

*Professional practice and innovation:***The development and design of an electronic patient record using open source web-based technology***Sharifah Mastura Syed-Mohamad, Siti Hawa Ali and Mohd Nazri Mat-Husin***Abstract**

This paper describes the method used to develop the One Stop Crisis Centre (OSCC) Portal, an open-source web-based electronic patient record system (EPR) for the One Stop Crisis Center, Hospital Universiti Sains Malaysia (HUSM) in Kelantan, Malaysia. Features and functionalities of the system are presented to demonstrate the workflow. Use of the OSCC Portal improved data integration and data communication and contributed to improvements in care management. With implementation of the OSCC portal, improved coordination between disciplines and standardisation of data in HUSM were noticed. It is expected that this will in turn result in improved data confidentiality and data integrity. The collected data will also be useful for quality assessment and research. Other low-resource centers with limited computer hardware and access to open-source software could benefit from this endeavour.

Keywords (MeSH):

Electronic Medical Records; Hospital Medical Records Department; Computer Software; Hospital Information Systems; Hospital Emergency Service; Malaysia; Developing Countries.

Introduction and context

Previous research has indicated that Information Communication Technology (ICT) interventions can improve the efficiency of healthcare services (Handel & Hackman 2008; Ovretveit et al. 2007). One potential area for ICT intervention is the computerisation of patient records (Williams & Boren 2008). Helleso and Lorensen (2005) have suggested that clinical information systems are important for continuity of care in hospitals and necessary for minimising adverse incidents, which can occur due to incomplete and/or disintegrated information. EPR use is no more time-consuming than that of paper-based systems. Pizziferri et al. (2005), for example, demonstrated that the benefits of EPR are not compromised by physicians having to sacrifice time with patients or their other activities during clinical sessions. Properly designed computerised systems have also been shown to improve quality and efficiency of care: for instance, Ludwick and Doucette (2009) found that by eliminating data duplication and redundancies, the use of EPRs avoided inappropriate action being taken by caregivers. User satisfaction is important to the success of any computerisation effort and this has been found

to be highly correlated to system layout (Meade, Buckley & Boland 2009).

Patients' attitudes towards access to their personal information is another important consideration when implementing EPRs. A study by Whiddett et al. (2006) found many patients unwilling to give consent for their personal information to be distributed unless it was specifically for the purpose of clinical care. They also wished to be consulted before any of their private information was released.

The current research setting

The Hospital Universiti Sains Malaysia (HUSM) located at the Health Campus of the Universiti Sains Malaysia, Kubang Kerian, Kelantan. It was established in 1983 as a referral and teaching hospital, and it currently provides a 747-bed service (Kamari 2008). Computerisation of the hospital systems has been in progress since 2000. Most of these systems were developed, implemented and maintained in-house by the Information Systems Unit (ISU). All systems were developed using open-source technologies that include Apache, Linux Slackware, PHP, and MySQL. At this point, more than 10 modules have been commissioned (Abdul-Rahman 2008). The core module is

Lifeline, which manages patient demographic information, patient appointments, and patient accounting. Other modules, including the Laboratory Information System (LIS), Online Prescription System, and E-Folder have also been developed. While the ISU has been attempting to develop more modules aimed at establishing a Total Hospital Information System (THIS), clinics and departments in HUSM have been looking forward to having patient records computerised. One of the centres in HUSM that is proactively pushing for computerisation is the One Stop Crisis Center (OSCC).

The OSCC is located in the Emergency Department (ED) and was established to provide care for abused patients, including victims of spouse abuse, child abuse, rape, and other forms of sexual assault. The OSCC is coordinated by a trained social worker. OSCC teams consist of medical officers (MO) and nurses from ED, specialists from the Department of Obstetrics and Gynecology (O&G), the Department of Pediatrics, the Department of Psychiatry, and medical social workers (MSW) from the Social Work Unit.

