Developing an EMR Simulator to Assess Users’ Perception of Document Quality

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Abstract
Simulators are used in research and training because they provide a realistic and safe environment for participants. In the course of conducting a comprehensive study of patient care documentation in electronic medical record (EMR) systems we found that use of a simulated EMR system could address logistic and conceptual barriers encountered in deploying a research instrument to assess user perceptions of patient care document quality. Designed for use by practitioners, nurses, and administrators at four VA hospital sites, the web-based EMR simulator presents clinical documents as they appear in VA’s CPRS production EMR, and administers a document quality assessment questionnaire. The EMR simulator was developed to overcome the contradiction of studying computerized documents with a paper instrument, to permit self-administration at multiple sites and to manage data collection. This paper discusses the motivation to evaluate EMR document quality, development of the quality questionnaire, and how the design of the simulator evolved and was pilot tested.

1. Introduction
Adoption of electronic medical records (EMRs) is at the center of national health care reform strategy. The EMR furnishes health care personnel with patient data captured by health care information systems (HCIS). Its primary function is to support health care decision-making by serving as the point of contact between human minds and the complex data stored in a HCIS. It provides a “viewing window” for information access and a “transaction window” for conducting health care business. The EMR interface should present the “right” amount of information to users. Otherwise, there is risk of information overload and “overlook” of important information that could lead to degradation of decision quality [1].

Decision-making is a central cognitive activity for EMR users. Many aspects of physician decision-making (e.g., problem formulation, diagnosis, and choice of therapy and tests) have been described from a formal logical perspective [2]. Also important, for physicians, nurses and administrative staff alike, is naturalistic decision-making [3], an emerging area of cognitive study which recognizes that expert decisions are frequently based on pattern recognition and situation awareness rather than formal logic. Both modes of decision making can be supported by the EMR. Rule-based decision making requires “facts” from the EMR: labs, demographics, studies and events. Naturalistic decision making relies on decisions cued by patterns of facts, many of which are expressed in the narrative text that is written by the clinicians, doctors or nurses, during patient care and found in notes, reports and summaries in the EMR. In both cases, decision making based on an electronic patient chart becomes increasingly complex as the volume of data in the HCIS increases [4]. Data display strategies that work reasonably well with sparse data may fail when data is abundant. Coping with the growth of data in successfully implemented EMR systems is an emerging cognitive challenge for EMR users.

We use the term computerized patient care documentation (CPD) to refer to the free text progress notes, consultation reports and summaries that reside in the electronic medical record. Free text narrative is signed by an author...
and is an official legal document. Categorical, numeric and image data (e.g., coded diagnoses, lab reports, prescriptions, appointments, bills and x-rays) are excluded. CPD is an important but problematic EMR information resource: while it can vividly and succinctly tell a patient’s “story”, clinical text, in contrast to published text, is often hurriedly created, highly variable, unedited, unstructured and voluminous. This poses a significant challenge to the health care worker whose decisions depend on effective interpretation and response to CPD text. Preliminary investigations of the U.S. Department of Veterans Affairs’ (VA’s) computerized patient record system (CPRS) have revealed important quality concerns that organizations adopting EMRs will face when they fully implement electronic documentation. These include the “copy and paste” phenomenon, poor formatting, clutter, and propagation of inaccuracy [5-7]. Each of these can negatively impact safety and human performance.

To date, most studies of the impact of documentation on work activity in an EMR have relied on observations and self-report. Paper-based study methods fail to replicate the computer experience, and practical and ethical considerations (privacy, safety, time and cost) limit controlled experimentation in production EMR systems.

Given realistic data and EMR interfaces, studies involving EMR document review could be conducted without disrupting operations. Because simulators provide a realistic and safe environment for participants, they are useful in research and training. The desire for a flexible, non-disruptive experimental approach motivated the effort to develop a simulated EMR testing platform capable of presenting real patient data, and equipping it with measurement tools such as questionnaires, exercises and timers. Also desirable was a method that could be applied at multiple research sites, scheduled at staff convenience, and conducted in the workplace. These considerations shaped the decision to build a web-based system that could eventually permit large scale interface testing involving many users at hundreds of worksites in the VA health care network.

This paper focuses on design issues surrounding the development of the simulator. First we present the conceptual foundations and the motivation for the simulator. Then, in section 2, we provide background information regarding CPRS, the VA’s EMR and in section 3 describe the larger study that the simulator supports. In section 4 we present the design methodology, and in section 5 provide a descriptive technical overview of the simulator. Discussion of the pilot tests and concluding remarks follow.

