number\ of\ correct\ documented\ symptoms - number\ of\ incorrectly\ documented\ symptoms}{Total\ number\ of\ symptoms\ to\ be\ documented} \quad (1)$$

A usability survey incorporating Likert scales for primary care providers ratings (with values ranging from 1 - strongly disagree to 5 - strongly agree) was administered after each experiment. The survey was designed to assess the usability of the EMR interface that participants used to document patient encounters. Questions were focused on evaluating the ROS, PE, and Dx note pages and asked specifically about degree of conformance of the interface designs with usability principles (e.g. preventing errors, effective information presentation, and efficient interaction). The principles we surveyed were based on Molich and Nielsen's [14] principles developed as a part of their heuristic analysis methodology for usability evaluation of interactive systems.

2.4. Hypotheses

Based on the results of literature review, it was expected that the enhanced EMR interface would increase the accuracy of documentation in comparison to the baseline interface (Hypothesis 1). In addition, it was expected that the perceived usability of the enhanced design for all note pages would be greater than the usability of the existing interface (Hypothesis 2).

2.5. Procedure

Prior to the experiment, three patient personas were developed (A, D, HD). Each persona included a patient history, any relevant labs, and a list of symptoms that were occurring. Based on the similarity of systems examined, bacterial pneumonia (BP) was chosen to be the patient persona for the training session. Each of the patient personas was assigned to an actress who memorized their respective history and symptoms.

The experiment occurred in two rooms, including an "office" and "exam room". The "office" contained a worktable for participant completion of all surveys. The "exam room" was setup to simulate an exam room, including a desktop computer on which the EMR interface prototype was presented, as well as a chair for the patients and an examination table.

All participants were initially asked to read and sign an informed consent form and a demographic questionnaire. Subsequently, the participant was escorted to the exam room for training, which included familiarization with the prototype assigned to them (baseline or experimental). To demonstrate comprehension of the interface, participants were asked to document and diagnosis a patient, whose symptoms were conveyed by the experimenter. After the training session, the participant would "see" and document three patients. After each patient, the participant was escorted back to the office while the exam room was reset for the next patient. Once a participant documented his/her last patient, they were again escorted back to the office where they filled out the post-experiment surveys. In total, the experiment lasted 60-75 minutes per participant and the care providers were compensated at a rate of $50/hour.

3. Results

3.1. Accuracy

An ANOVA was performed on the documentation accuracy response but revealed no significant effect of interface design type on PE ($F(1,17)=1.2334$, $p=0.2855$) or ROS documentation accuracy ($F(1, 17)=1.6885$, $p=0.2148$). However, as shown in Figure 2a, the mean PE accuracy of the enhanced design was slightly higher than the baseline interface. It is possible that with a larger experiment sample that the accuracy of symptom recording might have been sensitive to the EMR interface manipulation.

Since diagnosis was treated as a binary result with the provider either determining a correct or incorrect diagnosis, a contingency table analysis was performed on Dx accuracy but also revealed no significant effect of the interface design manipulation ($\chi^2(1) = 0.605, p = 0.4365$). However, the diagnosis accuracy for the enhanced design (87.5% correct diagnosis) was slightly higher than the baseline (79.2% correct diagnosis) Dx note design. Again the experiment sample size might have been a limiting factor in the sensitivity of our analyses.

3.2. Usability

The usability survey data revealed parametric assumptions violations (residual normality violation was identified using Shapiro-Wilk test and variance homogeneity violation was identified using Bartlett's test). Transcendental function transformations were applied to the responses but without success. Consequently, a nonparametric ANOVA was performed on the ranked usability ratings for the PE note page and revealed a marginally significant effect of the interface design type ($F(1,11)=3.6883$, $p=0.0811$). Figure 2b shows the mean usability ratings for the two prototypes of the PE note page. On average, the enhanced PE note generated higher ratings than the baseline condition. A nonparametric ANOVA on the ranked usability ratings for the ROS ($F(1,11)= 1.0714$, $p= 0.3184$) and Dx ($F(1,11)= 0.1835$, $p= 0.6767$) note pages revealed no significant effect of the interface design type.

