ELSEVIER

Development and evaluation of an integrated pharmaceutical education system

Chien-Tsai Liu [a,*], Yu-Ting Yeh [a], I-Jen Chiang [a], Hsiang-Yin Chen [b], Ting-I Lee [b], Wen-Ta Chiu [b]

[a] *Graduate Institute of Medical Informatics, Taipei Medical University, 250 Wu-Xing Street, Taipei, Taiwan*
[b] *Taipei Medical University Wanfang Hospital, Taipei, Taiwan*

Summary There is increasing evidence that patient safety can be improved by the introduction of an integrated computer-based medical care system in hospital settings. In this paper, we describe an integrated pharmaceutical information system (IPIS) in which a patient's profile including his/her medication records and prescriptions are collected from physician order entry systems and pharmaceutical systems along with the history of patient care in the hospital. Based on an individual patient's profile the IPIS can provide pharmaceutical education information specifically to meet the patient's needs. The IPIS has been developed and installed at Taipei Medical University Wanfang Hospital (TMUWFH) since July 2002. Evaluation of the system showed that it can help patients to effectively acquire drug information. This enables them to have a much better understanding of the pharmacological properties of the medicines they are taking, including adverse drug reactions and side-effects. In our opinion the system has the potential to improve both patient safety and treatment outcomes.
© 2004 Elsevier Ireland Ltd. All rights reserved.

1. Introduction

Most people in Taiwan acquire drug guidelines or pharmaceutical information directly from the medical professionals treating them. However, there is little incentive for healthcare providers to provide patients with comprehensive information. The current reimbursement policy of the Bureau of National Health Insurance [1] is based mainly on the volume of medical services, and not on the quality of care or patient education service. As a result healthcare providers do not devote significant resources to educating or informing patients.

In contrast modern patients wish to be better informed about their disease and the drugs they are taking. Frequent questions asked by patients relate to drug safety, including indications and contra-indications to taking drugs, therapeutic doses, drug reactions, possible allergies and food—drug interactions. In addition they request information about how to store their drugs and what they should do if they forget to take a dose [2]. Providing answers to all these questions is difficult due to a shortage of patient education professionals.

Appropriate pharmaceutical education could help patients have a better understanding of the benefits and risks of medication. This may help improve medication compliance and co-operation with caregivers. Empowering patients with drug knowledge is therefore desirable. If possible this

*Corresponding author. Tel.: +886-2-27203790x101;
fax: +886-2-27203393.
E-mail address: ctliu@tmu.edu.tw (C.-T. Liu).

should be accomplished in a cost-effective manner that does not increase the workload of existing healthcare professionals.

It has become increasingly clear that in hospital settings, patient safety can be improved by the introduction of an integrated computer-based medical care system [3—5]. There are at least two methods of data integration. One is the acquisition of fragmented or isolated data based on individual patient information stored in various hospital departments [6—9]. The other is the collection of patient education materials related to his/her medical treatment or care [2,10].

In this paper, we describe an integrated pharmaceutical information system (IPIS) that we have developed to provide pharmaceutical education materials based on an individual patient profile of his/her prescriptions. The profile can automatically be built up by retrieving relevant information from physician order entry systems and hospital information systems. The system incorporates a multimedia drug database containing pictures of individual medications, drug guidelines, summaries for drug use, and links to relevant materials. The system can only be accessed and used within the hospital.

2. Materials and methods

2.1. System architecture

The integrated pharmaceutical information system (IPIS) consists of an IPIS server and clients (as shown in Fig. 1). The client is an Internet based browser, which interacts with the server to retrieve and display the information for users. The IPIS server consists of the following major components: an integration gateway, a document manager, a drug database, a patient profile, and a system administration and management component.