1.1. Conceptual Foundations and Motivation

This work is part of a larger VA Health Services Research and Development effort to better understand and improve EMR documentation: identifying problems, sources of problems and possible solutions from the EMR user's perspective. As part of the overall goal of understanding threats to accuracy and efficient processing of document-based information in health care, it was felt necessary to define, quantify and validate a concept of “information value” in clinical documents. Recognizing that CPD is not the exclusive province of any single work role in a health care system, we chose a user-centered approach, and conducted focus group interviews of practitioners, administrators and nurses to understand their experience with the CPD system and to elicit user-originated concepts of document quality from a multi-role perspective. Using this information we developed and refined a document quality questionnaire. Then, we developed a simulated EMR system to present the questionnaire. The research process is summarized by the following steps:

1. Interview VA practitioners, nurses, and administrative staff to understand how they interact with the CPRS system.
2. Analyze interview transcripts to extract themes related to document quality.
3. Develop question items designed to elicit participants’ perceptions of the document quality, utilizing themes grounded in the interviews and incorporating non-redundant additional concepts identified in the literature [8].
4. Build a testing data set consisting of de-identified patient documents and supporting lab and prescription data.
5. Design and build a web-based EMR simulator to present test data and administer the document quality question items.
6. Pilot-test the simulator, refine it, and prepare a final version for deployment at VA sites to be used in the main study.
In the main study participants will be asked to review documents and evaluate their usefulness for performing typical work tasks. In its first iteration, the simulator will assess the effect of systematic modification of document length (see Section 4.2). A balanced incomplete block (Latin square) design will permit detecting whether a main effect of modified document length influences the perception of document quality.

To overcome disadvantages of studying computer use using a paper instrument, a web-based CPRS simulator was developed to present documents to research subjects. To support the research, the simulator was required to successfully implement the following modular functions: (a) provide the look and feel of the CPRS user interface, (b) present a set of patient documents and associated supporting lab and prescription data, (c) support the experimental design, (d) manage subjects, (e) collect data, and (f) implement security, protect data integrity and comply with the Institutional Review Board (IRB) requirements for the protection of human subjects. Each module presented methodological challenges.

The simulator was developed using iterative design and a user-centered approach. Its layered architecture allows flexibility for modification and expansion. These layers correspond to the six modules. A pilot study was carried out to assess usability and refine the data collection instrument prior to survey deployment.

2. Background

2.1 CPRS – the VA’s successful EMR

The VA’s EMR development effort began in 1977 [9]. In 1982, the VA nationally adopted a system that supported administrative, lab, and pharmacy operations and had some basic EMR functions. In 1997, the system implemented a graphical user interface. The on-screen presentation of the CPRS was deliberately fashioned to resemble a traditional chart, with tabbed sections for labs, orders, notes, consults, etc. VA hospitals started becoming “paperless” in 1999. By 2002 all 162 VA hospitals were paperless and the system was networked, permitting remote access to data between all VA facilities.

The graphical CPRS interface improved access to a wide range of patient information [10] and databases accrued from clinical operations both provide a rich resource for research and drive the VA’s quality improvement program [11-13]. VA’s CPRS is promoted as a model for other health care organizations [14], but CPRS users have also experienced unwelcome consequences of its success, notably information volume overload and input burden.

2.2 Unanticipated problems

Beginning around the year 2000 and counterbalancing projections that new technology would save lives and money [15, 16] several investigators described unforeseen adverse consequences of introducing health care information systems (HCIS) and EMRs. These included increases in errors seen with introduction of the HCIS [17-19], problems with documentation [5, 6, 20, 21], and even outright rejection of the EMR by clinicians [22, 23]. A growing realization arose that that existing information systems fail to accommodate the “complex socio-technical systems” of health care.

A recent report to the National Research Council (NRC) commissioned by the National Library of Medicine makes a similar critique. Its authors, informatics experts who surveyed eight leading HCIS systems, concluded that these systems [24]:

- appear designed largely to automate tasks or business processes
- are designed in ways that simply mimic existing paper-based forms
- provide little support for the cognitive tasks of clinicians or the workflow of the people who must actually use the system
- do not utilize human-computer interaction (HCI) principles, leading to poor designs that can
  - increase the chance of error,
  - add to work load,
  - compound the frustrations of completing required tasks,
  - introduce new forms of error that are difficult to detect

The NRC report also described insufficient support for clinical cognition as a key challenge in present day EMR systems [24].

