Identification of Design Features to Enhance Utilization and Acceptance of Systems for Internet-based Decision Support at the Point of Care

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Extensive utilization of point-of-care decision support systems will be largely dependent on the development of user interaction capabilities that make them effective clinical tools in patient care settings. This research identified critical design features of point-of-care decision support systems that are preferred by physicians, through a multi-method formative evaluation of an evolving prototype of an Internet-based clinical decision support system. Clinicians used four versions of the system — each highlighting a different functionality. Surveys and qualitative evaluation methodologies assessed clinicians' perceptions regarding system usability and usefulness. Our analyses identified features that improve perceived usability, such as telegraphic representations of guideline-related information, facile navigation, and a forgiving, flexible interface. Users also preferred features that enhance usefulness and motivate use, such as an encounter documentation tool and the availability of physician instruction and patient education materials. In addition to identifying design features that are relevant to efforts to develop clinical systems for point-of-care decision support, this study demonstrates the value of combining quantitative and qualitative methods of formative evaluation with an iterative system development strategy to implement new information technology in complex clinical settings.

INTRODUCTION

Using Internet technology to integrate clinical practice guidelines (CPGs) at the point of care can provide physicians with relevant clinical information that has been shown to improve the quality or expedite the process of care delivery.[1] These systems offer potential benefits for implementing and distributing CPGs effectively.[2] However, extensive utilization of these systems necessitates an understanding of the user interaction capabilities that will make these systems effective clinical tools in patient care environments. This research seeks to contribute to the growing understanding of this issue through a multi-method formative evaluation of an Internet-based clinical decision support tool, SIEGFRIED: System for Interactive Electronic Guidelines with Feedback and Resources for Instructional and Educational Development.

SIEGFRIED is an Internet-based system designed to interactively present CPGs at the point of care.[3,4] The system interactively traverses a CPG algorithm through a series of questions driven by data from a specific patient. As the user answers these questions, SIEGFRIED tailors the guideline recommendations to the specific patient. The CPG knowledge is stored in a relational database and is extracted and incorporated into a Java applet. The applet is delivered to a client Web browser for use at the point of care. The system also solicits feedback from users regarding guideline recommendations and provides hypertext links to relevant Internet-based resources of physician instruction and patient education. Figure 1 shows a SIEGFRIED screen for data entry.

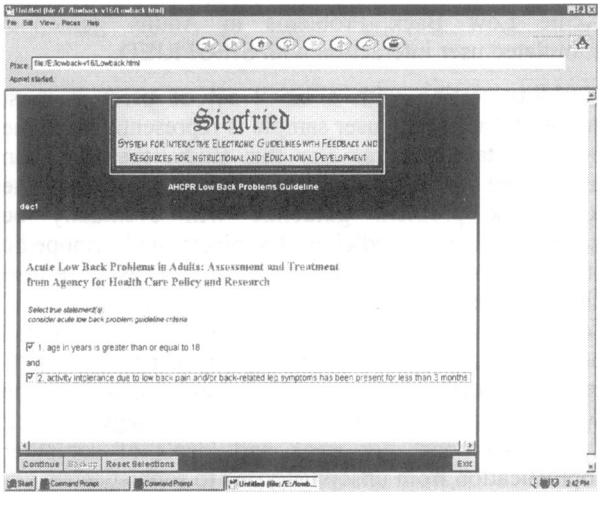

Figure 1. SIEGFRIED screen for data entry.

METHODS

As part of a comprehensive evaluation plan designed for the development and implementation of the SIEGFRIED system, a formative evaluation component was undertaken with the primary goal of improving the user interaction capabilities of the system by providing its developers with feedback from users. Specifically, the study sought to understand how users want to interact with an Internet-based, clinical decision support system and suggest design features that improve its usability and encourage its use in clinical settings. Friedman and Wyatt[5] and Anderson et al.[6]

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have recommended formative evaluation for use in conjunction with iterative system design as a means of further defining user requirements and refining the functionality of a system. Using iterative design methodology, it is better to conduct several smaller usability tests of prototype systems than to perform a single large-scale test, with an optimal ratio of benefit-to-cost demonstrated with as few as three representative users per iterative study cycle.[7] The formative evaluation reported here utilized six physicians using an evolving prototype of the system in a series of four scenario-driven interactions over a three-month period. Each of the series of user sessions focused on a different set of system interaction features. The first three sessions exposed users to system features that were defined in the initial system specifications: in Session 1, screen layout, input/output, and control; in Session 2, links to Internet-based physician and patient education materials; and in Session 3, user feedback on system recommendations. Compelling suggestions for system enhancements made by users during the earlier sessions influenced system development of features that were evaluated in later sessions: in Session 3, encounter documentation; and in Session 4, the ability to review and revise user input. Case scenarios developed by a project clinician to exercise the implemented AHCPR Acute Low Back Problems in Adults guideline[8] stimulated user interaction with SIEGFRIED.