The integration gateway is used to connect the IPIS server to the hospital information system (HIS). Through the gateway the IPIS server can retrieve a patient's clinical data from the HIS, such as medication orders, prescriptions, and medical records. The patient's clinical data combined with his/her demographic data comprise the patient profile. Currently the IPIS is used to help outpatients acquire their pharmaceutical education materials. Hence, the patient profile is organized into four categories: patient identity, visit time, diagnoses, and prescribed drugs. Each outpatient has his/her own electronic folder containing data from these four categories for each visit. Thus, when the patient logs into the IPIS, he/she can easily access the needed pharmaceutical education materials based on the links between his/her patient profile and the document manager.

The document manager organizes pharmaceutical education materials. Materials are in one of three formats—Microsoft Word (MSWord), Portable Document Format (PDF), or JPG. The appearance of a drug is usually represented by a JPG file, directions for the use of a drug, (published by pharmacy vendors), are usually represented by PDF files, and drug guidelines produced by clinicians
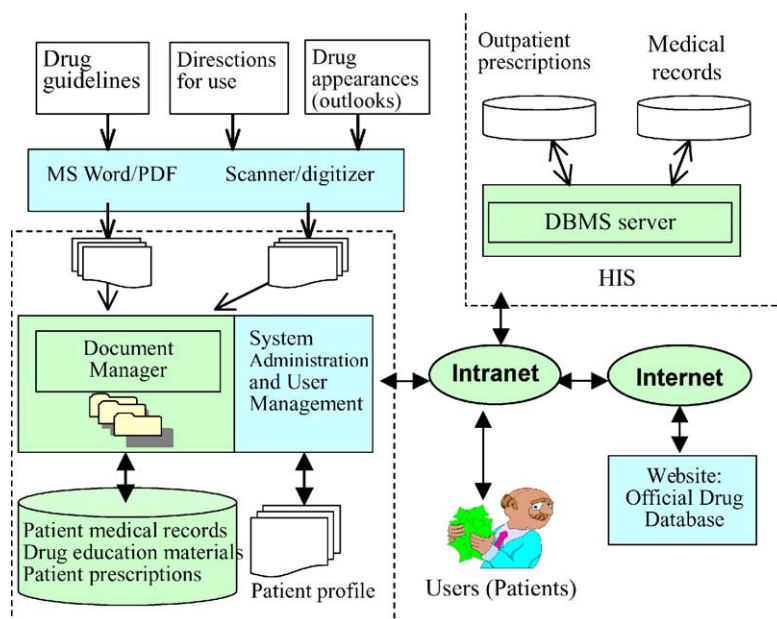

Fig. 1 An integrated pharmaceutical education information system.

Fig. 2 The hierarchical representation of the IPIS pharmaceutical documents.

and pharmacists, are represented by MSWord files. For each drug item, the needed education materials are associated with it. Thus, a hierarchy of pharmaceutical education materials can be formed from general to specific by the patient profile, drug guidelines, and directions of use, as shown in Fig. 2.

Once the patient enters into the system, his/her profile is first displayed as shown in the bottom screen of Fig. 2. The profile includes the patient medication history in which each row represents a prescribed drug and the prescribing doctor's note for the use of the drug. For example, in Fig. 2 the first row shows the prescribed drug is Herbesser 30 mg/tablet, the doctor's notes for the drug are: three times a day, one tablet each time, and take by mouth. If the patient wants to look for more detailed drug information, he/she can click the drug item, the detailed directions for use and the picture of the drug displayed on the front screen. Such organization of patient data and their education documents can enable patients to easily access their medication histories and necessary pharmaceutical education materials. More importantly, the system provides specific information according to the patient's requirements.

The IPIS has been developed and installed at Taipei Medical University Wanfang Hospital (TMUWFH) since July 2002 [11]. It has been developed to compensate for a shortage of patient education professionals and operates within the hospital. It cannot be accessed from outside the hospital and this considerably minimizes security concerns. Any patient who wishes to utilize the system must first apply for a user account and password and also provide their date of birth. As a safeguard against unauthorized use, these three pieces of information must be entered when logging into the system.

