Abstract

OpenMRS (www.openmrs.org) is a highly configurable open source electronic medical record system focused on developing countries. An international collaboration of individuals and institutions is contributing to developing and extending the core application and a network of implementers is configuring specific implementations of OpenMRS for treating and managing care for patients with HIV/AIDS and tuberculosis at sites in Eastern and Southern Africa. Support is critical for successful implementation and an OpenMRS implementers group has been formed driven by developers of OpenMRS with initial implementers from Kenya, Rwanda and South Africa and pilot implementers in Lesotho, Malawi, Tanzania, Uganda, and Zambia. The OpenMRS implementers group not only provides a first line of support to other implementers, but also performs functional testing and documentation. Support for local customizations is mainly provided through the OpenMRS Wiki, forum, and two e-mail mailing lists. The mailing lists are fairly active and responsive to issues arising during implementation, allowing a reasonably high level of support to be maintained for specific in-country implementations, and are supplemented with regular implementer meetings. Three meetings were held during 2006, in Eldoret, Cape Town and Dar-Es-Salaam. The first meeting of 2007 will take place in Mali during the Helina 2007 conference.

INTRODUCTION

OpenMRS (www.openmrs.org) is a highly configurable, scaleable and extensible open source electronic medical record (EMR) system for developing countries focusing mainly on managing information to facilitate treatment and management of patients with HIV infection [1].

The core application was originally developed from the AMPATH medical record system (AMRS) implemented in Eldoret, Kenya [2] [3] and, since then, OpenMRS has been implemented for HIV and TB patient and treatment management in Kenya [2] [3], Rwanda [4] [5] and South Africa. Several other pilot implementations are still being developed or tested, notably in Lesotho, Malawi, South Africa, Tanzania, Uganda and Zambia.

The OpenMRS application and code base was developed and maintained by a core developer group that includes the originators of the application based at the Regenstrief Institute and Indiana University in collaboration with developers from Partners in Health, Harvard University. Collaborators from the South African Medical Research Council (SA-MRC) recently joined the core group working on extensions to the core application for handheld devices and mobile phones as well as implementation issues.

One of the goals of the OpenMRS collaborative is to provide a well-designed, scaleable and accessible open source medical record system that can be used to manage clinical data and facilitate health care delivery in resource-constrained settings. Many other commercial and open source applications already exist [6] but, for several reasons, are not always accessible or useful to many potential users, especially those in limited-income countries [7].

Efficient, powerful data management and reporting systems are essential for monitoring and evaluating patient treatment and management and are typically also required for government conditional grants and donor funds used to provide HIV patient care and purchase drugs for antiretroviral treatment (ART). In limited-income settings, resources that could have been used for care and drugs are used to purchase or develop EMR systems.

Open source software potentially offers a partial solution to this problem by providing robust
configurable software developed by software development professionals at little or no cost to the site. In addition, having the code openly available allows sites with skills in medical informatics the opportunity both to evolve the system, to satisfy specific needs and contribute these functionalities to the larger community for all to use.

However, software development and licensing are only part of the costs involved in developing a clinical information system. Successful open source software, like commercial and custom-developed applications requires both maintenance and support.

As the number of OpenMRS implementations and range of functionality continues to grow it is essential to provide support for the network of implementers and users. To date, the OpenMRS collaborative has provided support through web-based software, tool and documentation, two e-mail list servers and a number of Implementers meetings in developing countries.

METHODS

OpenMRS Implementers Wiki,* Mailing Lists, and Project Website

The OpenMRS Wiki (www.openmrs.org) was developed to provide access to software, tools and documentation for developers and implementers. A forum is provided for discussion within specific topics (see http://forum.openmrs.org).

Three list servers have also been established: one for general announcements, one for developers, and one for implementers.

The OpenMRS open source project is hosted within the Development section of http://openmrs.org/.

Implementers Meetings

Three OpenMRS implementers meetings have been held to date:

1. Eldoret, Kenya during April 2006;
2. Cape Town during July 2006;
3. Dar-Es-Salaam during November 2006

The next OpenMRS Implementers meeting will occur at the HELINA conference in Bamako, Mali.

