

Designing for Ease of Use of Inpatient Technology to Communicate Medication Therapies

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Abstract

The fields of health services, medical informatics, and human-computer interaction have begun to investigate electronic approaches to providing detailed health information to patients. Building on a custom Personal Health Record portal infrastructure that we have developed to provide access to real-time medication information for hospitalized patients, we are currently engaging clinicians and patients in user-centered design sessions to explore patient-friendly views of the information. Through interactive browsing of organized views of this medication information in our portal, patients can maintain awareness of scheduled and completed medication therapies, and learn more about them by accessing educational summaries. To evaluate the impact of providing timely access to our portal in the inpatient setting, validated surveys will be used to measure patient satisfaction, engagement and knowledge of inpatient medications.

Introduction

As the trend toward patient participation in their own healthcare continues¹, opportunities are emerging for research to examine the effective design and use of technology to inform patients about their health status and care. For example, Personal Health Record (PHR) systems allow patients to access information from their medical records online. Researchers have addressed questions of user interface design, information sharing policies, and security in PHRs^{2,3}, and have demonstrated that PHRs can bridge critical gaps in continuity of care⁴. But PHRs have been designed primarily for retrospective review of data. More research is needed to yield insights into how Health Information Technology (HIT) can be used to educate and engage hospitalized patients and their families within the care context⁵. Our research pursues this topic through studies guided by specific research questions: What role can patient-facing HIT play in communicating information within the hospital setting, with its particularly complex organizational structure and information processes? Are there therapeutic benefits to enabling electronic communication with hospital patients through HIT? How can data presentation and interaction techniques affect understandability of clinical information?

Over the past two years, we have built upon a PHR platform, myNYP.org, to create a custom inpatient PHR portal infrastructure that delivers timely, patient-accessible information⁶. Our custom portal integrates data from an existing electronic health record (EHR) and PHR system to provide timely views of a patient's current and previous inpatient medications. This information is now available as alphabetical and chronologically-ordered lists of current and discontinued medication. The custom portal infrastructure provides the technological foundation upon which experimental presentation and interaction techniques will be introduced and studied in the hospital.

Our current research plans include a two-phase field study to improve the presentation of medication information in the custom portal, explore other refinements that make the portal easy for hospital patients to use, and evaluate the impact of providing it to patients during their hospital stay. In the first phase, both clinicians and patients will be engaged in user-centered design sessions exploring patient-friendly views of the information. Results of these sessions will guide the implementation of computational techniques (presentation and interaction techniques) that make salient medication information available in ways that support patient understanding of this information. After validating the usability and effectiveness of the techniques through iterative user-centered design sessions, we will integrate the techniques into the deployed custom PHR portal application. In the second phase, we will evaluate the impact of the enhanced medication display on patient satisfaction, engagement, and inpatient medication knowledge in a field trial with cardiology patients.

Background

The complexity of today's hospital environment can strain communication between patients, family members, and clinicians. Recent research has also found that patients' ability to remember medical information they receive in care settings is limited⁷⁻⁹. However, leaving the hospital without appropriate understanding of critical information has been correlated with poor health outcomes and repeat visits¹². Patients themselves believe that compliance with

treatment regimens may improve if they are given the opportunity to read their own charts, and access to test results presented in a clear, graphic manner^{13,14}. There is also evidence that hospital inpatients would like a timely, electronic view of their inpatient therapies such as medications, procedures and other care information^{5,15}. Evidence suggests that providing information to patients to assist them in understanding their clinical situation has been effective in promoting patient adherence to their care plans and engagement in clinical decision-making^{16,17}. Unfortunately, reviewing manually tailored information with each patient is costly in terms of time and resources. While the use of PHR systems post-visit can assist in continuity of care and patient education⁴, few technological interventions have been designed specifically to support inpatient awareness of the procedures, activities, or medications involved in their hospital care¹⁸.

One important application of HIT for inpatients includes support for reviewing inpatient medications. In one study, Cumber et al. found that while 90% of patients wanted to review their hospital medication list for accuracy, only 28% of patients reported having seen their medication list¹⁹. This study also revealed considerable deficits in patient understanding of their hospital medications, even among patients who believed they knew, or desired to know, what was prescribed to them in the hospital. The authors concluded that, "Without a system to incorporate the patient into hospital medication management, these patients will be disenfranchised from participating in inpatient medication safety"¹⁹.

We have conducted studies to characterize and analyze the design space for information delivery to hospital patients. This characterization considers situational factors unique to the care environment and the electronic information within it, to provide the means to organize a novel research agenda focused on the challenges and opportunities that exist in automatically extracting and formatting electronic health information for patients. It includes an assessment of the electronic information needs of patients at the point of care²¹, preliminary analyses of the usefulness of a variety of clinical information types to patients¹⁵, and preliminary examinations of patients' and clinicians' attitudes toward patient access to electronic information in hospital settings²⁰.

