Use of Online Resources While Using a Clinical Information System

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Background: *Clinical information system (CIS) use is likely to evoke information needs, yet information resources use during CIS use has not been studied.*
Methods: *We used CIS log files and a survey to characterize clinicians' use of resources and infobuttons (context-sensitive links from a CIS to specific resources) while using a CIS.*
Results: *We examined 38,763 uses of resources and infobuttons by 2,607 users to identify specific sources and contexts (CIS functions) in which they used them. Laboratory results review was the most frequent context and Micromedex was the most popular resource. Differences in resource use were related to context and user type. The survey confirmed that resources and infobuttons were perceived as useful for patient-specific questions while using a CIS.*
Conclusions: *Understanding context- and user-type-specific information needs can guide the development of infobuttons for use in a CIS.*

INTRODUCTION

One approach to helping clinicians resolve their information needs is to create links from clinical information systems (CISs) to other on-line information resources. Such links may play a variety of roles in diagnostic and therapeutic decision-making. While use of a CIS may raise questions that require resolution for timely, appropriate patient care, information resources can provide evidence and guidelines for resolving those questions. Direct links between the two not only facilitate access, but also can help automate the retrieval process by using relevant clinical data to help focus information retrieval. Attempts to link CISs to information resources date back over a decade.[1,2] Largely developed as proofs-of-concept, there has been little reported experience with their use in clinical settings.

The World Wide Web provides opportunities for creating such direct links, which we and others refer to as infobuttons.[3,4,5] This capability is partly due to the ease with which a link (called a Uniform Resource Locator, or URL) can be provided within one Web-based system to take users to another Web-based system, and partly due to the proliferation of high-quality, Web-accessible resources. In a typical approach, contextual information from the CIS (such as specific patient data being displayed) is passed to a search engine that presents results to the user.

Decisions about where infobuttons should appear in CIS user interfaces, and to which resources they should link, are based in part on the practical limitations of the user interface design and the resources available. However, additional attention must be paid to a) when in the users' interactions with the CIS the information needs arise and b) what questions need to be answered in those contexts.

Many researchers have examined the information needs of practicing clinicians, using methods ranging from surveys to observational studies.[6,7] These studies have reported several recurring findings: information needs frequently arise, the needs are often deferred or unresolved, and computer resources are infrequently used. None of the studies to date have reported on the information needs that arise while clinicians are using clinical information systems. Similarly, many studies have looked at how clinicians use information resources to answer clinical questions, but there have been no studies that report specifically on how these resources are used in the course of clinical practice.

We have therefore undertaken several studies[8] to learn more about the clinician information needs that arise while using our Web-based CIS, called WebCIS.[9] One study involves the direct observation of clinicians in this setting[10] and applying a coding method[11] to characterize these needs.[10,12] In the study described here, we used two additional modalities, log file analysis and a questionnaire, to understand how clinicians resolve their information needs. This paper reports on the methods and results of the latter study and provides the first analysis of the use of infobuttons in clinical practice.

METHODS

Log File Analysis

Like many clinical information systems, WebCIS keeps track of the actions of its users by recording events in a log file. The log file records note the application being used, the network address from which it is being used, the application function selected and, if relevant, the user ID, patient ID and specific patient data selected (Figure 1).

WebCIS users generally access information resources by selecting from a set of links on a Web page called "Health Resources" (Figure 2). This page is accessible from the WebCIS logon page (prior to