2.2. Evaluation method

One of the aims of the IPIS is to improve patients' drug knowledge. To evaluate if it does achieve this, we conducted a questionnaire survey of outpatients at TMUWFH for the period October to December, 2002. The survey questionnaire consisted of three parts: patient consent to participate in the survey including membership of the IPIS, questions prior

Table 1 Demographical data, N = 154

Variable	Counts	Percentage
Gender		
Male	72	46.75
Female	82	53.25
Age (year)		
Under (or equal to) 19	16	10.39
20–39	62	40.26
40–59	36	23.38
Over or equal to 60	40	25.97
Education		
Illiterate	9	5.84
High school (or under)	52	33.76
College or above	93	60.40

to using the IPIS (pre-test) and questions after using the IPIS (post-test). Pre-test questions included patients' demographic data such as gender, age and education, their drug knowledge and their access to drug information related to the drugs they were taking. In addition to drug knowledge and accessibility to drug information, the post-test questions included four questions to evaluate the ''ease of use'' of the IPIS. In order to investigate improve-

ment of patients' drug knowledge and accessibility to drug information, there were four identical questions pre- and post-test questions. However, there was one more question in the post-test questionnaire, which was used to evaluate whether the IPIS can provide more exact and appropriate drug information, and improve patients' knowledge in the use of drugs. The pre and post-test questions are shown in Tables 1–3.

Patients for the study were randomly selected, (1 in every 20), from a list waiting for their prescriptions to be dispensed. Selected patients were excluded if they had previously used the IPIS. During the survey, trained assistants were available on site to check that selected patients were first time users of the system, and to help patients operate the system. Patients who participated in the study was asked to answer the pre-test questions before using the IPIS system. The assistant then arranged for them to use the system, after which they completed the post-test questions. One hundred and fifty-four survey questionnaires were returned.

Each answer was represented using a five-point Likert scale: completely agree (5), agree (4), OK (3), disagree (2), strongly disagree (1). The results were collected, inputted into a computer, and analyzed using SPSS 8.0 software.

Table 2 The results before and after the use of the IPIS, N = 154

Question	Pre/post-test	Strongly agree (%)	Agree (%)	OK (%)	Slightly disagree (%)	Disagree (%)	Wilcoxon signed ranks test (Z)
You understood the use of prescribed drugs by your doctor	Pre	14.94	35.71	33.77	12.99	2.60	−5.849[*]
	Post	31.82	48.70	16.23	2.60	0.65	
You can avoid adverse drug reactions when understanding the drugs you are taking	Pre	30.52	40.26	20.78	7.79	0.65	−6.158[*]
	Post	48.70	48.70	1.95	0.65	0	
You know the contra-indications or side effects of the drug you are taking	Pre	10.39	25.32	37.66	20.78	5.84	−7.391[*]
	Post	36.36	42.86	14.29	4.55	1.95	
You can easily acquire drug information when needed	Pre	6.49	28.57	35.71	20.78	8.44	−9.520[*]
	Post	48.70	47.40	3.90	0	0	
The system can provide you exact and appropriate drug information	Post	55	31	14	0	0	

[*] P < 0.001.

Table 3 The results of evaluation on ease of use of the IPIS, $N = 154$

Question	Agree (%)	OK (%)	Disagree (%)
The drug information presented by the computer system is easily understood	81.17	18.83	0.00
You can easily locate the drug information you want	60.39	38.31	1.30
The computer system is easy to use	74.68	24.68	0.65
As a whole, the computer system is well designed and helpful	72.73	26.62	0.65

3. Results

3.1. Demographical data

The demographical data is shown in Table 1. The number of males and females in the study were roughly equal and their age followed a normal distribution curve. More than 60% of patients had received a college education or a higher educational degree.

3.2. Evaluation of drug information accessibility

Evaluating drug information accessibility before and after use of the IPIS can be done in a variety of ways. One is to test how much a patient knows about the drugs prescribed by his/her doctors. The other is to test how easily the patient can acquire the drug information when he/she needs it. The results are shown in Table 2. After using the IPIS, most patients (about 80%) agreed or strongly agreed that they were able to understand the indications for use and the contra-indications to their prescribed drugs. Similarly, most patients (about 96%) agreed or strongly agreed that after using the IPIS they were able to easily access the drug information they needed. This supports the view that the IPIS can provide specific drug information based on the patient's medication history, and can also provide patients with the specific information they seek.