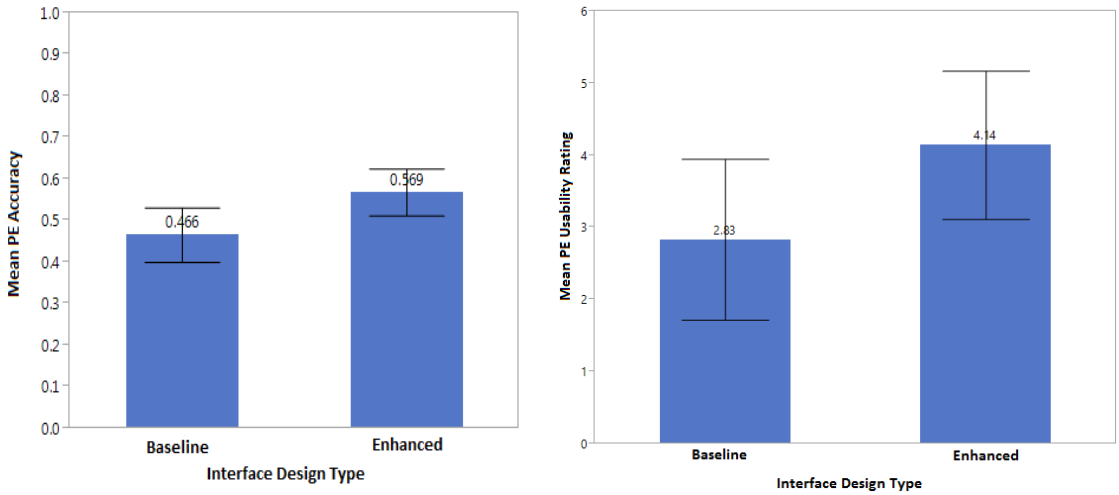


Figure 2: (a) Mean PE Accuracy; (b) PE Usability Rating

4. Discussion

Hypothesis 1 posited that the enhanced EMR interface would increase the accuracy of documentation in comparison to the baseline interface. This hypothesis was refuted. Since many of the participants had experience with EMR interfaces similar to the baseline prototype (6 out of 16 participants), it is possible that the novelty of manipulations as part of the enhanced ROS (EID), PE (cascading dialogs), and Dx (color-coding grouping of diseases) note pages led to a non-significant effect of the design type on provider performance. Furthermore, individual differences in performance might have also influenced the documentation accuracy results especially in PE and ROS note pages. Some participants appeared to exhibit cognitive tunneling during their diagnoses (i.e., skipping body systems that they thought were not important or relevant and asking many questions about a particular disease they had in mind). It was observed that some participants tended to ask detailed questions as much as possible; whereas, others tended to reach the diagnosis as quickly as possible and asked fewer questions, which resulted in more errors (less correctly documented symptoms) in PE and ROS documentation (e.g. 47% and 57% mean accuracy for PE in baseline and enhanced interface design).

Hypothesis 2 posited that the perceived usability of the enhanced design for all note pages would be higher compared to the usability of the existing interface. Although there was no significant effect of interface design type on usability ratings for the ROS and Dx note pages, the hypothesis was partially supported by a marginal effect of interface design type on perceived usability of the PE note page. It appeared that doctors preferred cascading dialogs for data entry slightly more than template-based presentation of data categories in the PE note page. Presenting information with cascading dialogs resulted in a less "cluttered" interface, which increased the usability of the enhanced EMR interface in terms of "effectiveness of information presentation" and "preventing errors". This result is in line with previous studies that observed a reduction in overall information content and complexity of EMR interfaces to promote task efficiency and ease of use [11]. Another study recommended limiting the use of templates for data entry [15]. However, the non-significant results on the ROS and Dx pages might again be due to the novelty of EID and color-coding of groups of diagnoses for participants who were used to working with template-based EMR interfaces.

5. Conclusion

The results of this study indicate that the usability of EMR interfaces, specifically the PE note page, can be increased through the use of cascading dialogs for data entry with dependency of successor dialog content on physician entries in predecessor dialogs. The advantage of such staged interaction is reduced user attentional load and decreased potential for errors. The study did not find any significant documentation accuracy or usability rating effects of an EID (graphical representation of the body) manipulation for system selection using a ROS note page or the use of color-coding of groups of diseases on a Dx note page.

5.1. Limitations

It is possible that the non-significant usability results for the enhanced ROS and Dx scores might be due to the novelty of manipulations of those notes (ecological interface and color coding) for physicians accustomed to free text and/or checkbox data entry formats. It is also possible that the non-significant results were due to the small experiment sample size (8 participants per interface design condition).

5.2. Future Work

A follow-up study with a larger sample size and increased participant training on the enhanced design will be conducted to further assess the usability of the enhanced EMR interface design.

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