3. Prior Work

Our ongoing research project, VA Health Services Research and Development project IIR 05-019, studies the CPRS documentation system and how VA employees work with it. As part of
this study, we conducted 14 scripted focus groups at four VA sites, interviewing 129 VA practitioners, nurses and administrative personnel in 2007 and 2008. CPRS users gave examples of the challenges they faced when navigating and working in the large “information space” of clinical documentation. A recurring theme was the EMR’s inability to present document information in ways that were a good “cognitive fit” with tasks. Too often, the information users needed to complete their work was scattered in different screens, or so combined with irrelevant information that users were slowed down and frustrated. Participants said they knew that the information they needed was present in the HCIS, but were stymied when it was hard to find or when access to information needed to complete a transaction was blocked. Other frequent themes included: poor support for communication between members of the care team; distress and irritation when copy-and-paste (which users also stated they were driven to use by time pressure) impeded use of the written record; and suboptimal support for the information needs of ward nurses. [25, 26]. Themes from the focus groups were distilled to four major categories: (1) irrelevant and redundant textual data, (2) difficulty with copied and pasted text, (3) awkward navigation and (4) poor fit with inpatient work.

The focus interviews revealed that VA users experienced many benefits from the CPRS. They cited CPRS as a reason they liked working at the VA. They valued computerized documentation because narrative helped “make sense” of other data in the EMR. Because users reported frustration, stress and time pressure in their work with CPRS, we anticipated their support in efforts to improve the system’s efficiency.

Accordingly we undertook to investigate document review, an activity common to all users studied, and in this instance, examined the impact of documents containing greater or lesser amounts of boilerplate and inserted data (factors frequently cited by our subjects as contributing to document “clutter”). Future studies will explore specific enhancement strategies to overcome other identified barriers. Use of a simulator will permit experimental evaluation in realistic work contexts.

4. Methodology

In this section we present the simulator modules and the associated methodological issues involved: (a) provide the look and feel of the CPRS user interface, (b) present a set of documents, (c) support the experimental design, (d) manage subjects, (e) collect data, and (f) implement security, protect data integrity and comply with IRB requirements

4.1. Simulator based evaluation using realistic patient data.

The appearance and navigation behavior of the production CPRS system is simulated on a web page, and modified to administer a document quality questionnaire. To maintain realism, actual patient records and supporting data were manually de-identified and presented in CPRS “look-alike” format. To test the hypothesis that cluttered documents were less desirable, documents were systematically altered to contain greater or lesser amounts of inserted text and boilerplate, in a balanced incomplete block design. Subject responses were solicited using a semantic differential of quality.

4

Table 1: Semantic differential: document quality dimensions

<table>
<thead>
<tr>
<th>This note doesn’t at all tell me what’s going on with the patient vs This note fully tells me what’s going on with the patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>It’s very difficult to skim to important information in this note vs It’s very easy to skim to important information in this note</td>
</tr>
<tr>
<td>It’s very difficult to distinguish the author’s text from template text vs It’s very easy to distinguish the author’s text from template text</td>
</tr>
<tr>
<td>This note doesn’t at all help me anticipate the needs of the patient vs This note fully helps me anticipate the needs of the patient</td>
</tr>
<tr>
<td>I always skip over this sort of note vs I always read this sort of note</td>
</tr>
<tr>
<td>I can’t at all follow what the author was really thinking in this note vs I can fully follow what the author was really thinking in this note</td>
</tr>
<tr>
<td>I have to wade through this note to get what’s important to me vs I don’t have to wade through this note to get what’s important to me</td>
</tr>
<tr>
<td>This note is incomplete (for this type of note) vs This note is complete (for this type of note)</td>
</tr>
<tr>
<td>This note is not at all consistent with the overall clinical picture vs This note is fully consistent with the overall clinical picture</td>
</tr>
</tbody>
</table>
dimensions identified in the focus groups or found in the literature [7, 8] (Table 1). To provide contextual patient data, the simulated EMR permits access to lab and pharmacy information. The questionnaire-simulator is accessed from a link placed in an e-mailed recruitment message.

Participants are presented with twelve de-identified notes from a single patient’s chart, four each in short, “native” (original) or long form, with the presentation order varying among subjects in a balanced incomplete block (Latin square) design. (Figure 1). Participants are instructed to review documents as they would in their typical work, and to rate each document on the differential scale. Such design is needed to reduce bias and learning effects.

4.2. De-identification and transformation procedures

Because health information is protected, a rigorous de-identification process was required. This consisted of replacing all patient, staff and place names and all identifying numbers with fictitious data. All dates were altered systematically to preserve proper chronology, and time values were truncated to the nearest hour.