Usability testing with a small set of users is most successful when the user sample is representative of the system's target users.[7] For this study, the physician users were chosen from the two facilities in which the low back problem guideline will eventually be deployed: family medicine (4 subjects) and orthopedic surgery (2 subjects) outpatient clinics. They were also chosen to include a representative range of clinical and computer experience. Participants were evenly divided between residents and attending physicians. In a self-reported survey of computer usage patterns,[9] the subjects reported hands-on computer usage ranging from 1-40 hours per week and levels of computer sophistication from unsophisticated to sophisticated.

After a brief instruction period at the beginning of each session, a physician used the system for approximately 40 minutes. Data collection methodologies used during each intervention included videotaping of the interaction sessions, follow-up interviews, and user satisfaction surveys. The videotapes captured users' interaction with the system, such as screens, cursor movements, and data entry, as well as their verbalizations. Users were instructed to think-aloud as they used the system and to comment on the system's user interface and functionality.

Following the user's interaction with the system, a twenty-item user satisfaction survey was administered online. The first sixteen items in the survey were the same for each interaction session. They were adapted from a validated instrument for assessing overall user satisfaction with system usefulness and ease of use.[10] The user was asked to assess the extent to which she agrees with each statement, using the scale of 1=strongly disagree to 5=strongly agree. Measures of system usefulness included content quality variables, such as relevance, sufficiency, accuracy, compatibility with practice standards, and ability of the system's recommendations and Internet-based informational links to meet clinical information needs. Also included were several measures of overall system value: positive impact on patient care, preference over other forms of guideline dissemination, and worthiness of time and effort. Measures of system usability included variables for output format and aesthetics, data entry, forgiveness of user exploration and mistakes, and general ease of use. Since timeliness of system responses in busy clinic settings is critical to success, two measures of response time, one general and one specifically addressing clinical use, were included. See Table 1 for survey items 1-16 and corresponding measures of usefulness and usability. Four sets of additional items were specific to the system features being assessed during each of the four design iterations. See Table 2 for survey items 17-32.

Table 1. Survey items 1-16, corresponding usefulness and usability measures, and means from repeated measures ANOVA for all subjects and sessions.*

Item ID	Mk	Survey Item	Mean
Q1	C	precise information	3.875
Q2	E	easy to use	3.917
Q3	F	output in a useful format	3.875
Q4	V	prefer the system	3.708
Q5	T	response speed adequate	4.042
Q6	E	forgiving	3.042
Q7	C	content is relevant	3.917
Q8	V	positively impact patient care	3.833
Q9	C	accurate	4.017
Q10	E	entering data easy to do	4.250
Q11	C	sufficient information	3.708
Q12	C	recommendations meet my practice standards	3.917
Q13	T	acceptable timeframe for clinical use	4.083
Q14	F	interface is aesthetically pleasing	3.667
Q15	C	support materials are appropriate	3.833
Q16	V	worth the time and effort to use	3.667

** Measures key: usefulness measures are C-content, V-overall value; usability measures are E-ease of use, F-format, T-timeliness. Responses range from 1 = strongly disagree to 5 = strongly agree.*

Table 2. Survey items 17-32 and means for all users.

Item ID	Survey Item	Mean
Session 1		
Q17	able to track my progress	3.167
Q18	screen layout effective	3.500
Q19	control buttons are convenient	3.667
Q20	separate windows	3.667
Session 2		
Q21	Web links are easy to use	3.833
Q22	supplemental materials (e.g., figures, and tables) add value to the program	4.333
Q23	patient education materials valuable	4.500
Q24	printing patient education materials	4.667
Session 3		
Q25	express opinions w/ user feedback feature	3.833
Q26	user feedback feature easy to use	4.167
Q27	summary of session data entry useful	4.187
Q28	printable summary with guideline recommendations and user feedback	4.500
Session 4		
Q29	review and revise was easy to use	4.167
Q30	review and revise is important	4.333
Q31	single, larger interaction window	4.667
Q32	track my progress through the clinical guideline	4.500

A brief, audiotaped, follow-up interview concluded each user interaction session, during which issues arising in either the session or the survey could be explored in more depth. Interaction sessions averaged one hour in length, including completion of the survey and interview.

