Evaluation of Web-Based Patient Information Resources: Application in the Assessment of a Patient Clinical Information System

Andre W. Kushniruk, Ph.D.[1], Vimla L. Patel, Ph.D.[1], and James J. Cimino, M.D.[2]
[1]Cognitive Studies in Medicine: Centre for Medical Education,
McGill University, Montreal, Quebec, Canada
[2]Department of Medical Informatics, Columbia University, New York, NY

The advent of Internet-based information systems has provided unprecedented opportunity for the widespread access to medical information. However, issues related to the evaluation of such systems to ensure their usability, effectiveness and to assess their effect on the provider-patient relationship pose a considerable challenge. This paper describes a framework for the distance evaluation of web-based information technologies. The methods are described in the context of an on-going evaluation of a system known as PatCIS, designed to be accessed by patients from home for obtaining health information, and for management of chronic diseases. We employ a multi-method approach that involves collection of a rich data set, including Web-based questionnaires, automatic logging of user activity and email communication with users. Our work in evaluation design is influenced from research in the areas of cognitive science and the field of usability engineering which aims to characterize the interaction of users with information technologies.

INTRODUCTION

With the increasingly widespread use of the World Wide Web for medical and health applications, the development of methods for evaluating these systems regarding their effectiveness and usability is becoming a critical issue. Designing effective evaluations in medical informatics can be difficult enough, but becomes even more challenging when it involves evaluation from a distance, i.e. assessment of use of medical information systems from varied locations ranging from the clinic to the home. In this paper, the focus is on development of a framework for designing effective evaluations directed at assessing patients' use of Web-based information systems. Examples will be provided in the context of a system we are currently evaluating, known as PatCIS (Patient's Clinical Information System), developed at Columbia University. This system provides patients with customized views of their own medical records via the World Wide Web. PatCIS allows patients with chronic illnesses, such as diabetes and asthma, to enter their health data and receive advice about management of their illness.

BACKGROUND

The effects of changes being brought about by emerging technology, such as Internet-based information resources for patients, must be considered in relation to patient understanding and provider therapeutic goals. In order to develop individualized, context-sensitive, useful information and guidelines that will end up being applied by patients, we must be able to evaluate how that information is understood, who is trying to understand it, and what problems occur in its comprehension and application. Over the past decade we have been involved in cognitive studies of reasoning and comprehension of medical information by both lay people and health care professionals. We are currently evaluating the use of PatCIS by patients to assess both its usability and its impact on the patient-provider relationship. For this work, we are applying a variety of approaches to evaluation throughout this project in order to develop a principled basis for understanding the effects of advances in health care information technology and telemedicine.

The evaluation of Internet-based technologies designed for use by patients, raises a number of concerns that go beyond conventional evaluations typically undertaken in medical informatics. In addition to assessing the usability and effectiveness of the computer system in the context of specified tasks, a number of other issues emerge when considering the evaluation of systems directly accessed by patients from home. These include: (1) determining the extent to which the patient's view of the system differs from that of the designers and how potential "mismatches" between the two influence the system's effectiveness, (2) going beyond assessment of user satisfaction to consideration of how patient's interaction with the system changes over time and how use of such technology impacts or changes the patients' interaction with human caregivers [1], (3) identifying problems in the users' interactions with the system, and (4) identifying technical and methodological issues for performing these evaluations remotely [2].

A number of studies have investigated use of Internet-based information systems by health care providers and development of evaluation instruments for assessing their use of information technology. However, an in-depth understanding of the effects of use of the WWW in providing users with advice and access to their medical data necessitates investigation. As health care rapidly moves towards widespread distribution of medical information via the WWW, such an understanding will become increasingly important.

In this paper we describe work on the development of evaluation instruments specifically designed for assessing patients' interaction with Web-based information systems containing their own medical data. Specific questions we seek to answer regarding our investigation of patients' access to medical data and advice include the following:

- how do patients' perceptions of use of technology change over time as they begin to interact and use this type of information system?
- how does patients' previous experience in using computers and expectations about using such technology affect their actual use of such systems over time?
- is the content provided by the system of value to patients?
- what problems do patients have in comprehending and applying information provided on-line?
- which aspects of the user interface of such systems can be improved or enhanced?
- how does use of the system affect what patients do regarding daily management of their condition, in terms of reasoning, decisions and actions?
- what are the limitations of Internet-based information systems in providing patient-specific information and how can they be improved from the point of view of usability (i.e. their efficiency, effectiveness and enjoyability [5]) ?

We have worked on refining a number of evaluation instruments, including web-based questionnaires, for obtaining baseline patient profiles and for addressing the issues raised above. This has involved working with the system design team in refining questions for patients regarding clinical aspects of their illness, their use of information technology as well as questions relating to their relationship with health care providers.