Patients that report to the OSCC are seen directly by at least five staff from participating departments. When a patient arrives at the ED, accompanied by a police officer or by family members, she/he first has to register. Then a nurse assesses the situation to determine the criticality level. If the patient is in a stable condition, she/he is interviewed by nurses who then complete the OSCC Report Form. Subsequently, she/he is examined by the MO on duty in the ED, and the MO completes an Emergency Department Form, a Physical Examination Form, and a Specimen or Lab Test Form. Following that, the patient is referred to a specialist in one of the appropriate specialties from O&G or Pediatrics. The case will also be referred to a psychiatrist for mental health and psychological assessment and to a MSW for social behavioural assessment. In the past, all these specialists and MSW would submit their examination and assessment reports using their own departmental forms. Depending on her/his condition, the patient would be either discharged or admitted. The patient will be given the necessary appointment and will also be followed up by a psychiatrist and MSW. The OSCC coordinator schedules periodic meetings to analyse care process and support given to patients. A medical report prepared by one of the clinical discipline is usually submitted to hospital authorities.

Throughout this process, assessment of patient information is crucial. Previously, a patient's OSCC record was kept in the patient's main paper folder that was stored in the Medical Record Library. However, since the caregivers who are involved in the process come from different departments, some patient infor-

mation was kept in those departments. Such dispersion of information could compromise patient care. It was also problematic for the coordinator to gather all information on one patient and prepare the monthly reports that are required by authorities. The OSCC team believed that some of these problems could be reduced by using an electronic patient record system (EPR).

Aim of the current paper

The aim of this paper is to describe the method used to develop an EPR for the OSCC and to demonstrate the system's features and functionalities. A discussion of implementation issues and suggestions for further improvements are also included.

Method

To leverage the good intranet backbone that was already available on campus, a web-based EPR was designed and developed. It was decided that open-source software should be used because our budget was limited and a skilled programmer in open-source software was already present. The interfaces are mainly in the Malay language with some modules in English. A mix of languages was needed to facilitate the existing workflow. Since the system is web-based, users can access the system from any web browser on any type of computer.

Prior to developing the EPR, we conducted situational assessments in the OSCC to study workflows and to identify the actual issues at hand. These assessments were based on a series of workshops that involved representatives from participating departments.

Participants and sample selection

The study sample consisted of 10 participants, two representatives from each of the following five participating departments (Emergency; Obstetrics and Gynecology; Pediatrics; Psychiatry; and the Social Work Unit). Participants were selected by the OSCC coordinator prior to the commencement of the workshop program. Three workshops were scheduled for February, May and October 2005. By agreement, all workshops were held on a Thursday morning, from 9:00am to 1:00pm (four hours). All ten participants attended all three workshops.

Workshops and procedure

The first workshop was conducted on 3 February 2005, the purpose being *to gauge user perceptions of an EPR and to determine their problems and needs*. We also discussed workflows and procedures, and we reviewed existing paper-based forms and filing

systems. Most participants wanted an EPR that followed their existing workflow as well as the entire paper-based forms format. However, our analysis of existing paper-based filing systems revealed that problems could occur in communicating essential information necessary for quality and efficient patient care. There was no uniform format for paper-based forms across departments and none were computerised. This meant that patient information was captured differently by the various departments, with each form varying depending on their particular workflow and requirements for patient management. The process of capturing information from patients was also repeated by different OSCC team members, and information kept separately in different departments. This often resulted in information that was incoherent or redundant.

Based on the findings from the first workshop, a prototype of a web-based system was rapidly developed using the open-source software MySQL and PHP. The OSCC Portal was designed to be used by all departments involved in the OSCC. We implemented facilitative design by following the OSCC workflow. All existing paper forms were transcribed into web-based forms with very minor changes in format; this helped reduce possible anxiety on the part of the already overloaded caregivers. Each user was given a personal login identification and password that would limit access only to their level of work.

The second workshop took place three months later, on 5 May 2005, the purpose being to demonstrate the prototype system to users and to gain additional

information and feedback from department representatives. Based on this feedback, changes were made.

