Context Sensitive Health Informatics: Human and Sociotechnical Approaches
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Exploring the Contextual and Human Factors of Electronic Medication Reconciliation Research: A Scoping Review

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Abstract. Medication reconciliation (MedRec) is an important task that occurs in a variety of different contexts. Similar to other healthcare practices, MedRec is transitioning from being a paper-based process to one that is performed electronically. This paper will provide a scoping review of the prevalent research topics from both contextual and human factors perspectives. Methods**:** PubMed and CINAHL were searched for all articles including the term "medication reconciliation". The 139 articles that met inclusion criteria were reviewed for themes and findings. Results**:** Three primary themes surfaced through this analysis: a) The contextual factors of MedRec, b) information technology (IT) in MedRec, and c) obstacles and opportunities for improving MedRec. Discussion: MedRec is performed in a variety of settings. The transition to electronic MedRec (eMedRec) has the potential to mitigate errors associated with a paper-based system but also creates opportunities for new technology-induced errors to occur. Interoperability with other health information systems is ideal. Additionally, Process standardization and workflow are important considerations when transitioning to eMedRec. Conclusion**:** As the process of medication reconciliation transitions from a paper-based to an electronic task, it is imperative to minimize the opportunity for human error and maximize the effectiveness of the system as a whole. Further, it is important for research to continue to explore original strategies for IT to enhance medication reconciliation.

Keywords. Electronic medication reconciliation, medication reconciliation, human factors, contextual factors, barriers, usability, patient safety

Introduction

Patients transition through different care settings, providers, services and levels of care. At every juncture of this journey opportunities arise that could promote or compromise patient safety with respect to medication dispensing. That is, at every point in care new medications may be prescribed, old medications may be discontinued, or current medications may be revised to optimize their efficacy. However, to make these orders most effective and with the greatest care for patient safety, it is imperative that every

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provider has access to all of the necessary information to make accurate decisions (e.g., what medications a patient has been taking, his or her allergies, previous medications that were not effective). Unfortunately, given the fragmentation of the healthcare system and lack of interoperability between clinical information systems, there is rarely a single source for current and accurate patient medication information. Medication errors that arise from this lack of patient medication information could have consequences such as adverse drug events and re-hospitalizations. Equipping providers with comprehensive medication information throughout care transitions is imperative to avoiding these negative outcomes. As a result of these risks, several organizations such as the World Health Organization, Safer Healthcare Now! (Canada), and the Joint Commission (United States of America), the National Institute for Health and Clinical Excellence and the National Patient Safety Agency (United Kingdom), have identified medication reconciliation (MedRec) as an opportunity bolster patient safety. According to the Joint Commission, "Medication reconciliation is the process of comparing a patient's medication orders to all of the medications that the patient has been taking." [1, p1]. In this review, we will explore a) the contextual factors of medication reconciliation, b) information technology (IT) in medication reconciliation, and c) MedRec obstacles and opportunities for improvement.

1. Method

A search of PubMed and CINAHL was conducted for all articles including the term "medication reconciliation", published from 2003 to October 2012, and a total of 218 unique articles were returned. These articles were reviewed by title and either abstract (where possible) or full article to exclude studies that did not include original research (e.g., editorials) or that lacked reference to MedRec. The remaining 139 articles were reviewed for findings and themes. Where it could be determined in the articles that met inclusion criteria, the following characteristics were recorded: type of MedRec (electronic, hybrid, paper), care facility setting and/or participants (e.g., emergency, intensive care, primary care, pediatrics, oncology), point of care of the MedRec investigation (admission, transfer, discharge, post-discharge, outpatient). Additionally, paper findings were summarized and emergent themes were identified.

2. Results

2.1. The Contextual Factors of MedRec

Ideally, MedRec should occur at every care transition. Although the studies in this review predominantly investigated MedRec at one or more points of care in inpatient settings (i.e., admission, transfer, discharge and post-discharge), there were a number of studies that explored the process in outpatient settings (See Figure 1). Transfer and post-discharge were investigated the least. Some studies compared discrepancies between points of care [2] to identify transitions that were more vulnerable to medication errors.