Initial pilot of custom PHR portal

Following the technical design and development of the custom PHR portal, we conducted a small pilot study of the first version, with five patients in a cardiac surgery step-down unit to gauge initial acceptance and understand design considerations for access to the portal via a tablet computer⁶. Participants used Apple iPad devices to access the portal, which provided a list-based medication view. We conducted detailed interviews to assess patients' knowledge of their inpatient care, as well as their perceptions of the usefulness of the application. Patients were highly enthusiastic about the ability of the portal application to supply health information such as their inpatient medication histories. This small pilot study also allowed us to glean design principles that will be used to design, build, and evaluate new presentation and interaction techniques to effectively communicate patient status and care progress to patients.

Research Methods

Study Sample

The sample for our planned two-phase field study will primarily consist of cardiology step-down patients (phase one: $n=15$, phase two: $n=40$). The sample will also include cardiology clinicians (phase one: $n=5$), which can include nurses, physician assistants (PAs), nurse practitioners (NPs) and physicians. Patients on the medical study unit are hospitalized with coronary or valvular heart disease, heart failure or arrhythmias, and undergo procedures involving intracoronary stents, transcatheter valves or automatic internal cardiac defibrillators (AICDs). Some patients may be undergoing evaluation for cardiac transplant or mechanical assist device and may be initiating therapy with intravenous inotropic medications. Patients on the surgical unit are recovering from coronary artery bypass surgery, valvular repair or replacement, or cardiac transplant. Patients in the study units are generally coherent and able to interact with their care teams (critically ill patients are treated in separate cardiothoracic intensive care and coronary intensive care units).

Study Environment

This study will be performed on the medical and surgical cardiac units in the Milstein Hospital at Columbia University Medical Center. Each study unit has 34 beds, with a nurse:patient staffing ratio of 1:7, and each patient has a primary nurse assigned. The typical length of stay is five or more days. Each patient has an attending physician who oversees his or her care. Resident physicians (housestaff) rotate in a staggered fashion through the medical unit in four-week cycles. Each unit is staffed 24/7 by PAs or NPs who cover patients that are not on the housestaff services. Nurses make regular assessments and use the electronic health record to document their findings, as well as medications administered.

Currently, information delivery to patients and their family members is performed primarily through verbal communication during bedside rounds. Cardiac transplant patients receive and maintain detailed printed medication administration records prepared by a nurse on the transplant team. Otherwise, little printed information is shared with patients or family members until discharge, when they receive documents detailing discharge instructions and home medications.

Phase 1: Improve the presentation of medication information in the custom inpatient PHR portal, to increase ease of use of the portal by hospital patients.

The first study phase includes the design and development of a user interface (UI) to display organized medication information, using computational techniques to vary the level of detail of information and information according to temporal³⁸ and categorical groupings. Level-of-detail of the display and event information will be varied automatically, according to information density in the current view, temporal signals (e.g., detailed visual information for the current twenty-four-hour period, with high-level visual information representing previous days), and categorical and thematic type information (e.g., drug classes, administration methods).

In this phase, we will develop these computational techniques while applying principles of patient-centered design and cognition to visual and interaction design choices^{14,22}. At least two alternative views will be prepared for subsequent user-centered design sessions: a view embodying computational techniques to organize the level-of-detail of the display according to temporal and categorical groups²³, and a list-based view showing separate lists for current versus discontinued medications (with options to sort chronologically and alphabetically).

For each of the alternative views, the UI design will employ colors and graphical representations strategically and use charts in accordance with public health literature guidelines on designing at appropriate public health literacy levels^{14,24}; medication names will also be linked to educational summaries, written for consumers, via the MedlinePlus Connect web service²⁵. A core design team consisting of experts in UI design in our academic departments will conduct heuristic analyses²⁶ of each of the alternative views. Descriptive analysis of heuristic evaluation sessions will be used to identify major issues regarding usability heuristics.

After addressing any usability issues identified through heuristic analysis, we will conduct user-centered design sessions ($n=20$) with patients ($n=15$) and clinicians ($n=5$), presenting alternative approaches to organizing medication information to each group. The target user group for the software is patients and their family members. However, we will include clinicians in user-centered design sessions to provide complementary insights regarding the effectiveness of the information display: clinicians can help us to determine if the organization of the content corresponds to the ways in which verbal explanations are given and comment on the perceived ease-of-use for patients. All participants will be asked to interact with both the list-based view and an alternative view embodying techniques to vary the level of detail of information and organize medication information according to temporal and categorical groupings.

