

An Assessment of Using Integrated Information Sources in Clinical Environments

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Abstract. This paper reports on continuing work being done at the Royal Hallamshire Hospital in Sheffield UK, which aims to provide a system where all reference and patient data are available within a single user interface – the Web. Specifically, the work is investigating the application and evaluation of the integration of Web based resources into the clinician's working environment within an evolving Integrated Clinical Workstation.

1. INTRODUCTION

Evidence Based Medicine (EBM) is an approach to patient care which ensures that potential advances in health care must be tested and proven to do more good than harm before they are incorporated into medical practice [McKibbin 96]. Electronic access to information sources from the user's normal work place is the only feasible way to bring EBM into everyday practice [Cochrane 99]. Having patient data and reference data available together in the hospital work place can provide the perfect work environment and an effective tool for all who can access it. The challenge is for IT system developers to provide usable interfaces which afford an environment which enables clinicians and other ward based staff to make effective use of such systems. Work being done at the Royal Hallamshire Hospital, a 700 bed acute hospital in Sheffield UK, aims to provide a system where all the reference and patient data are available within a single user interface - the web. Specifically, the work is investigating the application and evaluation of the integration of Web based resources into the clinician's working environment within an evolving Integrated Clinical Workstation (ICW) [NHS Centre 93].

Clinical staff working in a ward environment need to continually obtain or send information in order to treat patients effectively. For example:

- Information is needed to assist in the clinical decision making process, e.g. information about drug interactions, protocols of care etc;
- Information needs to be transmitted, e.g. when tests are ordered;
- Information needs to be provided and assimilated during the clinical learning process of medical staff [Shortliffe 87].

For several years, hospitals have been trying to acquire or develop in-house computer systems which mainly hold patient data. These systems can assist medical staff with future investigations on patients and help in improving patient treatment delivery.

2. THE INTEGRATED CLINICAL WORKSTATION AND THE WORK ENVIRONMENT AT RHH

2.1 The Results Reporting System (RRS)

At the RHH the Results Reporting System (RRS) is one of the systems containing patient data which has been developed to run in the ward environment. It is widely used and is mainly designed to enable clinical staff to send laboratory test requests and receive laboratory test results. The process of obtaining results starts with the clinician completing a request form on the hospital ward, sending it with a blood sample to the laboratories, and waiting for the result to come back to the ward after the sample has been processed by the laboratory. The computerised RRS has considerably reduced the delays for clinicians accessing test results. The system holds important clinical data that can be consulted at any time, day or night, by clinicians. The RRS is a good example of a patient based information system which clinicians use regularly in the course of their work on hospital wards.

Because they frequently have to deal with patients who are in more than one location, clinical staff move from room to room and floor to floor around the hospital. All the wards in the RHH have a terminal for the RRS system. Having created a hospital wide network which provides clinical information to the various departments, it is important to take the next step in the direction of creating a reference point for non-patient specific information available to doctors on that same network.

2.2 Reference Information Sources

The source of reference information used by clinicians varies from library books to equipment manuals and other treatment references, such as national standards (e.g. American Association of Anesthesia) and other local standards. Providing medical staff with the opportunity to access large amounts of information quickly means that it can be used for reference before treatment delivery or to increase their knowledge in a particular medical field. It would therefore seem to be very convenient for relevant data to be available on ward terminals from within a single human-computer interface [Chen 82].

Nowadays, use of the Internet is increasing substantially and has naturally lead to a growing interest amongst health professionals and, as a result, it is beginning to be widely used to support clinical decision making in the RHH. A large quantity of data can be found online on the Inter/intranet. This data is constantly updated and contains information about patients and their problems, appropriate care procedures, including their benefits and limitations, all medical and institutional resources, and other useful data.

3. THE INTEGRATED CLINICAL WORKSTATION AND THE INTERNET

At the RHH the system presents information on a local intranet, providing links of interest for clinicians. These links are a careful selection of sites and other reference data by specialties and different areas of work. Also, patient data is presented in a Web based interface to the RRS system on the same intranet. This aims to provide the RHH clinicians with all the patient data and reference data necessary for an effective Integrated Clinical Workstation.

