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Best Practices for Reducing Interface Errors in Electronic Medical Records

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As Electronic Medical Records (EMR) become increasingly prevalent, the application of human factors principles is essential to facilitate efficiency and usability of these systems and, in turn, to reduce adverse patient outcomes due to user errors relating to the EMR. This paper describes five "best practices" found in the literature which aim to prevent error in the use of Electronic Medical Records. These practices are: Watermarking, Information Control and Management, Hybrid Systems, Cross-Checking Methodology, and Interface Modification. The paper describes each practice and examines the research underlying each approach. Although some practices may be easier to apply than others, they all merit further research and have potential for error prevention on a large scale.

INTRODUCTION

With the advent of Electronic Medical Record (EMR) use in healthcare, medical professionals have encountered numerous challenges, many of which reduce the efficiency of healthcare systems and increase the risk of patient harm or death (Goulet et al., 2015). Errors that have occurred include, but are not limited to, entering information into the wrong patient's chart, recurring ineffective alerts, difficulty locating patient information, and inconsistent terminology (Hanauer et al., 2015). Because these and other errors can lead to such severe consequences, many studies have been conducted in order to propose possible solutions and decrease the risk of patient harm.

This paper provides a brief overview of a set of five most prevalent best practices found in the literature and is aimed at improving the design of electronic medical records. The researchers searched medical databases (e.g., PubMed and the PubMed Central) and conducted manual searches to retrieve cross referenced and up-to-date material. The best practices identified in this literature search are: watermarking (Yamamoto, 2014), file control (Yackel, 2010), hybrid systems (Laing et al., 2013), cross-checking (Freund et al., 2018), and interface design improvements (Zahabi et al., 2015). The purpose of this paper is to describe and discuss these best practices and provide recommendations regarding using them. This approach is believed to be a step in the right direction for improving the efficiency and safety of electronic medical record systems.

METHODS

This review began with a basic search method to generate more specific, subject relevant search terms. Researchers ultimately yielded results through keyword searches within the PubMed and the PubMed Central databases as well as an institution specific database. The search terms used were: Medical, Errors, EMR, Hospitals, Displays, Interfaces, Perceptual processes, ER/Emergency Department. Topic relevance was included in the selection process as well as content type, as the reviewers only selected journal articles. The resulting articles (N = 22) were categorized as either experimental (n = 15) or theoretical (n = 7). If an article was experimental, then its details were codified within these main categories: Sample Size, Sample Characteristics, independent variables (IV), dependent variables (DV), Levels, Effect Sizes, and Key Findings. If an article was theoretical then their respective categories were: Major Constructs, Current Issues in Science, Theoretical Structure, and Contributions of Theory. Articles that had theoretically, qualitatively, or statistically promising results were reviewed within this paper (n = 12) and grouped by topic similarity.

BEST PRACTICES

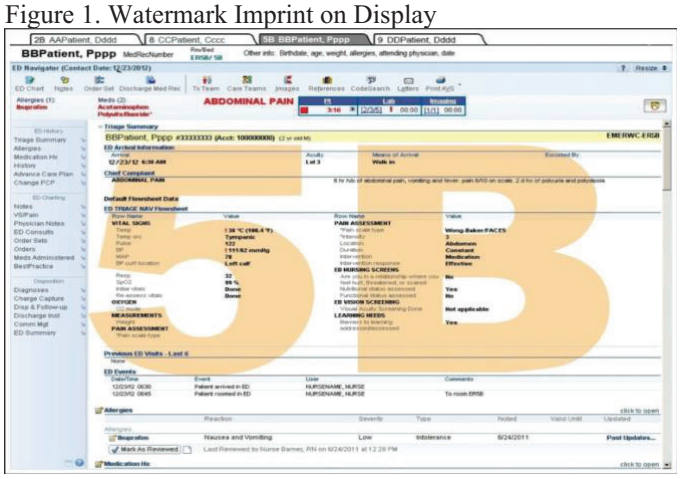
Watermarking

Entering medical information into the wrong patient's chart has been found to be one of the largest contributors to errors in patient care (Donaldson et al., 2000). In a review of the Epic EMR system, it was found that opening the chart for the wrong room was a common occurrence (Yamamoto, 2014). Since healthcare professionals tend to rely on room numbers for patient identification instead of names, the small text of room numbers in the system may have led providers to open the wrong chart and/or not notice if the incorrect chart was opened later (Yamamoto, 2014). Specifically, over a 3-month period, errors made individually by 24 physicians resulted in a 1.3% estimated mean error rate. This rate indicates that there may be approximately 520 wrong patient charting or ordering errors across the roughly 40,000 patients seen annually in the ER (Yamamoto, 2014).

