Using a Web-based Prototype and Human-Computer Interaction Concepts to Develop a Vision for a Next Generation Patient Care Management System

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Abstract
This paper describes the novel use of two tools to develop requirements for a new generation patient care system: a web-based prototype and a human-computer interaction framework. These tools allowed a development team to crystallize new requirements for a patient care system, illustrate to clinicians a radical change in care process models, and begin the change management process in a large enterprise. (Keywords: vision, requirements, HCI)

Introduction

A key barrier to users' acceptance of computers is their lack of user friendliness[1-3] and informaticists often hear providers say they want systems that are "easy to use." Incorporating human-computer interaction (HCI) and usability concepts into the design of systems can result in easy-to-use applications, plus: increases in user productivity, decreased user frustration, better utilization of applications, fewer errors, improved patient safety, fewer personnel to install and support cumbersome systems, less resistance to applications, potentially faster treatment and fewer funds to redesign and remedy problems.[4-6] Calculated cost savings are even more impressive when usability is incorporated into system design--from $39,000 - $41,700 for a small application to $6,800,000-$8,200,000 in a large business application.[7,8] Creating usable systems begins very early in the design process. To that end, the purpose of this article is to explain how a web-based prototype and HCI concepts were used to evaluate and expand requirements for a next generation Patient Care Management System (PCMS) at Intermountain Health Care (IHC).

Project Objectives

Starting in 1995, Intermountain Health Care began identifying care process models for the top 80% of the Diagnosis Related Groups (DRGs) treated in various IHC hospitals. The care process models were designed to ensure best practice in diagnosis and treatment by using a decision tree framework to present treatment guidelines. In parallel, interdisciplinary standards of care were consolidated and standardized across IHC so that a patient treated at any facility would receive the same standard of care without the corporation.

To better ensure compliance with the standards, the company investigated ways to link the standards into the documentation process. One option was to rewrite the current information system to support the new care model; however, IHC had already made a strategic decision to transition from the current system to newer technologies centered on a clinical data repository. The current system also had other limitations: a proprietary database that did not easily support population-based analysis; character-based data displays; non-integrated, encounter-based records; and the inability to link or share data among facilities.

After completing a market survey and inviting vendors to present their current applications, IHC found no product that met the projected needs. Also, it was apparent that even within IHC, there was not a clear vision of the proposed system. Therefore, the team constructed a web-based prototype to help articulate the vision, clarify concepts, demonstrate information flow and develop consensus about requirements.

Description of the Proposed System

The proposed system will be centered on problem-based care. Any clinician identifies patient problems or issues that require attention (diagnosis, sign or symptom, or adverse event). The system then displays problem-specific, interdisciplinary best practice standards to the clinician with proposed goals and measurable criteria. Next, the system presents a list of tasks to most efficaciously reach the proposed goals. Users are prompted to document tasks and identify the patient's response to care. This data is used to determine the patient's progress toward the goals and for corporate evaluations. Individual caregiver performance data would also be available as feedback to clinicians.

A major objective of the proposed system is to develop an interdisciplinary system with all members of the health care team charting in the same record

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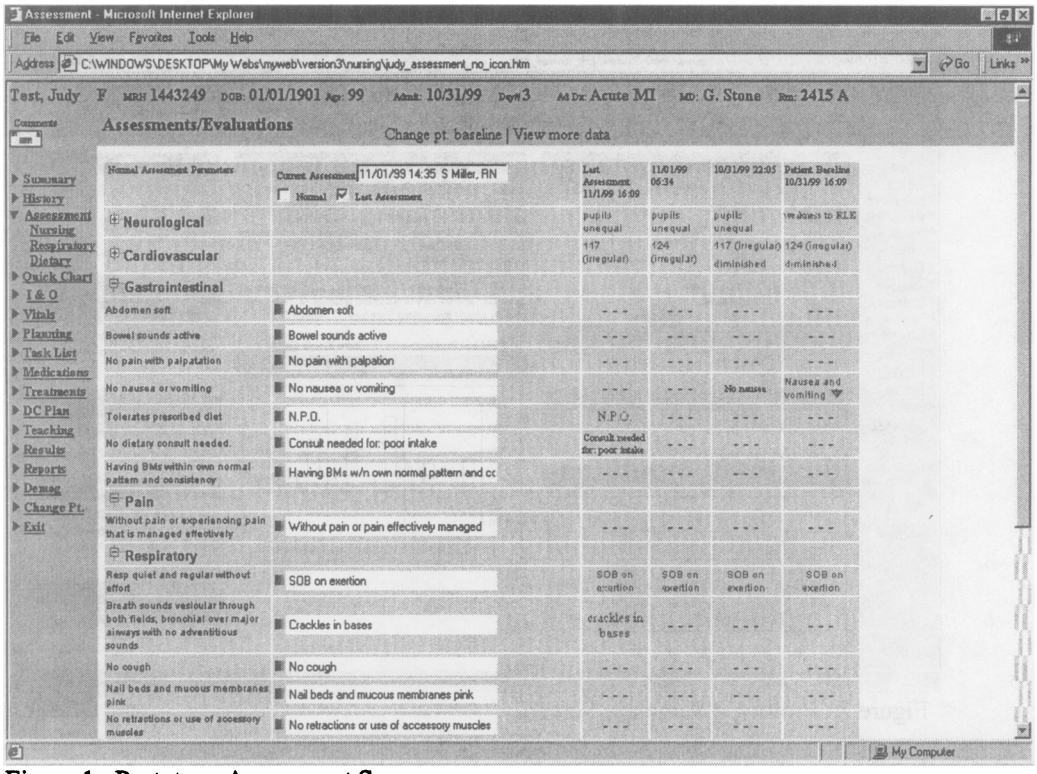