A carefully planned intranet seems ideal for this job as it combines both internal and external information sources, providing patient data and adequate reference data together. Using the existing network and terminals we have been able to research the clinicians' needs and provide them with an Integrated Clinical Workstation (ICW) which is shaped to their requirements. The system in use includes access to patient data, as well as access to reference data, including the RHH internal protocols. Access to different journals and medical databases has been increasing substantially, with Medline rated as one of the Clinicians' favourites. Some textbooks are also available and Email is widely used.

3.1 Evaluation Of The Use Of The Integrated Clinical Work Station On Hospital Wards

An exhaustive evaluation of the system described above was carried out with different groups of clinicians. This included; observation of use, completing questionnaires, structured interviews and a feedback form completed and collected on-line. All external links added to the provided system were evaluated by groups of senior members of staff (normally consultants) and the evolution of the system has been based on the results obtained from its evaluation.

Medical literature contains evidence that can be used to improve patient care, but only a small portion of it describes solid advances in diagnosis, prevention, treatment or cause of illness. In a typical week a health professional will treat many patients with different conditions and will need to make many decisions. There are many factors affecting those decisions and each individual possesses his/her own knowledge, experiences and values. If there is evidence of a treatment proved to be better than another, then health professionals need to be aware in order to support the medical decision making process. The system in place contains a general section with access to its specific sub-areas mainly organised by patient data and reference data. These sub-areas are essentially a varied selection of medical specialties, which contain different types of reference data such as hospital protocols, journals, textbooks or general search sites (by specialty). There is also a general interest area, which accesses medical reference databases such as Medline. The use of pre-reviewed sites and medical search engines has been particularly welcomed. Recently, some of the departments have started to have EBM ward rounds based on the provided system. We have started to extend use of the system to include other members of staff such as pharmacists, nurses, technicians and other interested members of the staff who we think would gain from its use.

4. Determining User Requirements

4.1 Method

Using the web to create a standardised interface is a potentially attractive approach to integrating reference material with patient specific clinical details.

Key questions to be asked are:

- Can the Internet and the intranet together provide relevant, timely, and unique information resources in the ward environment?
- What are the most important sources of information?
- Do web browsers provide an appropriate basis for the interface required for integrating these information sources in a clinical setting?

In order to address these questions, the opinions of healthcare professionals working within the RHH were sought. Methods used for this included observation of use, semi-structured interviews, questionnaires and a feedback form available on the system. Of these, the semi-structured interview provided the bulk of the assessment and this was based around an evaluation of the use of the clinical IT systems within the ward environment. The RRS had been previously modified so that access to the internet was provided from the same user interface. This was used in the semi-structured interviews to evaluate the use of internet technology for accessing reference information to support clinical decision making and associated requirements. The interviews were supplemented by use of a questionnaire which was used to identify the most commonly used sources of reference information and to gather data about the users' experience of the internet, computer usage and awareness of information availability.

4.2 Results

Forty doctors from the medical staff at the RHH were approached to take part in the evaluation process. The group's professional experience varied; with almost equal numbers of house officers, senior house officers, registrars and specialist registrars. All of the 40 doctors felt that an increased availability of reference material on the ward would improve their ability to deliver patient care. Ninety percent of those interviewed routinely used the RRS.

Table 1: Value of information sources in the routine treatment of patients. Median of 5 point visual analogue scale.	
Patient medical record file	5
Clinical information from RRS	5
Clinical advice from senior medical staff	5
Medical textbooks	4
Journals	4
Drugs reference sources	5
Protocols for care	5
Clinical studies	4
Internal audit reviews	4

The doctors were asked to assess the importance of commonly used sources of both reference and patient specific information using a 5 point visual analogue scale. An analysis of the results of their assessment is shown in Table 1. These show that an almost equal importance was attached to all the sources identified. The doctors were also asked to identify the most commonly used sources of information used. Table 2 shows a total of 28 different quoted sources of information, ranked in order of citation. The results show that the BNF, Medline, protocols of care and the *Oxford Handbook of Medicine* were by far the most commonly used sources of information. All the doctors interviewed stated that they consulted colleagues when requiring further information whilst evaluating the state of a patient or when planning their care.