Implementation Sites

Operational OpenMRS systems have been implemented at three sites:

1. AMPATH Clinic, Eldoret, Kenya
2. Rwinkwavu Hospital, Rwanda
3. Richmond Chest Hospital, South Africa

Pilot applications are currently being implemented by sites in Lesotho, Malawi, Tanzania and Uganda as well as by Cell-Life (www.cell-life.org) in South Africa and as part of the Millennium Village Project (http://www.earth.columbia.edu/mvp). In August of 2004, WHO sponsored a meeting in Nairobi for implementers, developers and users of EMR systems in Africa, out of which it became evident that pooling efforts with a common open source architecture had many advantages. http://www.who.int/kms/initiatives/EMR_Meeting_Report_2004.pdf. In addition to creating an economy of scale for development of sharable applications, a network of practitioners emerged which collaborates on the whole range of health informatics issues beyond code, to use of data to improve patient outcomes and facility management, to strategies to improve data quality to various approaches to improve active follow up of patients. WHO's interest in OpenMRS extends beyond the software's ability to collect data, but rather, how the use of the software increases access to health care of underserved populations, and how these innovations are shared through informal networks.

RESULTS

OpenMRS Implementers Wiki and Mailing Lists

The OpenMRS Implementers Wiki (http://openmrs.org/wiki/Implementers) and mailing list (implements@openmrs.org) are now the primary means of collaboration and communication between implementers and with the developers group. There are presently 87 registered users of the Implementers list.

Issues and questions pertaining specifically to OpenMRS implementers are posted to the implementers mailing list and/or forum and answered by implementers. If unresolved, issues are escalated to the separate developer mailing list.

The Wiki also acts as a central repository for implementation guides and versions of the compiled OpenMRS application. The content is easily edited by implementers who are encouraged ‘make it their own’ by editing content and posting useful tools and procedures in the same way as the development of Wikipedia (www.wikipedia.org).

First East Africa Implementer’s Meeting, 17-21 April 2006, AMPATH, Eldoret, Kenya

The first meeting for implementers of OpenMRS in the East Africa region was held at the AMPATH clinic, Moi University, Eldoret, Kenya during April 2006. The meeting was attended mainly by implementers from Kenya, Tanzania and Uganda as well as two representatives from South Africa.

* Wiki: A collaborative website whose content can be edited by anyone who has access to it.
The meeting included developers and implementers of OpenMRS as well as medical doctors and health service officials charged with managing clinics and hospital facilities. Workshops were held on developing OpenMRS which included encounter forms design software modification, and system implementation. Designing the encounter forms was key because they double as both the paper record and a vehicle for capturing data at the point of care. Hence, developing the forms required both groups of developers and medical professionals.

It also became clear at this meeting that an implementer’s group based in Southern Africa would be useful in order to take over some of the support burden and to supplement the developer’s network based in the USA, Kenya and Rwanda.

First Southern African Implementer’s Meeting, 24-28 July, Monkey Valley, Cape Town, South Africa

The first OpenMRS Implementer’s meeting in Southern Africa was held at the Monkey Valley resort near Cape Town, South Africa in July 2006, funded by grants from the ACACIA and Connectivity Africa programs of the International Development Research Center (IDRC) and the Fogarty International Center, National Institutes of Health (FIC-NIH), USA.

Representatives from the core developer group and 66 implementers and potential implementers from Botswana, Rwanda, South Africa, Switzerland, Tanzania, Uganda, USA, Zambia and Zimbabwe met for five days to further discuss OpenMRS implementation and development issues.

The meeting comprised presentations and practical sessions. Presentations alternated between reports of implementations in partner countries and at specific sites, and core OpenMRS technical discussions. Proposals for new development initiatives were also presented and prioritized. Technical workshops explored implementation issues and introduced new users to OpenMRS.

Seven key recommendations resulted from the Monkey Valley meeting:

1. Develop a dedicated implementers web site;
2. Implement a desktop version of OpenMRS;
3. Develop an open source XForms Design Application;
4. Develop systems specific for tuberculosis and for integrating care TB HIV co-infection;
5. Develop OpenMRS applications for handheld devices and mobile phones;
6. Enable concept sharing;
7. Develop OpenMRS Reporting Systems.

Desktop Version of OpenMRS

A session at the Monkey Valley meeting was devoted to the development of a desktop version of OpenMRS. The current version of OpenMRS is a robust, tiered application that uses an open source database server (MySQL) and necessarily requires some configuration in order to function correctly in a multi-user, client-server environment.

Although OpenMRS and the required open source database and Java runtime software are relatively straightforward to install, it was suggested by some implementers that a desktop version of OpenMRS would be useful in sites that lack the technical expertise to install the client-server version.

This desktop application would be limited to sites with sufficiently few patients (less than 2,000) for whom a single data-entry clerk or health care provider could enter visit data.

It was also suggested that the installation of OpenMRS could be streamlined and a single install program developed.