In order to investigate the dependant sample of patients between before and after use of the IPIS, we adopted Wilcoxon signed ranks test with 99% (i.e. $\alpha = 0.01$) confidence interval to calculate the statistical significant difference between two results. From Table 2 we can conclude that the IPIS can help patients acquire drug information, and improve their drug knowledge.

3.3. Evaluation on ease of use of the IPIS

There are at least four factors to consider when evaluating the ''ease of use'' of the IPIS: under-standability, document navigation, system manipulation and usefulness. The results are shown in Table 3. Most study patients (81.2%) agreed that the drug education materials presented by the system could be easily understood. About 60% of patients were able to easily locate the drug information they wanted, and 74.7% considered the system easy to use. Most patients (72.3%) were of the opinion that the IPIS was useful. Very few patients (less than 1.3%) had negative views about the IPIS. Based on the survey results we believe that most patients will accept and appreciate the IPIS and similar systems.

4. Discussion

With the increasing popularity of the Internet, people are beginning to get accustomed to gaining medical information, finding medical support or receiving medical consultation using the World Wide Web (WWW). This may be beneficial. Matarrese and Helwig demonstrated that when healthcare providers provide adequate health education via the Internet, patients have increased satisfaction with their healthcare providers, and improve their ability to take care of themselves [12]. The IPIS takes the advantages of the popularity of the Internet, and provides pharmaceutical education based on an individual patient's medication profile. It enables patients to access their complete medication records, and can provide them with a range of drug information including the appearance of the drugs, a hierarchical structure of directions for use of the drugs, and drug guidelines. Therefore, the IPIS can be a useful supporting system for healthcare providers in improving patient pharmaceutical education. It should be made clear that although the IPIS uses Internet browser technology, it can only be used within the hospital; it cannot be accessed via the Internet. However. familiarity with the Internet makes it easy for hospital patients to use the IPIS.

There are already many web sites providing health information for the general public, e.g. WebMD (http://www.webmd.com/), and Impact-

Health (http://www.impacthealth.com/). However, there are two problems with these web sites. One is that provided information is usually a generalized overview such as the etiology of a disease, its symptoms, and treatment. However, most patients know these basic facts and want more in-depth information. Obtaining the specific information they want can be difficult. The other problem is the lack of assurance of the credibility and reliability of the information posted on many of web sites.

The IPIS addresses both these issues. The system has been designed to help patients easily obtain the specific information they desire. It automatically acquires the patient's prescriptions from hospital databases and creates the patient's profile. Through the profile, the patient can easily access his/her complete medication records, and the pharmaceutical education materials pertaining to the drug the patient is applying. The education materials provided by the IPIS are crafted to each patients needs, and also approved by the hospital's physicians and pharmacists. This combined with the fact that the system is provided solely by the hospital for its patients will reassure patients of the reliability and credibility of educational information contained within the system.

Reeder observed that in keeping with the development of the consumer movement [13], patients are now regarded as consumers of the medical service industry, and medical professionals as healthcare providers. This mode of customers and providers in the patient—doctor relationship creates a need for sharing responsibility between patients and medical professionals regarding decisions and actions on medical treatment [14]. This is in keeping with a world-wide move towards patient empowerment, but requires an informed patient to participate in the decision-making.

The Internet is a vast source of medical knowledge and enables today's patient to be better informed than ever before. However, the sheer volume of medical knowledge is also a drawback. As mentioned above patients may find it difficult to obtain specific information and in addition information posted on some websites may be inaccurate and out-of date. The IPIS enables patient to easily obtain relevant, reliable, accurate, current information required for shared decision making.

The study indicates that after using IPIS most patients have a much better understanding of the medication they are taking, and potential adverse drug reactions and side-effects. The patients agreed that the IPIS could help them acquire necessary drug information easily. After using IPIS they had more confidence in their doctors and were more willing to follow their instructions. As a result, the IPIS should help improve medication compliance, avoid adverse drug reactions, and improve patient outcomes and safety.