4.3 Discussion

The analysis of the results from the semi-structured interviews provided the inputs to the next iterative cycle of the user centred design methodology. These showed that if reference information was to be provided through workstations on the wards, then the following must be provided:

- A selection of one or more textbooks in general use with rapid access to searching facilities based on subject
- A link to an on-line BNF which could be quickly accessed
- Patient care and investigation protocols in a form which could be made patient specific
- Medline access with links so that the full journal articles could also be accessed
- Direct access to the major medical journals, particularly the most recent editions

Part of the semi-structured interview evaluated the ease with which clinical users could access Web-based information. The results from this suggested that a Web browser interface could be successfully used on the wards.

5. A PROTOTYPE CLINICAL WORKSTATION

5.1 Method

The results from identifying the user requirements formed the inputs to the design of a prototype clinical workstation which was implemented and then evaluated on the wards at the RHH. A Web-enabled interface to the RRS was developed so that there was a unified look and feel between the patient specific and reference data. The top-level navigation screen for the workstation supported links to both the RRS and the most important sources of reference data as identified in Table 2. The system using the interfaces shown in Figures 1 and 2 was implemented and deployed on the wards. Where required, links to the Internet were achieved through a firewall to ensure confidentiality of patient data.

Table 2: Information sources identified by users ranked by frequency of citation	
BNF (British National Formulary)	25
Medline (Database of medical article citations)	23
Protocols of care	15
<i>Oxford Handbook of Medicine</i>	9
On-line major journals (e.g. <i>British Medical Journal</i>)	3
BIDS (bibliographic service for the academic community)	2
<i>Lancet</i> (medical journal)	2
Medical textbooks	2
<i>Oxford Handbook for Acute Medicine</i>	2
Specialist web sites	2
<i>Blood</i> (Journal of the American Society of Haematology)	2
Cochrane database of systematic reviews	1
Atlas of diagnostic signs (pictorial)	1
Guidelines for SHO _s /HO _s (hospitals and departments)	1
E-mail	1
BMA (British Medical Association)	1
<i>British Journal of Haematology</i>	1
Guillian's haematology companion book	1
Haematology web sites	1
<i>Harrison's Principles of Internet Medicine</i> (Stone RM)	1
ACP Journal Club (American College of Physicians)	1
Details of staff on call for different specialties	1
Chronological list of patient admissions and clinical visits	1
Copy of the most recent discharge/summary clinic letters on-line	1
Embase (biomedical and pharmacological database)	1
<i>Journal of the Society of Gastroenterology</i>	1
Newsgroups	1
<i>New England Journal of Medicine</i>	1
RRS (Results Reporting System)	1
Clinical discussion group mailing list	1

To simplify navigation of the information space, a two tier menu structure was used. The top level of the hierarchy was related to the medical specialty (Figure 3) and the second level to the key information sources within that specialty (Figure 4). Links to specific information sources (e.g. specific journals) and links to other sources which identified further information sources were included on the screens; examples of this type of source are the databases Medline and Bids. The aim of this structuring was to provide a simplified approach to information finding.



Fig. 1: An example screen from the web enabled RRS system.

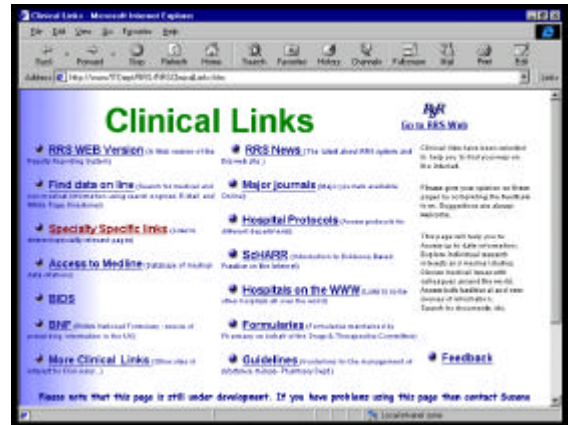


Fig. 2: Top level screen for the prototype workstation giving access to patient and reference information.



Fig. 3: Links to reference information organised by clinical specialty.