Figure 1. Prototype Assessment Screen

and using the same data elements over time. Thus, the new system will have a longitudinal, interdisciplinary patient history, pulled forward with each admission and updated. Contributions of all team members will be integrated in this one record. Also, based upon user experiences with the current system and the potential of information overload, another objective is to use presentation methods that help focus attention on important data, e.g., the use of color and icons to display significant findings and hiding normal data from view. Third, the proposed system will enable the clinicians to use a "charting by reference" model of documentation so that if the standards are followed, the clinician indicates by exception only the elements not performed.

The Prototype

Mock screens were developed to help clarify concepts and demonstrate information flow to the design team and to the larger clinician community. The prototype focused on the acute care setting and showed one data flow in the proposed system (Figure 1). The prototype was also used to demonstrate the proposed vision to potential vendors. Most important, this novel process provided an opportunity for end users to drive requirements early in the process. Because many of the proposed concepts were new, it was essential to demonstrate what was meant by "charting by reference", and illustrate how the standards of care could be integrated in the care planning process. Similarly, the prototype was used to represent how interdisciplinary integration could be achieved.

Microsoft FrontPage was used to build a web-based prototype. The software was fairly intuitive to use and enabled rapid screen development. However, the software was limiting, e.g., FrontPage controls required a FrontPage web server to support proper function of the controls. Also, some web page components did not display in quite the same manner across browsers.

Another important concept essential to the success of the new system is the construction of a patient summary screen (Figure 2) integrating the patient's plan of care with the Kardex. This prototype of a summary view was meant to present a "snapshot" view of significant data about the patient.

Lessons Learned From the Prototype Development

During development, the team decided to mock up dummy web pages with no database on the back end. However, the stateless nature of web pages made it difficult to present a realistic flow of data from screen to screen. JavaScript was used to simulate an interactive system and mimic screen flow, but it became a challenge to maintain two different sets of JavaScript for Internet Explorer and Netscape browsers. Eventually the team decided to support only Internet Explorer because the prototype was used primarily for demo purposes and Internet Explorer supported more of the desired functionality. The development team also learned that the web user