EVALUATION METHODOLOGY

We have been involved in evaluation of use of a variety of Web-based information resources, ranging from on-line clinical guidelines to patient information systems. The evaluations we have developed and are currently employing include several methods of on-line data collection (e.g. of patients' usage of the system accessed from home) [6]. We feel that a multi-method approach is often needed, in order to adequately address the objectives of evaluation, such as those described above. From our prior evaluation experiences we have found that individual methods alone can provide valuable information (e.g. logging of user interactions, questionnaires, or interviews etc.), however, in order to gain in-depth understanding underlying use of a system more than one complementary method may be required [6].

Web-based Baseline Questionnaires

In our studies of use of Web-based systems, we typically begin by deploying on-line questionnaires to obtain baseline information about users. In addition, in some of our studies (e.g. investigations of guideline use over the Web) we also have developed questionnaires which are scripted to appear at the time in which certain system functions are accessed (e.g. to ask the user why they are invoking a particular component of a system). In our study of patient users, several on-line questionnaire scales were developed using HTML so they can be accessed by subjects from their homes via the World Wide Web [7]. In our evaluation of PatCIS, the following baseline questionnaire scales (which are presented to users once, on first login to PatCIS) focus on assessing several major aspects of patient care and patient interaction with clinical information systems:

- User Demographics: Items regarding demographics include standard questions about the patient's age, sex, ethnic background and family status. This questionnaire was filled out by subjects at the beginning of the evaluation, to obtain basic demographic information.
- Relationship with Health Care Providers: This questionnaire contains items to assess patients' interaction with health care professionals, including who they interact with and how often. Subsequent to an initial baseline presentation of this questionnaire, users may also be asked whether they perceived their interaction with health care professionals as changing (using a five point scale ranging from "no change" to "considerable change").
- Expectations About System Use: The objective of this questionnaire is to assess users' subjective expectations about their use of information systems (prior to using the system for the first time). For example, this questionnaire was presented to patients at the beginning of our study of PatCIS to assess the extent to which patients believe use of the system will affect how they manage their illness (on a five-point scale,

ranging from "considerable change" to "no change"), as well as how willing they are to use such an information system. A modified version of the questionnaire (deployed using email) was presented to subjects several months later to determine how subjects' expectations compare to their perceived experience.

- Prior Computer Experience: The accurate assessment of computer experience is an important aspect of assessing users' interaction with innovative information systems. Questions regarding the prior use of computers are typically given at the beginning of our evaluations to assess level of computer literacy. Questions include how often the patient uses a computer, when he/she first started using a computer, and what type of computer systems (e.g. IBM-compatible systems running Windows, or Mac) and programs (e.g. word processing, email etc.) are typically used.

Email Questionnaire on Usability

We have developed a variety of usability questionnaires designed to assess both problems in users' interaction with information systems and changes in their perception of their interaction with systems over time. In our study of PatCIS a questionnaire was emailed to patient users approximately nine months after they first started using the system. Email was used to deploy this questionnaire since log files of usage of PatCIS indicated that some users rarely logged on to PatCIS, while others logged on at variables intervals (a paper copy of this questionnaire is being mailed to patients who do not respond to the questionnaire deployed via email).

- Usability Problems: The intent of this questionnaire is to obtain information about problems users may be encountering in interacting with the system (i.e. problems in performing functions that the system is designed for, and other problems of an ergonomic nature). The questions are based on standard usability scales for assessing user interfaces [8] and also contain text-entry boxes where subjects can enter their responses to the following questions: Is the text on the screen easy to read? Are the graphs and tables easy to understand? What features do you like? What features don't you like? What new features would you like? Was medical advice provided helpful? What is your overall impression of the system?

- Changes in Patient Perceptions: In our follow-up questionnaire given to PatCIS users (via email), patients were also asked to indicate (on a 5-point scale) if they felt their relationship with their provider had changed since using the system, and also how willing they were to enter their own data over the WWW (which were also contained in the baseline questionnaire given to users on first log in for comparison).

Log Files of System Use

Log files capturing information about usage of system features are automatically collected from all subjects' interactions with the system under study. The information includes a record of functions accessed by the user, buttons pressed, and time spent in each function. Previous evaluation of web-based clinical information systems (designed for use by physicians) has shown that for purposes of obtaining feedback for system improvement, such analysis of log files can provide a rich source of data, particularly in determining which functions of a system may or may not be getting accessed by end users [9].

Video-based Usability Testing

For a selected subset of subjects, cognitive usability testing methods we have developed will be employed in the next phase of the evaluation. This involves asking subjects to interact with PatCIS to perform typical tasks (e.g. data entry or review, access of information). Subjects are asked to "think aloud" while doing so, and complete video recording are made remotely of computer screens (using NetMeeting software to remotely view the patient's computer screen), as well as audio recording of their verbalizations (using a speaker phone connection). Using computer aided methods for video analysis we have developed, problems encountered by patients while they interact with the system are identified (see [10] for methodological details).

EXAMPLE – EVALUATION OF PATCIS

We have been involved in a pilot evaluation of PatCIS over the past ten months, applying the methods described above. To date 8 patients have enrolled in the study and more subjects are currently being recruited in a second nine month phase of the study. Analysis of the log files of patients' interactions to date indicate that certain functions of the system have been used frequently by the patients. The majority of patient accesses were to review their laboratory data, this was followed in frequency by patients viewing their medical reports. Other features of PatCIS, such as the educational features, advice functions and patient data entry were used more sparingly [9].