The third workshop was conducted on 6 October 2005, with hands-on activities for the different groups so that users could develop a feel for the system using real data available from paper-based forms. Based on feedback collected during this third workshop, further refinements were made to the system. Subsequently, pre-implementation training was conducted for the different groups in their specific departments.

Results

In August 2006, the system was made accessible through the USM intranet. At that time it was decided that the implementation should be carried out in parallel with the paper-based system because there were insufficient computers for all users. Nurses were paid overtime to key in data outside their roster time. Due to their workload, the MOs and specialists did not have time to key in data themselves. However, the MSWs and the psychiatrists managed to key in data from their records. Even without data from MOs and specialists, the system has proved capable of producing statistics and various reports that have been used in meetings and for cross-checking with manual record keeping.

Descriptions of web-based forms

Figure 1 shows the modules developed for all participating departments. The web-based registration form includes all sections available on the paper-based form. To reduce typing, we provided drop-down lists,

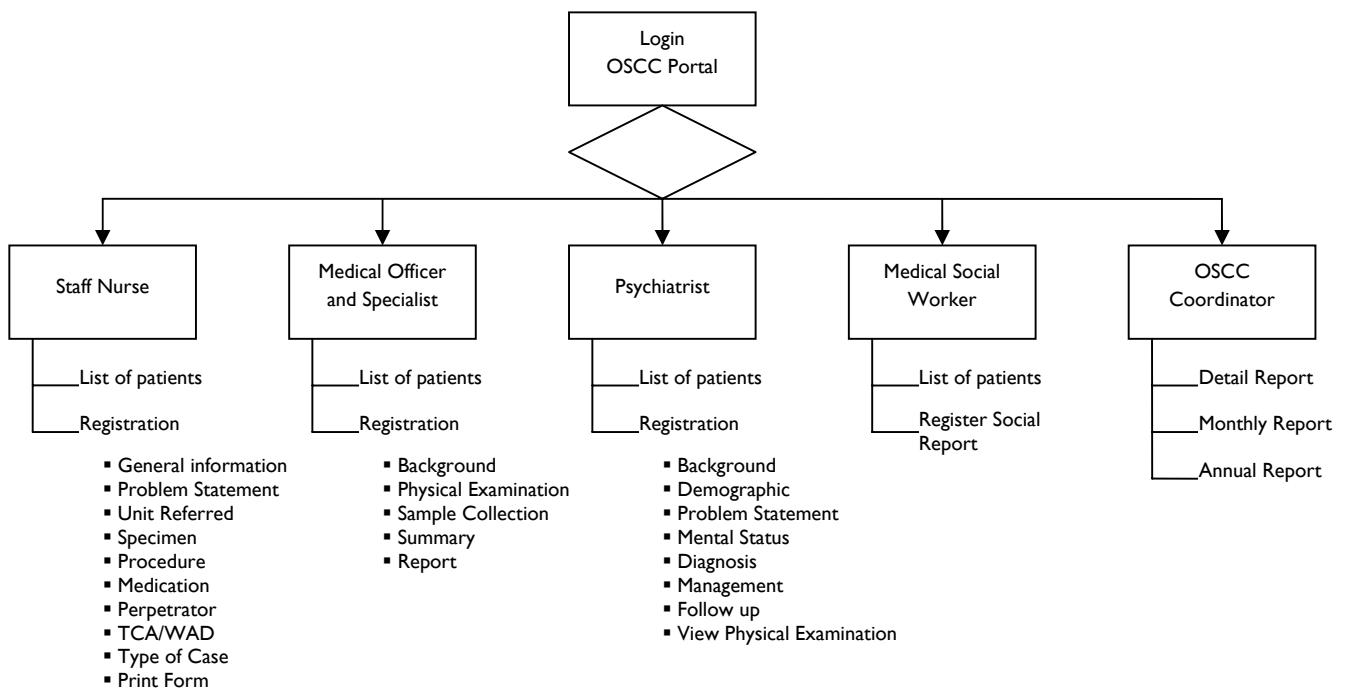


Figure 1: Modules in the OSCC Portal

check boxes, and radio buttons. On a patient's initial registration at the ED, the OSCC nurse can login to the system and register the patient as an OSCC case.