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Mar  2 16:16:46|WebCIS|ciminoj|156.111.145.61|3131313 |lab^2003-03-02-05.19.00.819650|view
Mar  2 16:18:55|WebCIS|ciminoj|156.111.145.61|3131313 |healthresource|view
Mar  2 16:18:58|Resources|(nobody)|156.111.145.61|| |url^http://salk.cpmc.columbia.edu/mdxdocs
```

Figure 1: Examples of WebCIS log files. The fields separated by the "|" delimiter represent date and time, application, user ID, IP address, patient ID, patient data reference, and activity. In this example, the user was reviewing a specific laboratory result within WebCIS, clicked on the Health Resources link on the WebCIS menu, and then selected resource, Micromedex. Note that the user is not recorded for this third action, but can be inferred from the prior log file record since the Health Resource page was accessed from within WebCIS.

logging on to WebCIS; referred to as *anonymous usage*) and on the WebCIS main menu (after logging on).* Since July 2002, WebCIS has logged the resources selected from the Health Resources page; however, user IDs are only captured when the page is selected from the WebCIS menu (since no user ID is needed for anonymous usage).

Figure 2: The WebCIS Health Resources Page

WebCIS has included infobuttons as part of its design for over six years. Infobuttons currently exist that link the pharmacy orders display to Micromedex (the *Pharmacy Button*, shown in Figure 3), microbiology culture results to PubMed (the *Culture Button*), and microbiology sensitivity results to Micromedex and PubMed (the *Sensitivity Button*).

We examined six months of WebCIS logs (August 2002 through January 2003) for instances in which information resources or infobuttons were selected. To understand the context in which these functions were used, we noted the user's activity immediately prior to the selection of the resource or infobutton. The users' role (nurse, houseofficer, attending physician, etc.) was obtained from WebCIS's user directory.

User Survey

We sought to understand why users were choosing these functions and what their experiences were with them. We developed a questionnaire that asked users to identify which resources and infobuttons they use, how often and why they use them, and whether they access the Health Resources page anonymously or from within WebCIS.

We used the log file to identify all WebCIS users who used at least one resource or infobutton during January 2003. We e-mailed the questionnaire to a random sample of these users for whom valid addresses were available from the WebCIS directory. Answers on the questionnaire were compared to the respondents' activity, as reflected in the log files.

RESULTS

Log File Analysis

During the study period, users selected health resources 33,949 times, of which 19,913 were selected from WebCIS. In addition, infobuttons were selected 4,814 times. Thus, we could study a total of 24,727 actions by users while they were using WebCIS. There were 2,607 users; user types included 51% housestaff, 34% attending physicians, 5% nurses, and 10% other users types (pharmacists, physicians assistants, administrators, etc.).

The most frequently used resource was the pharmacy knowledge base Micromedex, which accounted for 57% of the actions. Other popular resources included Ovid Medline (7%), NYP's Online Formulary (7%), Harrison's Principles of Internal Medicine (5%), PubMed (5%), Health Journals (5%), Medline*plus* (3%), and ICD9-CM (3%). Anonymous usage showed nearly identical distribution across the resources. Of the 4,814 infobutton uses, 82% were the Pharmacy Button, 11% were the Sensitivity Button, and 7% were the Culture Button.

*https://webcis.cpmc.columbia.edu//wc_clinicalrefs.cgi

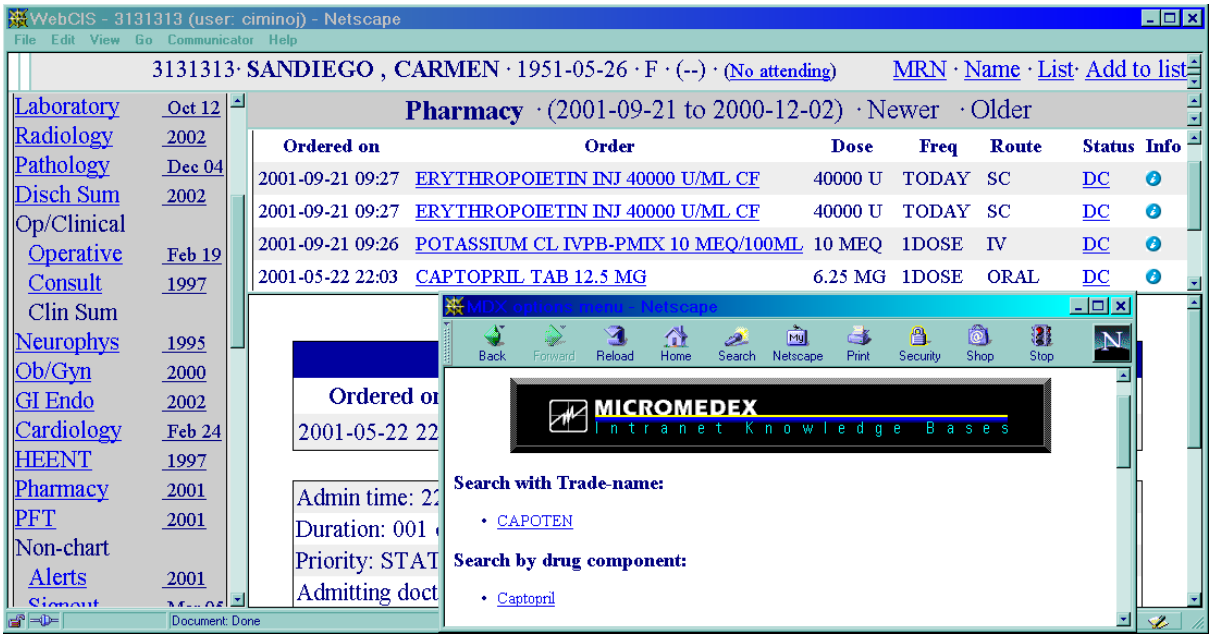

Figure 3: The Pharmacy Infobutton. The screen depicts a WebCIS display of pharmacy orders. The user has selected the infobutton ("i" icon to the right) for the "Captopril Tab 12.5 MG" order. The infobutton window is shown in the lower right, with links to Micromedex that will search for "CAPOTEN" and "Captopril".

Examination of the contexts in which health resources were used showed that 52% of the resources uses occurred while users were reviewing laboratory reports; 9 % occurred while reviewing radiology reports, 7% while reviewing clinical notes, 3% while reviewing pathology reports, 2% while reviewing visit lists, 2% while reviewing pharmacy orders, and 2% while reviewing discharge summaries. Overall, these seven contexts accounted for 77% of all instances of health resource use. The contexts for infobutton use are implied by the button names: 82% for pharmacy order review (the Pharmacy Button) and 18% for laboratory results (Sensitivity and Culture Buttons).