Data Analysis

Items 1-16 of the user satisfaction survey were repeated in each of the four administrations of the survey. The physicians' responses to each of these items were analyzed using a repeated-measures analysis of variance. A Tukeys studentized range test was used to assess changes in responses to individual items between time periods. The remaining 16 items (i.e., four sets of four survey items each, corresponding to the system interaction sessions) were analyzed using an analysis of variance for individual item and set means, including a Tukeys test for significant differences between responses to items within sets.

Content analysis methodology was used with the verbal data from audiotaped interviews and videotaped user interaction sessions.[11] The transcribed interviews and the time-stamped videotapes were reviewed to identify data segments related to physicians' preferences for interaction with an Internet-based clinical decision support tool. These segments were coded and these codes were sorted into categories that represented patterns and themes of preferences across subjects and within each version of the SIEGFRIED system. The scheme used included categories for subjects' comments regarding screen layout, data entry, comprehension and presentation of output, Internet-based links, summarization and documentation, system solicitation of user feedback, review and edit capability, and appropriate uses of the system. Categories were often further subdivided. For example, the Internet-based links category contained subcategories for navigation, browser functionality, and link content types. These categories correspond well to those developed for the study of other medical information systems[12] and on the usability literature.[7]

RESULTS

The results of analyzing the responses to items 1-16 of the user satisfaction survey (see Table 1) show that physicians were most satisfied with the ease of data entry and timeliness of responses. Physicians found the system's incremental, guided data entry approach, which requests only the specific patient data as needed to traverse the guideline, easy to use (Q10). The physicians also found the system's response times to be adequate (Q5) and acceptable for clinical use (Q13). Physicians were also satisfied with the accuracy of the system's recommendations (Q9), with the relevance of the information provided (Q7), and the system's ability to meet their information needs (Q1).

Satisfaction with three of the usability measures increased during the four interaction sessions. See Table 3. Physicians' satisfaction with general ease of system use (Q2) and presentation format (Q3) was significantly increased from the first to the last session. The physicians' satisfaction with system forgiveness of user exploration and mistakes increased significantly from Session 3 to Session 4 (Q6).

Table 3. Significant changes in means of perceived usability measures for each session (item identifiers refer to Table 1).

Item ID	Session 1	Session 2	Session 3	Session 4	F value
Q2	3.667	3.833	3.833	4.333	3.75
Q3	3.500	4.000	3.833	4.167	4.07
Q6	2.333	2.667	2.833	4.333	15.27

The results of analyzing each of the four sets of feature-specific survey items 17-32 corresponding to the functionality implemented for each interaction session are shown in Table 2. Users expressed satisfaction with the majority of feature additions and enhancements. Physicians were particularly positive about the review and revise feature introduced in Session 4.

The qualitative analysis of the verbal data contained in the videotaped user interaction sessions and interviews developed several themes regarding users' preferences for interaction characteristics that enhance system usability and usefulness. Each is briefly described below with illustrative excerpts from the data in italics.

Navigation, Control, and Context Awareness
These issues were important to all users and manifested themselves both within individual screens (e.g., alternatives for navigating through lengthy text and the use of visual cues) and as users navigated among the screens comprising a guideline (e.g., review and revise capability, an overview of the guideline algorithm). Focusing on guideline navigation, users identified several reasons for wanting to back up through screens to which responses had been previously given, with both review and revise capabilities. A physician may *"need to see the link between a red flag workup and the patient-specific finding that initiated it."* Or the presence of a patient finding thought to be absent may be discovered during subsequent questioning of the patient or examination of the record. Also, physicians indicated there is value in being able *"to run variants on the basic set of patient data (i.e., what if), particularly when the results of tests are not yet known."*

Additionally, users identified several reasons for wanting to be able to track their progress through a particular guideline's logic. A guideline overview can serve to estimate time to complete a guideline or to place the system's requests for patient data in the context of paths that will emanate from specific responses, such as *"wanting to know that responding 'yes' for neurologic symptoms in lower limbs will trigger a workup for sciatica."* A graphical representation of the guideline's decision and recommendation nodes with "thumbnails" of corresponding screens was suggested. It would be updated dynamically as the user traversed the guideline, serving as a memory and navigational tool.

Presentation and Content
Physicians had specific preferences for the content and presentation of guideline requests for patient data, guideline recommendations, and informational Internet-based links. First, they preferred telegraphic, clear presentations of guideline-related information to the narrative descriptions characteristic of many guidelines. Early versions of SIEGFRIED used narratives extracted verbatim from the guideline. Our users suggested *"a better use of the recommendation screen for the focused medical history and physical and neural examinations would be a bulleted list of items to include."* Second, physicians wanted recommendations to include evidence information, when available, *"because evidence quality could influence my decision to follow a particular guideline recommendation."* Third, users wanted strong visual clues to what they should be paying attention, such as when scrolling is necessary.