Once the patient's information has been keyed in by the nurse, the MO or specialist can view the patient's list that has been referred to her/him. While interviewing and examining the patient, the MO or specialist could complete the online form as listed in Figure 1. Information that has already been entered by the nurse will be displayed, so the doctor can verify it and enter the other information required in the form. Generally, the data in the forms were assigned positive default values, so doctors did not have to fill or click every field. The doctor just needs to add the necessary data encountered during the interview and the physical examination of the patients.

The psychiatrist assigned to provide care to a patient could also log in to the system and view information that was keyed in by the nurse and doctors. The psychiatrist could also enter additional psychiatric information based on the sections listed in Figure 1. As for the MSW, they could enter their social report data, including family background, siblings, family socioeconomic status, patient's observations and suggestions for patient management.

Data security

All information is kept in a relational database that can be accessed at any time by authorised users at the USM health campus. Data are captured at all stages of care from registration to follow up. The integrated data are used to produce individual patient reports and periodic statistical analyses that can only be accessed by the OSCC Coordinator. Feedback from participants, together with our own observations during the workshops, revealed that the majority of participants had positive perceptions of the EPR; however, one participant, citing legal implications, had reservations regarding the confidentiality of the records.

All modules are password protected so a user can only access modules that have been authorised to them. There are various levels of authorisation corresponding to each group of users. In addition, user login and interventions to any part of the system are recorded by time stamping. The system is capable of producing log sheets of all users and can show who accesses which module at what time. All patient data are linked through a unique patient registration number (RN). Additional actions are taken for data integrity, whereby the database is backed up at weekends and the database server is kept in a server farm with firewall protection.

Discussion

In this section we discuss user access to the system, user satisfaction with the system, the possibilities of future patient access to their data, and possibilities for future use and development through the world-wide community of open-source developers.

User access

All caregivers are able to access the portal through the campus-wide network. Even though each module serves different purposes for different groups of caregivers, the modules are integrated. More specifically, through the OSCC Portal, any caregiver is able to access each patient's information from one source. Prior to the development of this system, most caregivers did not use computers as tools for clinical recording. Taking this into account, it was thought that existing technologies could be used to help staff members and offer them the opportunity to work and interact with a system based on their existing workflow plan, while also catering to the specific needs of the center.

User satisfaction

In the beginning, several staff members faced difficulties in using the system because they were unfamiliar with using computers for clinical recording. Some felt that the use of computers reduces communication with patients because they have to key information into the computer rather than spend time interviewing and examining the patient. This problem was resolved after caregivers had attended training sessions and systematic approaches were demonstrated. Moreover, using the system could be made easier and the process feel more natural if the OSCC provided touch-screen notebook computers to caregivers. As previously demonstrated by Pizziferri et al. (2005), using EPR did not take longer than paper-based systems and the benefits could be achieved without physicians sacrificing time with patients or other activities during clinical sessions.

Meade, Buckley and Boland (2009) found user satisfaction to be an important aspect of any computerisation effort and highly correlated to the system layout. Accordingly, the screen design for the OSCC Portal is based on simple and user-friendly methods, governed by the principle that users should type as little as possible and that they can use a touch-screen notebook computer to fill in information. Currently, analyses of users' satisfaction are evaluated through daily practice and via reported problems. A proper measure of user satisfaction will be done using a validated questionnaire such as the Questionnaire for

User Interaction Satisfaction (QUIS) (Questionnaire for User Interaction Satisfaction n.d).