The correlation between context and resource use mirrors the frequency with which the contexts themselves are used. That is, the most common use of WebCIS is laboratory results review, by an order of magnitude over other results reporting. We therefore examined the use of each resource and infobutton within a given context (Table 1). In general, the popularity of Micromedex remained predominant. However, two exceptions were noted. There was a disproportionate use of Medline*plus* while reviewing the patient visit list, when compared to other contexts. Also, the use of the Pharmacy Infobutton exceeded the use of all resources when users were reviewing pharmacy orders.

Because the majority of users were physicians, the frequency of use for each resource or infobutton reflected the use by these two subgroups. When resource and infobutton use was studied with respect to user type, therefore, the housestaff and attending usage were similar to the overall usage reported above, and with each other. Some differences were noted for other groups, however. While housestaff and attendings used Micromedex 62% and 61% of the time they used resources or infobuttons, nurses only used Micromedex 42% of the time, while others used it only 27% of the time. Use of bibliographic databases (PubMed and Ovid Medline) was also much lower for these two groups (1% or less), although use of Medline*plus* was similar to the two attending groups. Nurses and other users had an increase in the use of the Pharmacy Button, using it 40% and 51% of the time (respectively), compared to 5% for housestaff and 4% for attendings.

User Survey

The WebCIS usage logs showed that in the month of January 2003, 1055 individuals used at least one health resource or infobutton. We selected 300 at random and were able to obtain valid e-mail addresses for 250 of these. The percentage of user types reflected the distribution of user types in the six-month population. Forty-five questionnaires (18%) were returned: 23 attendings, 19 housestaff, 2 nursea and one other (a pharmacist).

Three attendings reported that they used health resources less than once a month or not at all, while all other respondents reported usage ranging from several times a month to several times a day. The top

	Laboratory Reports (%)	Radiology Reports (%)	Clinical Notes (%)	Cardiology Reports (%)	Pathology Reports (%)	Visit Lists (%)	Pharmacy Orders (%)	Discharge Summaries (%)
Micromedex	56	57	61	59	49	42	9	62
Ovid Medline	7	7	8	5	8	4	1	6
Formulary	7	6	6	6	7	3	1	7
Harrisons	5	6	4	5	6	3	1	7
PubMed	5	5	5	4	8	2	1	3
Journals	4	4	5	9	8	3	1	3
Medline*plus*	3	3	2	3	3	32	1	2
ICD9-CM	2	4	4	2	3	2	.2	3
Pharmacy Button	-	-	-	-	-	-	84	-
Culture Button	3	-	-	-	-	-	-	-
Sensitivity Button	3	-	-	-	-	-	-	-

Table 1: Use of Health Resources and Infobuttons in Specific CIS Contexts

five most popular resources reflected the popularity seen in the log files: Micromedex (40), PubMed (28), Harrison's (27), Ovid Medline (26), and full text journals (21). Most resources were rated as "very helpful" by almost all respondents; the exception was Harrison's, which was reported to be "very helpful" by 11 respondents, "somewhat helpful" by 14 (including 9 housestaff) and not helpful by one. All respondents indicated that they use the resources to help answer patient-specific questions.

We attempted to correlate self-reported resource use with that which was actually observed in the log file. Our review showed that generally, users had been using the resources they reported as "very helpful" and not using those they reported as "not helpful"; however, the log file showed less activity than was self-reported. Because we could not verify which respondents used which resources in an anonymous way (26 respondents indicated that they used the anonymous method some or all of the time), we cannot determine if this reflects over reporting or anonymous usage. We did, however, note 42 uses by an attending who reported never using them.

Much lower rates of infobutton use were reported, with 28 reporting that they did not use infobuttons (27 stated that they were unaware of the existence of infobuttons). Log file analysis showed, however, that most of these respondents had actually used infobuttons one to six times over the previous six months. Of the remaining respondents, the Pharmacy Button, Culture Button and Sensitivity Button were rated as "very useful" by six, ten and seven respondents, respectively; they were rated "somewhat useful" by six, five and two respondents, respectively. Two attendings found the Culture Button to be "not useful". The log file confirmed that the self-reported infobutton users had used infobuttons between one and 22 times. Except for the pharmacist, all respondents who said they used infobuttons did so for patient-specific questions.