5. Conclusion

Although medications treat and cure diseases, they have the potential to cause harm, for example by causing adverse drug reactions. With the increasing popularity and growth of the Internet there is a trend for patients to acquire information about their own health and their drug medications from the World Wide Web. It may however, be difficult for patients to obtain the specific information they require and it should also be borne in mind that not all information on the World Wide Web is accurate, reliable or up to date.

In this paper, we described an integrated pharmaceutical information system based on an individual profile of his/her prescriptions. The profile can automatically be built up by accessing the related hospital information systems. We also designed a multimedia drug database containing the appearance of drugs, directions for drug use and drug guidelines. Within the hospital, a patient can access his/her drug information by keying in his/her account name, date of birth and password.

Evaluation of the IPIS showed that most patients can use it to easily obtain the drug information they require. Use of the system also resulted in patients having a much better understanding of the medications they were taking, and possible side-effects and adverse drug reactions. As a result, the IPIS should improve drug compliance and improve patient safety. These in turn should improve the doctor—patient relationship and treatment outcomes.

The IPIS currently can only provide patients with medical knowledge related to their medication. Extending this knowledge to provide them with further information about their disease, including health maintenance management, is the next step of our research.

Acknowledgements

References

[1] The Bureau of National Health Insurance (BNHI), Taiwan, Website at: http://www.nhi.gov.tw/.

[2] C.F. Chien, A web-based system for customized drug information support, Master Thesis, Graduate Institute of Medical Informatics, Taipei Medical University, July, 2001.

[3] L.T. Kohn, J.M. Corrigan, M.S. Donaldson (Eds.), To Err Is Human: Building a Safer Health System, Washington, DC, National Academy Press, 2000.

[4] Committee on Quality of Health Care in America, Institute of Medicine, Crossing the Quality Chasm: A New Health System for the 21st Century, Washington, DC, National Academy Press, 2001.

[5] W.W. Stead, R.A. Miller, M.A. Musen, W.R. Hersh, Integration and beyond: linking information from disparate sources and into workflow, J. Am. Med. Inform. Assoc. 7 (2) (2000) 135−145.

[6] W.Ed. Hammond, The use of health informatics to improve health and healthcare, J. Inform. Technol. Healthcare 1 (5) (2003) 321−330.

[7] P.J. Branger, A. van't Hooft, J.S. Duisterhout, J. van der Lei, A standardized message for supporting shared care, J. Am. Med. Inform. Assoc. (1994) 473−477.

[8] P.J. Branger, J.S. Duisterhout, Communication in healthcare, Methods Inform. Med. 34 (1995) 244−252.

[9] C.C. Lin, J.R. Duann, C.T. Liu, H.S. Chen, J.L. Su, J.H. Chen, A unified multimedia database system to support tele-medicine, IEEE Trans. Infor. Technol. Biomed. 2 (3) (1998) 183−192.

[10] L.G. Reeder, The patient-client as a consumer: some observations on the changing professional client relationship, J. Health Social Behav. 13 (1972) 134−143.

[11] C.T. Liu, Y.T. Yeh, C.F. Chien, H.Y. Chen, C.M. Yang, W.T. Chiu, A web-based pharmaceutical information system, Formosan J. Med. 7 (4) (2003) 485−491.

[12] P. Matarrese, A. Helwig, The development and assessment of web-based health information for a corporate Intranet−−a pilot study, in: Proceedings of AMIA Annual Symposium, 2000, pp. 551−555.

[13] L.G. Reeder, The patient-client as a consumer: some observations on the changing professional client relationship, J. Health Social Behav. 13 (1972) 134−143.

[14] J.J. Cimino, S.A. Socratous, P.D. Clayton, Internet as clinical information system: application development using the World Wide Web, J. Am. Med. Inform. Assoc. 2 (1995) 273−284.

Available online at www.sciencedirect.com

SCIENCE @ DIRECT°