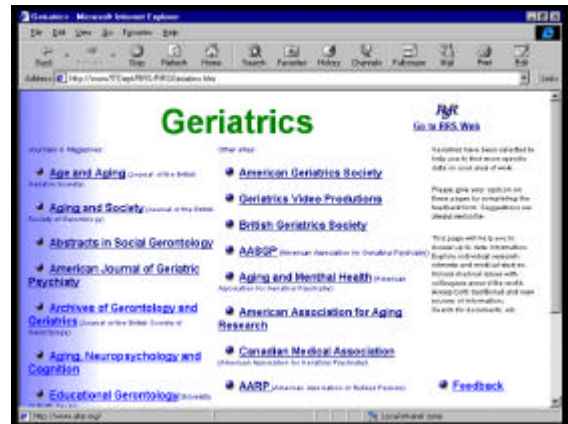


Fig. 4: Specialty reference sources available for Geriatrics - selected from the screen shown in Fig. 3.

The prototype was then evaluated. The system was implemented on a number of wards and a questionnaire was used to elicit user satisfaction with the facilities provided. Doctors were asked to complete the questionnaire within the context of a recent clinical problem where they had needed to access reference material. Sixteen senior medical staff completed the questionnaires. Of the sixteen respondents, 1 was from general surgery, 2 were from general medicine, 4 from anaesthesia, 5 from ophthalmology, 1 from clinical neurophysiology, 1 from the diabetic centre, 1 from infectious diseases and 1 from neurology. Details of the questions asked, along with an analysis of the responses is shown in Tables 3 and 4.

5.2 Discussion

The results from the questionnaire (Table 3) show that the majority of respondents used the Inter/intranet facilities provided through the prototype system as a source of reference data. The importance of reference information in the clinician's working routine can be judged from the fact that 5 out of the 16 spent between 1 and 3 hours per search. The original requirements elicitation showed that reference information searching was a significant problem. The results of the questionnaire confirm this finding, since all respondents cited Medline as one of the facilities used in the prototype and the majority also used one of the medical search engines.

Table 3: Information source usage identified by 16 senior doctors as part of the evaluation of the first prototype workstation	
Sources of data used (includes multiple choices):	
Library	5
Inter/intranet sources	13
Personal reference books	5
Time to find the required data:	
1 hour or less	11
1-3 hours	5
Purposes of looking for reference data (includes multiple choices):	
Confirm diagnosis	1
Identify treatment options	6
Personal interest or research	12
Context of the search for reference data (includes multiple choices):	
Clinical concern	10
Clinical investigation	5
Research	3
Ward round	1
Postgraduate lecture	1
Basis of this search (includes multiple choices):	
Diseases	10
Treatment	6
Specialty	5
Keywords	4
Drugs	2
Complications (drugs etc.)	2
Use of reference information from the prototype system (includes multiple choices):	
Medical search engines	13
General medical sites	12
Specialty specific links	13
Medline	16
Medical Journals	14
Electronic BNF	7
Other medical sites	2

We can conclude from this that any tools which can significantly reduce the time spent searching for reference information must improve working efficiency and, if EBM is to play a significant role in routine patient care, then efficient search tools for finding appropriate reference information must be developed. This view is further confirmed by the majority of respondents citing 'personal interest or research' as one of the purposes for obtaining reference data, while 'clinical concern' and/or 'clinical investigation' were the most commonly cited contexts in which the search was performed.

These responses suggest that the use of reference data is currently part of an ongoing continuous professional development activity rather than one which is integrated into the clinical decision-making process. Improving the search facilities must be a priority in the next prototype. The user requirements identified the BNF drug reference as one of the key sources of reference information. However, only 7 out of the 16 used the on-line version provided in the prototype system. In view of the importance of the BNF in clinical decision making, this finding requires further investigation.

The questionnaire not only aimed at identifying what facilities from the prototype system were used, but also at subjectively evaluating its value and acceptance. The majority of the respondents (11/16) used the prototype system as a source of reference information. One problem with Inter/intranet resources is that it is possible to make a large quantity of information available but that in doing so, finding specific information becomes very difficult. The majority of respondents felt that the quantity of data provided through the prototype was appropriate to their needs (14/16). Perhaps more importantly, the majority of respondents (13/16) felt that the quality of the data was satisfactory. This is particularly important if the information retrieved is to be used for clinical decision making.