DISCUSSION

The log file analysis and survey reported here provide important complementary information about how clinicians used online information resources to answer patient-specific questions when using a CIS. In general, we see that a resource that provides specific drug information, such as Micromedex, is extremely popular and used in many different CIS contexts. More importantly, we are able to pinpoint specific contexts where specific information resources seem to be preferred. For example, a link from the WebCIS's visit list function to Medline*plus* (a National Library of Medicine site with patient education resources) may be useful.

User-specific differences are likely to play a role in which resources will be most useful in a given context. For example, although the survey did not have enough nurse respondents to generalize about which resources nurses prefer, an assumption that their preferences may differ from those of physicians seems reasonable and is supported by the log file analysis. Analysis that correlates user type, context and resource use may reveal other patterns.

One important finding relates to the quantitative documentation of infobutton use. Our results provide the first evidence that context-sensitive, resource specific links, which are now being developed by

several research groups, are in fact used, useful and in some cases preferable to generic links resources.

Several aspects of our study limit the inferences we can make. First, we studied clinicians who use resources and infobuttons; we have no information about clinicians who *don't* use these functions. Other methods are needed, since a log file can't show what it doesn't see. We must rely on our parallel observational study to help us identify nonusers.[10]

Secondly, the small number of self-selected respondents to our survey (18% surveyed, which is less than 2% of WebCIS users found in the log file) limits the generalizability of our findings. Nevertheless, the findings on the survey do corroborate the findings from the log file, strengthening the validity of each.

Before we can determine what infobuttons to create, we will need to know more about which ones will likely be most useful. The data presented here give us clues, but additional analysis is needed. First, we need to examine further the context, user type and resource. We already know, for example, that nurses use the Pharmacy Button in the context of pharmacy orders. But we have not yet examined what they, or other specific user subgroups, do in other contexts.

Second, we need to study data-specific information resource use. We know, for example, that Micromedex is the resource of choice for users reviewing laboratory results. We now need to determine if this is occurring with *specific* test results. For example, the users may have one particular use for Micromedex when reviewing a dilantin level versus when they are reviewing a decreased hematocrit (e.g., drug dosing information versus hematologic adverse reactions). We can retrieve the test type from the log file (see Figure 1).

Third, although the log files can tell us when, where, what and how the users are accessing information resources and infobuttons, they cannot tell us why. For example, at present we can only guess the reason for Medline*plus*'s popularity while reviewing patient visit lists. Our survey is not specific enough, and relies too heavily on memory recall, to provide the detail we need for determining what infobuttons should do in a specific context based on a specific user type. Although we may ultimately need to make empiric choices, we are seeking to augment what we have learned from our log file analysis with direct observational studies.

Finally, our study was limited to clinicians using WebCIS. However, we believe that the information needs we are discovering will be broadly applicable to clinicians at many institutions. We can test this hypothesis by integrating infobuttons with clinical information systems.

CONCLUSIONS

This study demonstrates that patient-specific information needs do arise when clinicians use a CIS and that information resources and infobuttons are used, and useful, for resolving these needs. Our results will allow those who build infobuttons to propose ones that can be used in specific contexts, for specific user types to answer specific questions. The next question to ask will be whether infobuttons reduce clinicians' unmet information needs.

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