Internet-Based Links
Regarding web links, physicians want Internet-based links to recognizable, high quality sources of patient education materials (e.g., proper lifting technique), physician information (e.g., *"how to interpret a straight leg raise test because it is often done incorrectly"*), and memory and organizational aids (e.g., NSAIDs subclasses and common side effects). Users indicated that they wanted progressive access to more detailed information, with hierarchically organized web pages, clearly labeled links, and indexes. Users' comments favored standard Web browser functionality, including history, bookmarks, and printing.

Encounter Documentation and User Feedback
A user feedback feature designed to allow physicians to comment on the appropriateness of the system's recommendations to a specific patient/case was found to be most valuable for noting exceptions to expected care. Subjects said that the extra time required to provide the feedback would be warranted only if the information was used in conjunction with a system-generated encounter summary to provide documentation that also includes the guideline-specific patient data that was collected and the system's recommendations. This documentation tool was seen as *"a valuable way to record important quality of care information,"* e.g., that the appropriate course of care was followed, that an alternative care path was followed and for what reasons, and that appropriate patient education materials were discussed. A quality assurance documentation tool was also viewed as an incentive that could sustain physicians' interest in using the system.

DISCUSSION

This study shows that there are critical design features that can enhance physicians' perceptions of the usability and usefulness of point-of-care decision support systems. These features are relevant to the burgeoning clinical system development efforts to produce robust point-of-care decision support within electronic medical records systems and to deliver just-in-time physician and patient education materials via the Internet. They are particularly relevant to increasing the access ease and efficiency of using CPGs at the point of need. Implemented within standard, readily available Java and Web browser development environments, these features have the potential to enhance the utilization and acceptance of a wide variety of point-of-care and Internet-based clinical tools.

One such set of design features addresses the question, *"What makes this system usable and time effective within the often hectic clinic setting?"* The usability design criteria that emerge as most important to our subjects are clear, telegraphic representations of guidelines and related information, facile navigation within and between windows and through guideline logic, and a forgiving and flexible interface that is tolerant of errors and exploration. As the SIEGFRIED prototype evolved, these interaction capabilities were implemented with positive results evidenced in the

surveys by steadily increasing satisfaction with overall measures of system usability (Q2, Q3) and a significant increase in satisfaction with the system's review and revise capabilities in Session 4 (Q30). From the verbal data, physicians' comments additionally reinforced the value they placed on well-organized and succinct methods of conveying clinic information, including the structure of guideline logic itself.

During initial system design, consideration of the time pressures of clinic practice resulted in a fast client-side Java applet implementation, whose primary time-limiting factor was Internet retrieval speeds for external links. Although performance resulted in high satisfaction ratings for system response time (Q5, Q13), physicians were nonetheless hesitant to assert that the system benefits were worth the time consumed by its use (Q16). In interviews, physicians indicated that incorporating clinical guidelines within an electronic medical record, with its potential to eliminate considerable data entry and integrate encounter documentation with quality assurance, was seen as a promising approach to time pressure concerns.

A second set of critical design features responds to the question, *"What can this system give me that adds value to my practice?"* Interviews with our physicians indicate that system acceptance was perhaps less dependent on improving usability, despite its undeniable importance, than on creating tools that add value to the practice setting. Features perceived as adding value include an encounter documentation tool, viewing and printing of patient education materials, and availability of physician education and memory aids during the patient encounter. During Session 2, which focused on Internet-based links to clinical information, survey results showed that although the prototype's initial link navigation capability was not particularly easy to use, physicians still perceived considerable value in the ability to access the clinical information (Q21-24). When the user feedback feature and encounter summaries of data entry and guideline recommendations were implemented in Session 3, users were most satisfied with the potential for combining these to produce a documentation tool that could perform a task currently consuming additional clinician time (Q28). Verbal data elaborated these points.

This study also demonstrates the value of a multi-method approach that couples formative evaluation and an iterative system development strategy for implementing new information technology in complex clinical settings. We found quantitative and qualitative methods complemented each other as we sought to understand how physicians wanted to use the evolving SIEGFRIED system — a result similar to that described by Kaplan and Duchon in their post-implementation study of a laboratory system.[13] The results of a single implementation and small sample necessitate further research. Other evaluation methods and settings can provide additional insights. As access to SIEGFRIED is incorporated into electronic medical record systems, we will be conducting a controlled clinical trial using both objective and subjective measures of acceptability among users, in addition to assessing the impact on compliance, care process, and costs.

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