As noted by Ludwick and Doucette (2009), properly designed computerised systems can improve quality and efficiency of care. With the OSCC paper-based filing system, the patient has to go through a series of interviews with different caregivers who have to repeatedly ask the same questions, as required by the different forms. This procedure can aggravate the condition of a traumatised patient. By using the OSCC Portal, the information captured by an earlier caregiver is made available to a later caregiver, therefore reducing interview times and anxiety to the patient. In addition, by using the OSCC Portal, the information entered by earlier caregiver can be verified and, if necessary, corrections can be made by a superior authorised care giver. The access to structured and well-organised data offers better insight into a patient's condition, which leads to improved care.

As Ludwick and Doucette (2009) have demonstrated, by eliminating data duplication and redundancies, EPRs can help avoid inappropriate action taken by caregiver. The time needed to fill in various forms can be reduced, so the amount of quality care time may increase. In addition, the coordinator's management time may be reduced because the OSCC Portal can be used to generate details or help develop a statistical report in various formats. Furthermore, the collected data can be used for research purposes.

Patient access

At present, patients and their families are not actively involved in the system processes, but their role as a data source remains crucial. Note that patients should be informed that their data are stored in the system and that they should be able to request a copy for their own use. So far, data stored in the system are not yet used for research purposes and patient permission is acquired for their data to be kept in the database. This is consistent with the study by Whiddett et al. (2006) regarding patient attitudes toward sharing their health information where it was found that many patients were not willing to have their personal information distributed other than for purposes of clinical care and that they would like to be consulted before their information is released. This can be resolved by obtaining patient consent at an early stage in the process of patient care.

Further enhancements to the system can provide interfaces to patients, such as forum, blogs, and support groups. Patients who are mainly victims of abuse could anonymously share their experiences in recuperating and overcoming their problems. Frost and Massagli (2009) have shown that patients who choose

to share their health experience within a community may benefit from the process, helping them engage in dialogues that may help self-management.

Community development

Since this is a web-based system that was developed using open-source software, other organisations with similar setups and who are interested in adopting this system have free access to download and run it. Further enhancements to the system can be done collaboratively among various organisations. In a low-resource environment, the implementation of a web-based open-source application should not be a burden in terms of cost. The principal prerequisites are basic computer hardware and appropriate programming expertise. Open-source electronic medical records have proven beneficial in many developing countries (Fraser et al. 2005; Mamlin et al. 2006).

Conclusion

The OSCC Portal may offer great help in data recording and in supporting caregivers throughout the care process. The collected data are suitable not only for patient care, but also for quality assessment, research, and management. To achieve these goals, the best data management should be assured. This need is quite obvious in an OSCC, which is a demanding environment with continuous information overflow and increased pressure for immediate decisions. The proper use of EPR could save time of caregivers in their daily practice. As a result, the OSCC could invest the saved working time in improving care to patients and to other activities.

The OSCC Portal could be expanded to include other modules for public access, such as lessons or forums intended for patients and family members. These could contain articles regarding crisis handling and reports on their psychosocial functioning to aid in continuous care. With the presence of voluminous data in the database, there is a need to develop a data mining engine that can be useful to researchers. This data mining would be immensely useful for research purposes.

It is hoped that other OSCCs will be set up in the nation, and centres intending to do so could benefit from the experience gained using the system described here. It is clear that EPR may open up unexpected paths to new directions in future practice and research. Overall, the EPR system in our OSCC can be considered as a useful tool for improving patient records and care management, as suggested by Nowinski et al. (2007) and Ovretveit et al. (2007). We also hope that the software developed for this program can be used

by the OSCCs in other hospital settings, customised to suit local needs.