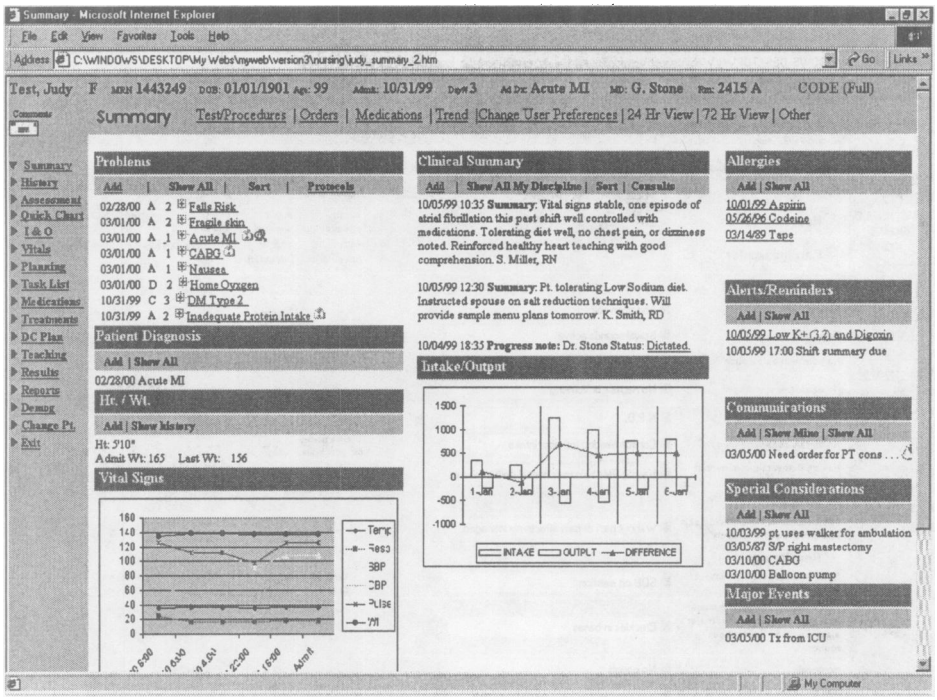

Figure 2. Prototype Summary Screen.

interface was not as robust as the Windows environment, e.g., typical right mouse functions are not available and dynamically changing the data on a screen is difficult.

Difficulties were encountered when clinicians attempted to use the prototype after it was published on the company's Intranet. All of the features and links were developed for the one demonstrated pathway, so if users clicked on other hyperlinks or buttons, they encountered blind alleys or hyperlinks that led to a blank page. Also, dummy data was used, so the prototype lacked a sense of clinical accuracy. Clinicians commented that the examples used in the prototype were too simplistic, and although it was helpful to understand the concepts, they were unsure how screens would look with real data for more complex patients. Unfortunately, due to the particular technical architecture, clinicians had to type in a long URL to access the site. Perhaps because of this and the fact that the prototype was less intuitive without explanation, few clinicians submitted comments about the product. Clinicians supplied comments from the website that often critiqued the look and feel of the product or focused on missing data elements. Users found it difficult to look beyond these issues to evaluate the underlying model and workflow.

The team's next steps concentrated on correcting these user interface issues. To make the prototype more realistic, chart reviews of actual patient chart data were done to identify missing components and to determine where each element would be documented in new system. Similarly, clinicians were asked to log the shift activities on a typical day and these scenarios were also used to refine the prototype. Subsequently, the prototype was presented to various groups within IHC to evaluate whether the proposed care model was acceptable and workable. These sessions also introduced the changes in care delivery that would need to occur to support this new care model of interdisciplinary and problem-centric care.

Various screen styles were explored. Users stopped critiquing the look and feel of the product when it included: a navigation bar on left side of the screen, a patient header info in a banner bar across the top of the page, and use of the right side of the screen to display module specific content. Within the module specific area, buttons represented functions specific to that module. Also, a comment button was available on each screen for users to send screen specific feedback. Once the prototype was relatively stable, a more thorough HCI evaluation was undertaken.

Human-Computer Interaction Evaluation

HCI is the study of how people design, implement, and use interactive computer systems and how these systems affect individuals, organizations, and society.[5] HCI deals with people and computers and the ways they influence each other.[9] Usability is a subset of HCI and addresses specific issues of human performance during computer interactions within a particular context.[10] Usability includes topics such as ease of use, user satisfaction, efficiency of use, error-free/error-forgiving interactions and the seamless fit for an application to the task(s) at hand. Several usability assessments are possible, including usability testing or an assessment by a human factors expert, which is the method used here.

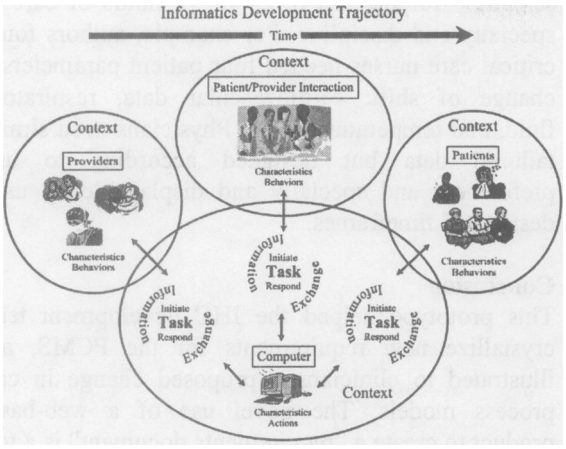

Figure 3. Health HCI Framework

Tools for a HCI Evaluation

Two tools were used by a human factors expert to evaluate the initial PCMS prototype: a framework for HCI and corresponding work design processes in acute care settings. The Health HCI Framework (HHCIF) is a tool depicted in Figure 3.[12] As may be seen, major elements of HHCIF are: users, computers, context, tasks, information, interactions, and time. This framework builds upon earlier work[11] but expands beyond nurse to provider (or a team of providers), adds a patient (or group of patients), and adds the interaction among these elements.