Fortunately, a simple remedy for the room number/wrong patient errors may be the use of a watermark. An example of this solution is demonstrated below in Figure 1 (Yamamoto, 2014). In a study on watermarks, 80% of the clinicians who participated in the study felt that adding a room number watermark would greatly reduce wrong patient errors. A fixed room number watermark would allow users to maintain a constant visual of the room number through the

text that would be laid over it. This solution would aim to fix a problem caused by small text in a small area of the display.

Figure 1. Watermark Imprint on Display



Information Control and Management

Yet another problem that healthcare professionals encounter with the use of electronic medical records is losing track of or being unable to locate specific documents or test results in a patient's file. In a review of a result management system used by approximately 2,166 healthcare personnel, one employee reported that he was not receiving the necessary results and messages in his electronic inbox (Yackel, 2010). Based on this employee's feedback, the researchers discovered that the results were being filed correctly into the EHR (electronic health record) but that this action was not generating messages in the necessary provider's inboxes (Yackel, 2010).

A number of recommendations exist in the literature to better fit the users' information management needs. One proposed practice to avoid this issue would be to program EMR settings to fit the needs of the user. Examples include multilevel data views with visual cues, recommended search terms, and handling of spelling errors and logic validation. Another beneficial practice would be to monitor usage of inboxes used by healthcare providers to ensure that users are not leaving inboxes unchecked and messages unread for long stretches of time. This would allow users to see messages as they are received and lessen the chances that results will be lost (Yackel, 2010).

Additionally, using search functionality can assist providers with locating information in a patient chart. For example, using a search engine, similar to how one may use Google, would make it significantly easier to locate patient information by searching for specific elements or documents in patient charts (Hanauer et al., 2015). One such engine is the Electronic Medical Record Search Engine (EMERSE) (Yackel, 2010). The focus of EMERSE is locating and retrieving data in EMRs. EMERSE was compared to three other specialty surgical registries to identify a rare symptom associated with congenital heart surgery within patients and it generated the highest sensitivity for identification of symptoms (96.9%) and had comparable performance on other evaluative measures (Hanauer et al., 2015).

In a study on cognitive performance in EMRs, physicians expressed that EMRs made it easier to find information in some cases because "the labs are always with labs and X-rays are with X-rays." Essentially, all information can be found in one place and is organized by function. However, other physicians expressed difficulty with finding information in the chart due to the overwhelming nature of the system. Physicians stated that information may be almost impossible to find in the system unless they knew exactly where to look for it. Others were frustrated that certain information could not be accessed at the same time. For instance, a prior progress note could not be viewed at the same time that a new one was being written (Holden, 2011). Electronic medical records may still improve with altered structure and temporal organization targeted at facilitating common actions and tasks.

Hybrid Systems

Another approach is using hybrid EMR systems. For example, based on the components of EMR systems, the electronic surgical registry (ESR), and a clinical decision support system (CDSS), a hybrid electronic medical record system (HEMR) has been developed (Laing et al., 2013). This system integrated both electronic and hand-written data. Electronic data can be entered at key points, such as intake, and a printout can also be added to a file where handwritten notes for daily rounds and procedures can be included. In this manner, the system incorporates both electronic and handwritten data. One advantage of this type of system is that it allows some degree of ease of employee transition to a new system. Additionally, it can allow for facilities with limited funds and resources to utilize EMRs without shouldering the full financial burden.

A study was conducted to assess the effectiveness of the HEMR. Of the 50 surgical interns who were surveyed after using the system, 72% stated that they found the data entry process to be easy. Seventy eight percent of the participants had no previous experience with an electronic registry or EMR system. The average time to complete an admission entry was 13 minutes. The average time to complete a discharge was 10 minutes. One study found that 96 % of users favored the new HEMR system due to improved legibility, ease of retrieval, and faster processing (Liang et al., 2013). A few limitations to the study were underreporting of adverse events and weaning off of old systems. Switching to a new system revealed that there was previously no way to accurately transfer the number of adverse events that occurred (Laing et al., 2013).