Studies in this review were conducted in a variety of care facilities that provide specific services (i.e., intensive care unit, emergency department, pre-operative, children's pre-surgical, trauma, neurosurgery, behavioral health unit, nursing homes,

internal medicine, medical unit / ward, skilled nursing facility) [4]. Further, studies in this review also focused on differing segments of the population (i.e., women, elderly/geriatric patients, pediatrics, indigents) [5] or condition specific sub-populations (i.e., those with cardiac problems, diabetes, strokes, cardiac obstructive pulmonary disease, renal disease, cancer) [6].

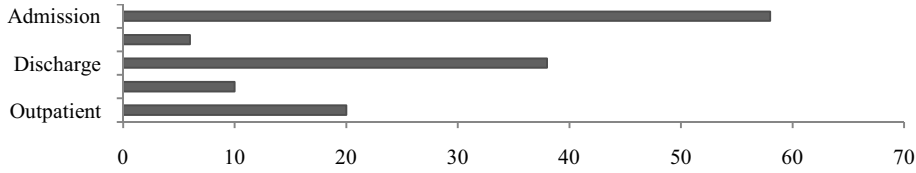

Figure 1. MedRec Investigations at Different Points of Care

2.2. Information Technology (IT) in MedRec

Several studies in this review investigated different ways for IT to enable and optimize MedRec. The studies in this review ranged from MedRec processes that were entirely paper-based, to hybrid combinations of paper and electronic, to fully electronic. As with other paper-based processes, MedRec can often be susceptible to failure (e.g., lost or misplaced documents) or incompletion, which has the potential compromise patient safety. Other shortcomings of electronic MedRec (eMedRec) systems identified were intravenous medications not included on discharge medication lists, and that the discharge and discontinued medication lists were confined to a single page [7]. These examples provide evidence that there are opportunities to improve the efficiency of the process and ameliorate the risk of human error by adopting eMedRec systems that are optimally designed.

The two most obvious uses of IT to improve MedRec are: 1) using an electronic system to perform MedRec, and 2) implementing integrated electronic medication lists. The utility of electronic systems to provide comprehensive medication lists often remains limited due to interoperability challenges but they can serve as valuable complements to the medication information provided by patients and caregivers [8]. In support of this argument, patient-generated medication lists were found to be more accurate than Electronic Health Record (EHR) lists in an outpatient setting [9].

Other research has focused on exploring less obvious opportunities for leveraging IT in MedRec. For example, Lesselroth and colleagues [6, 10, 11] developed and tested an Automated Patient History Intake Device to guide patients through generating their electronic medication lists before seeing their providers. Two studies targeted the optimization of medication data display to convey the chronological order of medications patients were currently and previously taking [12]. Research has also explored the possibility of predicting medications that are likely to have been omitted through the use of collaborative filtering [13]. Certain characteristics (i.e., age of record, prn, anti-infective, inpatient) were found to be predictive of the accuracy of medication records in clinical information systems [5]. A rule-based algorithm was able to reconcile 23.4% of potentially reconcilable medications [14]. Thus, adoption of this technique would reduce the number of medications to be reconciled and thereby increase task efficiency. Additionally, an eMedRec prototype designed based on Work Domain Ontology (WDO) was found to reduce cognitive load and improved user

efficiency in comparison to two other MedRec tools [15]. These studies investigated more creative ways to optimize human performance in MedRec.

2.3. Obstacles and Opportunities for Improving Electronic MedRec (eMedRec)

Many studies discussed factors impeding the success of eMedRec. As with other health information systems, lack of interoperability creates challenges to efficiency. Recognizing the value of interoperability for increasing patient safety and reducing medication errors, a patient summary was developed that integrated clinical data from heterogeneous, distributed systems by constructing a single display based on the ISO/CEN EN13606 Standard for architecture and communication of EHRs [16].

Although complete interoperability is ideal, the most frequently cited system providers reported wanting integration of eMedRec with computerized order entry (CPOE) [17, 18]. This is a logical position because CPOE independent of MedRec, requires redundant data entry and thus diminishes efficiency. However, examples exist of successfully integrated EHR and CPOE systems to facilitate building the mostly accurate medication list through reconciliation and using these medications to write admission and discharge orders [19].