In order to further investigate underlying these usage patterns and to assess patients' subjective experience in using PatCIS, nine months after their initial login, subjects received a questionnaire, which was emailed to them. The questionnaire included several 5-point scales for assessing the following:

- Willingness to enter data into PatCIS
- Willingness to review their own health data over the WWW
- Perceptions of their interactions with health care providers

Table 1 provides examples of several of the questions used, along with responses from four users. Subjects were also asked to respond to questionnaire items (on a 5-point scale) related to aspects of human-computer, to assess the following:

- Ability to understand graphs and tables
- Clarity of screen sequences
- Usefulness of help and information buttons
- Learnability of the system
- Usefulness of linkages to other sites
- System reliability and speed

Results to date indicate that all users found that information presented was presented on the screen in a way that was easy to read, graphs and tables were comprehensible and that overall the system was reliable. However, from our preliminary analysis, areas where user responses indicated that the system might use improvement included improving error and system messages, as well as streamlining the sequence of screens.

Table 2 provides the overall impressions of PatCIS from four patients who have used the system for at least nine months. The most positive ratings came from subject 4 who, from examination of the baseline questionnaire, had the most extensive computer background. In addition, analysis of log files indicated that this subject used the various features of the system most extensively. In contrast, user 3 had the least computer experience and reported considerable trouble in attempting to login and access PatCIS (this subject stated he had trouble in using the Secure ID card for gaining access to PatCIS).

Current work includes conducting interviews with users to assess for example, why they find PatCIS useful or not useful (these interviews are being conducted over the phone and users' responses to questions and their "thinking aloud" are being audiotaped and transcribed). We are also contacting patients who enrolled in the study and who have not yet used the system (according to our log files) in order to determine why.

Table 1 – Examples of questionnaire items and responses from four current PatCIS users (deployed nine months after user's first login).

Question	User 1	User 2	User 3	User 4
How often do you use PatCIS?	Once a month or less	Several times a week	Never	Once a month or less
For what purposes do you use PatCIS?	- Review data - Education	- Review data	- Review data - Education - Advice	- Review data - Advice
I find PatCIS useful	Definitely agree	Unsure	Unsure	Definitely agree
I am willing to enter my own data into my record using the WWW	Definitely agree	Unsure	Unsure	Agree
I am willing to review my own health information using the WWW	Definitely agree	Agree	Agree	Definitely Agree
PatCIS has improved my interactions with health professionals	Definitely agree	Agree	Unsure	Definitely agree
PatCIS has improved my understanding of health and illness	Definitely agree	Disagree	Agree	Definitely agree
PatCIS has changed how my health care is managed	Definitely agree	Unsure	Disagree	Definitely agree
Have you had problems in using PatCIS?	"Occasionally,it is very difficult to access, typically in evening"	None		"Sending e-mail from the site."

Table 2 – Overall Impression of PatCIS of four users after a nine month period.

User 1	User 2	User 3	User 4
"PatCIS makes it much easier to actively participate in my wife's medical care by allowing me to closely monitor her lab results. It also allows me to more intelligently interact with her doctors."	"I find it very good for my purposes. By and large I have no idea to improve it. However, I remain confused about getting it from a remote computer."	"I feel as though I am in a very unique position, I know what my problem(s) are, and it's just a matter of time. "	"Overall program is excellent. Would be better if you could access it over Internet Explorer as that is what most people have. Could present a problem on old machines with limited memory."

Using the multi-method approach described above, we are working on identifying problems and issues of those patients who have adopted use of the system. We are now following up with more detailed targeted usability testing of potentially problematic areas based on this pilot data (e.g. sequencing of screens, usefulness of error messages, need for further user training). Finally, we are currently extending the study with enrollment of a new set of patient users over the next year.

DISCUSSION

In this paper we have described our perspective of evaluating Web-based information systems, in particular, use of a patient clinical information system. In designing such evaluations, we adopt a multi-method approach in order to assess a variety of related questions (ranging from assessment of user expectations to analysis of specific interface problems). Methods, involving evaluation from a distance, have a number of distinct advantages, including the ease in creating and administering evaluation instruments via the web. However, previous work in assessing use of systems by physicians and patients [5,10] has indicated that questionnaires alone may need to be supplemented by other techniques, such as interviews with patients (which can be conducted via telephone communication), and use of in-depth usability testing methods, with at least a few subjects. In this way, the limitations of any one method can be offset by the advantages of another. For example, questionnaires may tell us what users think they may be doing while interacting with a system, however automatically logged data of user interactions may provide more detail on what they actually do (which is often not the same [6]).

Deployment of PatCIS, and commencement of evaluation is currently underway, including data collection using the above methods involving a subset of the complete subject population. As the project proceeds and more subjects enroll in the study, the data collection methodology will be iteratively refined.

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