The HHCIF includes concepts from developmental psychology which give insight about how to structure elements among non-equivalent members during interactions, including between a computer and a human. Members interact in a system of mutual influences and behave according to respective characteristics. Interactions are embedded in a context. Therefore, the outcome of the interaction is different according to the environment in which the elements interact. The interaction changes across time, and the outcome is dependent upon the length of time the members have been interacting.

Provider-patient-computer interactions allow for managing and communicating information within a health context. Providers, patients and computers interact in a system of mutual influences with information as the medium of exchange among them. During this information exchange, provider, patient, and computer behaviors occur relative to their respective characteristics. These interactions occur within a context, even a virtual one, and the interactions develop as they move across time. More detailed information is available elsewhere.[12] For the analysis, clinical processes were embedded within in the HHCIF elements. Thus, typical scenarios and processes of care were used to test the completeness of the model within the scope of functions proposed by PCMS.

HCI Evaluation of the PCMS Prototype

To begin, the scope of the PCMS prototype (PCMSP) was compared to elements in the HHCIF. Although the intent of the PCMSP was interdisciplinary interactions with computers, the current PCMSP centers around only the dyad of nurse and computer. The framework suggests other critical additions: the triad of patient-provider-computer, teams of providers, and patients themselves. The triad of patient-provider-computer is important in acute care, e.g., patients can receive discharge educational material displayed via technology with a provider speaking to them about the material. Second, most acute care is rendered in teams – interdisciplinary teams and teams within single disciplines. Thus, additional requirements need to be added to support activities such as rounding by physician teams, communication of patient care changes to other disciplines, the hand-off of work within teams, such as from nurses' aids or technicians to the professional nurse, and from nurse to nurse during change of shift. Most important, the PCMS requirements need to be expanded to address patient-computer interactions. As patients become more involved in system use, applications need to be designed to fit their specific needs, e.g., email from patients to providers for simple requests such as prescription refills, capabilities for patients to schedule their own appointments on-line, and remote access to educational material, patient-patient interactions, or allowing patients access to track their own problem list and discharge summaries in a truly patient-centered record. This HCI assessment suggests that a broader vision for the PCMS be created in which this one detailed view could reside.

The PCMSP provides an intriguing link between problems, interventions based upon standards of care, and documentation. From a HCI perspective, this tight link will be a radical change in care processes for providers, potentially forcing providers to accommodate the computer's processes rather than the other way around. Currently, the problem list and standards of care are used as reference material but do not drive the care process. Providers begin anywhere in the process without first defining a problem and selecting a standard, e.g., they can write orders at any point in the process. An immediate concern is whether this process change will be workable for clinicians. A more optimal design would allow providers to enter the process at any

point and not force providers to enter a problem before continuing with computerized care.

Order entry functions need to be made more explicit in the prototype. Orders provide an integrating mechanism to documentation and are a centerpiece of an acute care application. Orders might be embedded within the standards of care and launched as order sets directly from the plan of care, for instance, and then autopopulate other functions such as a medication administration record. Since the rest of the functions are tightly integrated, orders need to be a part of that integration.

The prototype also needs to assist providers with other kinds of information synthesis than those currently displayed. For example, a "home" screen needs to be tailored to fit the information needs of each discipline. The home screen for critical care nurses might contain a high-level data about their assigned patients for that day with flagged critical values, as well as icons for options such as email, knowledge databases, work schedules, and hospital procedures. Physician screens might have these same options plus their outpatient schedule for the day. More important, information synthesis for providers can be facilitated by creating tailored summary screens – for the last 8, 24 or 72 hours of care by specialty and discipline. For example, authors found critical care nurses needed four patient parameters at change of shift: cardiovascular data, respiratory, fluid, and temperature data.[1] Physicians need similar tailored data but designed according to user preferences and specialty and displayable by user-designated timeframes.

Conclusion

This prototype helped the IHC development team crystallize new requirements for the PCMS, and illustrated to clinicians a proposed change in care process models. The novel use of a web-based product to create a "requirements document" is a tool others can employ. The use of a human factors expert to complete a HCI assessment pointed to major missing functions early in the development process. Many of the HCI suggestions were incorporated into the requirements definition stage of a joint development project between IHC and a vendor. Future HCI assessments should evaluate how the functions are instantiated with usability testing. Both of the tools, the prototype and HCI framework, resulted in a more clear and expanded vision for the new Patient Care Management System at Intermountain Health Care.

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