Cross-Checking Methodology

First proposed in 2015, the Cross-Checking methodology focuses on health professionals cross-checking each other's information to decrease errors (Freund et al., 2018). The cross-checking methodology aims to decrease the number of adverse events by prompting healthcare providers to "proofread" patient charts. This methodology stems from work in emergency rooms (ER). Practitioners working in the ER often

have numerous patients under their care and cannot rely on a colleague for backup. This means that practitioners must rely on multitasking and rapid decision making, which can lead to errors and adverse consequences. In using the cross-checking method, practitioners meet with a coworker three times a shift and they exchange relevant information about the patient via EMR software. The information includes sex, age, chief complaint and main medical history, main clinical findings, main investigation available or outstanding, treatment given in the ED, and a brief summary of the plan (Freund et al., 2018). This information was reviewed by the colleague, who then commented on the information. A similar practice is implemented at a pediatric hospital in Boston between resident shift changes (Starmer et al., 2013). As the resident undergoes the process of "handing off" handwritten or virtual patient data to their colleague, they review and discuss that information in a specific and intentional manner (Starmer et al., 2013).

Results from Freund (2018) indicated that there was a 40% reduction in consequential events in the cross-check condition compared to the standard condition. In the cases of preventable adverse events or near misses, there was risk reduction of 39.0%. In Starmer et al. (2013) there was a decrease in the number of errors for every 100 admissions (a reduction of 33.8 errors to 18.3 errors). This shows potential for the use of cross-checking in significantly reducing error and other risks. More research is needed for generalizability, but given these results and relative ease of implementation, it has the potential to be a viable solution.

Interface Design Improvements

The last method is improving the interface design. Zahabi et al. (2015) conveys that there should be eight facets of EMR design: Software interaction, learnability, facilitation of user cognition, degree of user control and software flexibility, degree of matching of system structure and content to the real world, design of graphics, system navigation, and editing capability and consistency.

While the HCI design principles are discussed at length in the literature, notable items include the use of prompts, reminders, and mindful positioning of interface buttons. For instance, "patient-note mismatch" errors occur often within the EMR system, but this may be curbed with the use of pop-ups, which would show and then prompt the user to compare patient details. This would ensure that notes are being applied to the correct patients. One example is the use of prompting for information change when a specific alert is being consistently overridden. Other prompts can be used to schedule tasks like immunizations and can be used to cross-check allergies or interactions (Horsky et al., 2012). In a broader design application, role specific interfaces that comprehensively monitor medical processes can potentially reduce significant error (Li et al. 2012). The literature proposing improvements on the EMR interface is limited and is currently in the early stages of testing and development. However, it directly addresses common issues that practitioners face that could lead to error and ultimately to patient harm.

LIMITATIONS

This paper is meant to provide a brief overview of interventions and does not provide a comprehensive analysis of these topics. Further literature review is needed to conduct a more in-depth analysis of this set of best practices and the effectiveness of each method. Furthermore, non-experimental studies were included as part of this overview and do not provide experimental data regarding the effectiveness of these practices. An inherent limitation to this review is the limited amount of published research dedicated to EMR error occurrences and HCI considerations within that topic, which is something to be considered for future studies.

FUTURE RESEARCH

In order to gain a better understanding of these interventions and their effectiveness, further experiments should be conducted to explore the implementation of these practices in EMRs and the degree to which they improve usability. Usability testing would provide researchers with more in-depth information regarding which parts of the system are most problematic and which interventions improve usability. This testing, in addition to error analyses, may also shed light on additional usability issues in EMRs that require testing and intervention. This type of testing will most likely result in a broader list of best practices than those reviewed in this paper. Additional considerations include cultural and regional implications for EMR design. For instance, the use of different structures and symbology may differ across cultures as a result of social and socioeconomic factors.

CONCLUSION

Although EMR systems have been beneficial to the medical field in many ways, challenges exist regarding these systems. As described in this paper, the literature presented numerous solutions for error prevention in EMR interfaces. The solutions presented address overarching issues that practitioners and other stakeholders encounter regarding EMRs. Each solution provides measures that can be used to resolve these problems and could potentially reduce risk in an already vulnerable system. Watermarking leverages attention for users due to its saliency, allowing practitioners to constantly be aware of a patient's room number- a simple yet impactful solution. Information control and management designs the EMR with the practitioner in mind, which would allow them to better manage patient details. Cross-checking systems is a cost effective and low-tech means for error prevention with EMRs. Other interface solutions include providing prompts and reminders for healthcare providers. These solutions are not without their own caveats, but as time progresses and with additional research, these best practices could be implemented as a standard means for EMR usability and error prevention.

Disclaimer: The views expressed in this paper are those of the authors and do not reflect the views of the affiliated institution.

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