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References

- Abdul-Rahman, A. (2008). *The development of information systems in Universiti Sains Malaysia* (online) Available at: [http://health-informatics.kk.usm.my/resources/Hospital Information System in Universiti Sains Malaysia Hospital.pdf](http://health-informatics.kk.usm.my/resources/Hospital%20Information%20System%20in%20Universiti%20Sains%20Malaysia%20Hospital.pdf) (accessed 16 October 2009).
- Fraser, H.S.F, Biondich, P, Moodley, D., Choi, S., Mamlin, B.W. and Szolovits, P. (2005). Implementing electronic medical records system in developing countries. *Informatics in Primary Care* 13: 83-95.
- Frost, J.H. and Massagli, M.P. (2008). Social uses of personal health information within PatientsLikeMe, an online patient community: What can happen when patients have access to one another's data? *Journal of Medical Internet Research* 10(3) (online) Available at: <http://www.jmir.org/2008/3/e15/HTML> (accessed 16 October 2009).
- Handel, D.A. and Hackman, J.L. (2008) Implementing electronic medical records in the emergency department. *The Journal of Emergency Medicine*. Forthcoming Doi:10.1016/j.jemermed.2008.01.020.
- Helleso, R. and Lorensen, M. (2005) Inter-organizational continuity of care and the electronic patient record: a concept development. *International Journal of Nursing Studies* 42: 807-822.
- Kamari, Z. (2008) Hospital Universiti Sains Malaysia (HUSM): 25 Years of excellent service. *Malaysian Journal of Medical Sciences* 16(1):16-24.
- Ludwick, D.A. and Doucette, J. (2009). Adopting electronic medical records in primary care: lessons learned from health information systems implementation experience in seven countries. *International Journal of Medical Informatics* 78: 22-31.
- Mamlin, B.W, Biondich, P.G., Wolfe, B.A., Fraser, H., Jazayeri, D., Allen, C., Miranda, J. and Tierney, W.M. (2006). Cooking up an open source EMR for developing countries: OpenMRS - a recipe for successful implementation. In *American Medical Informatics Association (AMIA) 2006 Symposium Proceedings* AMIA: 529-533.
- Meade, B., Buckley, D. and Boland, M. (2009). What factors affect the use of electronic patient records by Irish GPs? *International Journal of Medical Informatics* 7(8): 551-558.
- Nowinski, C.J., Becker, S.M., Reynolds, K.S., Beumont, J.L., Caprini, C.A., Hahn, E.A., Peres, A. and Arnold, B.J. (2007). The impact of converting to an electronic health record on organizational culture and quality improvement. *International Journal of Medical Informatics* S174-S183.
- Ovretveit, J., Scott, T., Rundall, T.G., Shortell, S.M. and Brommels, M. (2007). Implementation of electronic medical records in hospitals: two case studies. *Health Policy* 84: 181-190.
- Pizziferri, L., Kittler, A.F, Volk, L.A., Honour, M.M., Gupta, S., Wang, S., Wang, T., Lippincott, M., Li, Q. and Bates, D.W. (2005). Primary care physician time utilization before and after implementation of an electronic medical record: a time motion study. *Journal of Biomedical Informatics* 38: 176-188.
- Questionnaire for User Interaction Satisfaction (QUIS) (n.d). (Online) Available at: <http://lap.umd.edu/quis/> (accessed 16 October 2009).
- Whiddett, R., Hunter, I., Engelbrecht, J. and Handy, J. (2006). Patients' attitude towards sharing their health information. *International Journal of Medical Informatics* 75: 530-541.
- Williams, F, Boren, S.A. (2008). The role of electronic medical record in care delivery in developing countries. *International Journal of Information Management* 28: 503-507.

Corresponding author:

Sharifah Mastura Syed-Mohamad PhD, MSc, BSc
 Coordinator of Health Informatics Unit
 The School of Health Sciences, Health Campus
 Universiti Sains Malaysia
 16150 Kubang Kerian
 Kelantan
 MALAYSIA
 Tel: 0609 7673823
 email: sharifah@kck.usm.my

Siti Hawa Ali MA, BA(SocSc), CQSW
 Coordinator of OSCC HUSM
 The School of Health Sciences, Health Campus
 Universiti Sains Malaysia
 16150 Kubang Kerian
 Kelantan
 MALAYSIA

Mohd Nazri Mat-Husin BSc(IT)
 IT Officer
 The School of Health Sciences, Health Campus
 Universiti Sains Malaysia
 16150 Kubang Kerian
 Kelantan
 MALAYSIA