The tools provided for searching the Internet for specific information were generally found to be satisfactory (11/16). However, the questionnaire identified more general problems of accessing information through the system, since only 9 out of the 16 were satisfied with the tools provided. Of the remaining 7 respondents, 3 made no reply, identified in the analysis with a 'no' response. The remaining 12 responses were partitioned according to whether they had familiarity with the RRS. Nine routinely used the RRS and of these, 7 expressed satisfaction in the way the reference information was accessed through the prototype system. This suggests that familiarity of use may play an important factor in acceptance.

Table 4: Results of the evaluation of the first prototype clinical workstation by 16 senior doctors	
Evaluation of information on ward-based system ('yes' replies):	
The information provided was useful	11
The quantity of data provided was:	
Too little	2
Enough	14
Too much	0
The quality of data provided was:	
Adequate	13
Not adequate	2
Evaluation of navigation strategy ('yes' replies):	
Was the information on the Internet easy to search and find?	13
Was the information accessed through the system easy to search and find?	9
Was it easy to find specific information once an Inter/intranet site was selected?	14
Once found, was the information in a format that was easy to use?	15
Did the information retrieved fulfil expectations?	13
Was the information found appropriate to the problem identified?	13
Should the clinical links be expanded?	15
Do you prefer searching for data on computers rather than in books/libraries?	15
Compare gathering data on the prototype with traditional methods ('yes' replies):	
The prototype system is better	14
The prototype system is more effective	14
The prototype system is quicker	14

5.4 Conclusions

In this paper we have described the first two cycles of an iterative prototype development of a clinical workstation that aims to integrate patient and reference information to support clinical decision making within the framework of evidence based medicine. The first cycle identified the user requirements whilst the second constructed and evaluated a prototype within the clinical environment. Evaluation of the prototype system showed that the majority of doctors who took part were satisfied with both the quantity and the quality of the information provided through the prototype system. They judged it to be a better, more effective and quicker method of accessing reference data.

One key finding in the user requirements was the value of inter-professional communication in evaluating different therapeutic and investigation regimes. Whilst not part of the current project, it is clear that future developments will have to include facilities for collaborative working among healthcare professionals. A simple way of achieving this would be initially through the use of internal newsgroups, allowing a more detailed set of user requirements for the functionality to be determined.

The need for an effective method of searching for reference material was clearly identified in the user requirements. However, this need was not completely satisfied by the prototype system. If the workstation is to actively support clinical decision making

within an EBM framework, then reference data must be directly accessed from some form of automatically generated hypertext link. The results of the evaluation of the prototype clinical workstation suggest that a keyword search based on diseases and treatments would be a high priority for the next prototype. Single terms could be used to access locally defined protocols of care [Roberts 97]. However, an approach using complex combinations of terms with automatic contextual reasoning would be required for searching large information resources such as Medline if a small number of highly relevant information sources were to be identified.

The BNF drug reference was identified in the user requirement as one of the key sources of reference material for clinical decision making. However, less than half the doctors who took part in the evaluation used it. This surprising result requires further investigation. One possibility is that the information is often required as part of the process of prescribing a drug. Since the drug prescription cards are currently paper records, it could be that the information needs to be available in the same physical location as the drugs records are stored. A partial task analysis could be valuable in investigating this finding further.

When using Internet sources to support clinical decision making it is essential that due regard is taken of the quality of the information provided. There is no automatic requirement for peer review as with the quality medical journals. Within this study, explicit navigation paths were only provided to 'approved' medical sites where the information provided had been peer reviewed. There is, however, nothing to stop users accessing any material on the Internet. A logical extension of integrating EBM into clinical decision making is that the sources used to support a particular decision ought to be referenced as part of the patient record. Clearly, this will not occur unless reference data is integrated with an electronic patient record. If this integration were provided, then it would offer the potential for rapidly producing a large volume of reference material based on clinical experience. The material could be systematically reviewed in a similar manner to that used in the Cochrane Collaboration and then rapidly disseminated. This would make clinical decision making within an EBM framework more viable since the focus for reference information would shift from academic studies to clinical practice.

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