Three versions of each document were created: (a) “original/native” (keeping the document as is); (b) “short” (systematically removing information) and (c) long (adding information). The systematic length changing procedures used were:

1. Native to Short Transform:
   a. Suppress headers and footers
   b. Display abnormal labs, but otherwise suppress inserted lab, medication and problem lists
   c. One-line display of vital signs.
   d. Summarize boilerplate lists of normal findings with the phrase: “within normal limits”.

2. Native to Long Transform
   a. Insert problem, lab and medication lists in provider notes, in the longest available format
   b. Display vital signs in 8-line format.

4.3. Testing scenario.

Subjects are instructed to read the electronic chart and perform a document review typical of their work as practitioner, nurse or administrative staff. They are told that the exercise is designed to last thirty minutes.

4.4. Subject recruitment and deployment

Physicians, nurses and administrative staff will be randomly selected from staff lists furnished by their departments and sent e-mail messages inviting them to volunteer to participate anonymously in the study. Clicking a hyperlink in the e-mail will access the testing system. Follow up e-mails will be sent to remind subjects to either complete the study or withdraw.

5. Simulator technical description

The CPRS simulator replicates the look and feel of the production EMR. Instead of a desktop application it is deployed as an enhanced web portal. The portal sends out invitation e-mails, with a text introduction and a link to set a password. Participating subjects can then log into the portal, view instructions and rate the
Figure 2: Orientation Screen

Figure 3: Simulated EMR
notes. Next, an orientation screen, with optional tutorial (Figure 2) appears.

The CPRS simulator is built in a powerful, flexible Content Management system called Plone (http://plone.org). Plone is built on top of Zope (http://zope.org/), an object-oriented application server. Plone, Zope, and the CPRS simulator are all programmed in Python. We are using Plone3, buildout based. Three cprs packages (eggs) were developed; cprs.policy, cprs.theme, and cprs.content. Cprs.policy is responsible for workflow, and controls the installation. Cprs.theme is a Plone skin, handling site wide templates and css. Cprs.content is where all the custom content types are held. Examples of the content types are cprs notes, medications, notefolder, and medicationfolder.

Three forms of notes, original/native, short, and long exist in the system. There are also three note folders, notesA, notesB, and notesC. Using a Latin square as the key to implement the balanced incomplete block design, notes in one of the three forms are added to the folder. Each folder displays the same set of note titles (derived from the source notes), but the length form of the notes within varies between the folders. For example, if the first note in folder notesA is in the long form, the corresponding note in folder notesB will be in the short form, and that in folder notesC will be in the native form.

The subject role is recorded when the subject is added to the system. When a subject logs in for the first time, the note folder that the subject may access is set. The portal keeps track of the last folder type assigned to subjects in each role and increments it for a new subject in the role. This technique assures equal exposure of folders A, B, and C to subjects within their role. In this application, AJAX (Asynchronous JavaScript and XML) was used to create a rich, interactive interface. Navigation icons provide visual feedback of completion of ratings for each note. Figures 3-4 illustrate the simulated EMR screen and the questionnaire used to rate each note on a semantic differential scale (Table 1).

6. Results

The research team piloted the questionnaire in paper form, finalized the questionnaire, implemented the web-based simulator, and then performed two rounds of pilot testing of the application. Observed sessions with nurses, practitioners and administrative personnel resulted in clarified user instructions, improved...
wording of semantic differential items and the appropriate number of notes to present. The revised version was used for a final round of pilot testing by administering to three unobserved subjects using the e-mail recruitment method. After each subject had completed the study they were interviewed to get their opinion regarding the process and identify any areas for improvement. Subjects found the simulated CPRS to be quite familiar and had no trouble with navigation or completing ratings of the notes within the allotted time. None of the subjects chose to view the animated tutorial suggesting that it was straightforward to follow the familiar user interface. At the time of this writing, the system is being deployed to sixty subjects at one VA hospital, and deployment to two additional VA facilities is imminent.

7. Concluding remarks

The impact of the VA CPRS simulator for current and future study of the EMR user interface is potentially high because it provides a convenient way to investigate the important, but neglected area of EMR user cognition. It presents a realistic environment for conducting EMR user interface research without disrupting or requiring expensive changes to the production EMR system. It has the potential to improve the efficiency of recruiting participants at multiple sites and promises to reduce the costs, errors and delays associated with paper based surveys.

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8. References