Patients will be asked to comment on the perceived ease of use of the software application. When possible, screenshots, touch interactions, and time for task completion will be captured by usability software. Semi-structured interviews will also be conducted with all patients included in UI design sessions. Results of interviews will be used to glean user preferences, understand limitations of the proposed medication information views, and refine information density on the display. Using a “think-aloud” protocol, all participants will be asked to interact with alternative medication information views, and to verbalize their experience using the software. In particular, they will be asked to interact with both the list-based view and an alternative view embodying techniques to vary the level of detail of information and organize medication information according to temporal and categorical groupings.

Qualitative data from user-centered design sessions and interviews will be iteratively coded using descriptive, thematic analysis. Results of this analysis will inform subsequent iterations of the medication display. Based on these results, we will determine if a temporally and/or categorically organized view of medication information is preferred to a list-based view. The custom PHR portal infrastructure will be extended for the integration of our techniques to vary level of detail and organize the medication information according to preferences learned from our user-centered design sessions, in preparation for extended use in a larger field trial.

Phase 2: Evaluate the impact of the enhanced medication display on patient satisfaction, engagement and medication knowledge in a prospective trial.

Field Trial Design. In the second phase, a larger field trial will be conducted to assess the effectiveness of the UI developed in the first phase. Forty patients will be divided equally into two demographically and clinically-similar study groups of twenty: 1) tablet with access to general consumer health information (CT1); and 2) identical tablet

with the custom PHR portal extended to include the views of electronic medication information designed according to the results of UI design sessions conducted in the first phase (CT2). Health literacy will be assessed²⁷ for descriptive purposes. Within 12 hours of each participating patient's admission to the cardiology step-down unit, the research assistant will invite the patient to participate in the study. The sample size of 40, which is clinically feasible to obtain during the time period of our study, would allow us to detect a large effect size (.8) with a power of 80% and alpha for significance set at .1. This effect is based on a statistical power calculation for the student's *t*-test, the expected method used for data analysis of scored instruments.

Field Trial Measures. The described study will test differences in *patient satisfaction, perceived patient engagement, and medication knowledge* during hospitalization for the *custom PHR portal intervention group* (CT1) as compared to the *generic tablet group* (CT2).

Medication Knowledge Measurement. To validate the effectiveness and quality of the organized medication information display (CT2), patients' knowledge of their medications will be assessed using the Medication Knowledge Score (MKS)²⁸. Unlike other medication knowledge assessment tools, such as the Drug Regimen Unassisted Grading Scale (DRUGS), which assesses only the identification of the correct medication name, dose and timing and the ability to open medication containers, the MKS measures patients' knowledge of medication indications and serious potential side effects. For each of a patient's medications, the MKS will be used to measure the patient's knowledge of the medication's name, dose, indication (what the medication is for), and potential side effects. For each medication, the MKS score is the number of correct answers out of a possible four. These scores will be assessed at the conclusion of patient use of the electronic medication information view.

Satisfaction and Engagement Outcome Assessment. Delone and McClean conceptualized information systems success according to six dimensions: information quality, system quality, service quality, intention to use/use, user satisfaction, and net benefit²⁹. Informed by this work, we will measure perceived quality and perceived satisfaction using patient and clinician surveys and analysis of information system audit logs. The patient and clinician survey instruments are derived from the 26-item Telemedicine Satisfaction and Usefulness Questionnaire³⁰. The patient survey includes two scales that measure: 1) satisfaction with hospitalization and perceived engagement with health care providers; and 2) perceived usefulness of the tablet system. The survey has 13 items on satisfaction and engagement (six and seven questions respectively), and 10 items on perceived usefulness. All questions are measured on a 5-point Likert scale. The Patient Survey and MKS will be administered three to five days after the start of a patient's admission to allow time for usage over the course of the hospital stay.

Data Analysis

All study instruments will be scored and summarized using descriptive statistics. Experimental groups will be compared on sociodemographic and health literacy scores to assess the equivalence between the groups at baseline. Categorical data (e.g., gender, education, and race) will be compared using Chi-squared analyses. Instrument scores (e.g., health literacy) and continuous data (e.g., age) will be compared using *t*-tests. Summary scores from the Likert-type scales used for measurement of engagement, satisfaction, and perceived usefulness will be treated as continuous variables; thus, the hypotheses will be tested using *t*-tests. We will also conduct correlational analyses to examine associations between predictor variables, such as health literacy, and outcome variables such as medication knowledge scores, given that these may be important variables to control for in a future study.

Conclusions

We expect that studying the inpatient use of our custom portal will advance scientific knowledge in the field of patient-clinician communication and yield insights into factors influencing patient-facing technology adoption and use in the inpatient setting. Conducting our field trial and evaluating data collected from our study instruments will allow us to share valuable experience with technology deployment and evaluation in the field. Finally, we hope that our evaluation of the custom portal can reveal new opportunities for HIT to increase patient engagement, knowledge, and satisfaction.

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