As with other health information systems, eMedRec could also benefit from the application of usability evaluations. In one study, researchers identified usability issues (e.g., low visibility of button to launch the MedRec program) as contributing to low adoption of an eMedRec tool, in an outpatient setting targeted for patients who were recently discharged from the hospital [20]. Despite previous interventions attempting to increase the use of this tool, adoption remained low; however, the authors discussed usability issues (that have since been ameliorated), which may have deterred providers from using this tool.

Exploring existing paper-based practices for idiosyncratic processes that may not be immediately apparent through observation may reveal opportunities to improve eMedRec. By analyzing patient medication lists for discrepancies, Owen, and colleagues [21] determined that annotation played an important role in MedRec. Similarly, linking medications to patient problems / diagnoses was identified as a key MedRec principle [22]. Given that diagnoses and medications are intimately related, access to integration of this information facilitates provider cognition.

Two obstacles identified in paper-based or hybrid MedRec processes that may also impact eMedRec are: process standardization and workflow. Eliminating the variability associated with how it is MedRec is performed was shown to improve its consistency and effectiveness [3] and reduce adverse drug events [22]. Several studies have investigated improving MedRec efficiency through workflow modifications. For example, the quality of the MedRec process in the emergency department was improved by increasing the participation of patients and clerical staff in the generation of medication lists [4]. One study used the findings from their failure modes and effects analysis (FMEA) to reduce medication errors at discharge by redesigning workflow and defining specific roles and responsibilities for MedRec at discharge [23]. Thus, it is apparent that process standardization and workflow are important considerations that can either facilitate or impede MedRec.

3. Discussion

MedRec is performed in a variety of settings, with different populations and for patients with diverse and often complex conditions. Thus, many of the contexts where MedRec is conducted have factors that make them unique from other settings. Many of these different combinations of conditions have been studied with paper-based processes, but as the transition is made to eMedRec, it is not prudent to assume that one solution will suit all of these contexts and various user needs. Thus, designing flexibility into eMedRec systems is important to accommodate the diverse conditions in which is it performed.

eMedRec has the potential to ameliorate many of the issues associated with paper and hybrid processes and improve patient safety; however, like other health information systems, it is also possible that implementing eMedRec can introduce new and different errors. Thus, it is prudent to investigate these systems to ensure any technology-induced errors are identified and ameliorated prior to potentially compromising patient safety [24, 25].

Important research has been devoted to exploring creative approaches to augment traditional MedRec processes. When paper processes are mimicked in an electronic system, opportunities could be missed for improving the process by modifying it through adoption of electronic systems. Research about how healthcare providers generate and use mental models to perform paper-based MedRec successfully should be used to guide the design of eMedRec systems to scaffold provider cognition and decision-making.

Similar to the introduction of other health information systems, interoperability is an important goal for eMedRec implementation to optimize efficiency and benefit users. That is, the more seamlessly these disparate health information systems are integrated, the more efficient eMedRec and other processes (e.g., medication ordering) can be performed. Further, improved process efficiency is likely to garner support and facilitate adoption from users. Another potential strategy for increasing efficiency is increasing the role of the patient in eMedRec. In addition to reducing provider resources for MedRec, patients may also benefit from increased engagement and awareness.

One of the advantages to eMedRec is that process standardization can be embedded in these systems. That is, certain affordances and constraints can be designed into the system to ensure the steps are performed sequentially, in a timely manner, and that all tasks are completed. When an eMedRec system is implemented, it is prudent to augment workflows, roles, and responsibilities, to ensure participants in the MedRec process are aware of the sequence of tasks, other expectations (e.g., time to complete medication list after admission) and for what they will be held accountable.

4. Conclusion

As the process of MedRec transitions from a paper-based to an electronic task it is crucial to minimize the opportunity for human error and maximize the effectiveness of the system as a whole. As such, it is imperative to leverage existing evidence so to circumvent implementation obstacles whenever possible. Further, it is important for research to continue to explore original strategies for IT to enhance MedRec. Barriers that currently hinder eMedRec that are related to contextual factors include: different

settings, varied patient populations and input into the process, idiosyncratic and non-standardized workflows, usability issues and integration with other health information systems (e.g., CPOE). Human factors approaches (e.g., usability testing, FMEA, clinical simulations) should be applied to identify and resolve these issues.

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