Open Source XForms Design Application

OpenMRS currently uses InfoPath version 1.1 (Microsoft Corporation) to design and complete web-based encounter forms, used either by data entry clerks or by clinicians at the point of care. Although InfoPath is widely available as a core element of the Microsoft Office 2003 Professional suite, it is not available in sites using earlier versions or the Standard version of Office 2003, or non-Windows operating systems such as Linux.

At the Cape Town meeting, a proposal was presented for an open source forms designer application based on the XForms (http://www.w3.org/MarkUp/Forms/) standard. The purpose of this application would be to provide a standards-based alternative that could be used in sites without access or where it is inconvenient to use Microsoft InfoPath.

OpenMRS Applications for Handheld Computers and Mobile Phones

Handheld computers (PDAs) are particularly useful in developing country settings and have been successfully used for several common medical data collection applications (e.g., see [8]). A small subset of OpenMRS data are already being collected via PDAs by AMPATH’s in-home care program that aims to lengthen the time between clinic visits for patients on antiretroviral drugs.

A main aim of the South African group is to develop medical data and patient management applications for handheld computers using the OpenMRS application. OpenMRS provides functionality for managing concepts and encounters...
such as medical encounters between patients and medical service providers or between persons and interviewers in ancillary support programs. The same basic process is followed in which patients (interviewees) and encounters are managed and the observations associated with the encounter.

The handheld implementation group will investigate two generic designs for the handheld computer application, a thin client design utilizing the handheld device as a platform for a simple XForms filler and a thick client design running a simpler mobile version of the OpenMRS software. Others will implement an OpenMRS port for Epihandy, an open source handheld application for Windows ME (http://www.epihandy.org/).

**Mobile Phone Applications**

Cellular telephones are ubiquitous in Africa and an obvious choice for digital information processing. A plan was developed by the South African group, the IDRC and Cell-Life (http://www.cell-life.org/), to develop mobile phone extensions to OpenMRS.

**Concepts and the Concept Collaboration**

Sharing concepts was also discussed in Monkey Valley. Part of the power of OpenMRS stems from the creation of dictionary concepts that can be reused in multiple forms and other applications. However reuse of concepts from one solution domain to another requires careful planning.

Implementers can standardize concepts in domains where possible (eg, within a program or country) and a concept mapping function used as the practical solution to concept and data integration.

**Reporting**

PIH presented a pilot reporting system. When combined with decision support tools developed by Regenstrief (including Arden Syntax support), this logical query system will be expanded to support developing routine and ad hoc OpenMRS reports

**Second East Africa Implementer’s Meeting, 1 November 2006, Dar es Salaam, Tanzania**

A third meeting in 2006, funded by the World Health Organization, was held in Dar es Salaam with the meeting of East African IeDEA sites (International epidemiological Databases to Evaluate AIDS; http://www.iedea-hiv.org/index.cfm), and implementers from South Africa. Demonstrations were given of local implementations in Tanzania and Uganda, with special focus on developing data entry applications and maintaining the concept dictionary.

**Operational OpenMRS Implementations**

**Ampath Clinic, Eldoret, Kenya**

The implementation in Kenya has been documented elsewhere [2] [3]. To date, AMPATH OpenMRS contains more than 415,000 visit records containing over 7,000,000 discrete observations for more than 40,000 enrolled patients receiving care in a network of 19 HIV/AIDS care clinics.

**Rwinkwavu Hospital, Rwanda**

The major OpenMRS project for the EMR team at Partners In Health (PIH) is in Rwanda [4] [5]. The system was implemented in August 2006 after major extensions to the original code used in Kenya in February 2006. These included allowing the representation of more complex data relationships in forms and was addressed by the use of “concept sets” to group concepts that describe the same entity such as the attributes of an allergic reaction (symptoms, drug implicated, comments, etc). The previous PIH EMR system in Rwanda was used more interactively by medical, pharmacy and lab staff, necessitating better tools for drug order entry, data analysis and reporting.

The OpenMRS system is now fully operational on a Linux server in Rwinkwavu hospital, Rwanda, with additional installations planned in other nearby clinics. Almost 2,000 patients on ARV therapy are being tracked with the system. A rollout to all the national AIDS clinics in Rwanda has been agreed with the health ministry.

**Richmond Chest Hospital, South Africa**

OpenMRS has been implemented at the Richmond Chest hospital in KwaZulu-Natal province as part of a PEPFAR-funded project to provide ART to qualifying TB patients.

The Richmond Chest Hospital OpenMRS system integrates the ART forms of the KwaZulu-Natal provincial department of health and the TB Patient Treatment card of the National TB Control Program. Dedicated data entry clerks enter data into OpenMRS from these paper forms.

A multi-user version of OpenMRS on a local area network is used to capture backlog data from paper forms. For routine use, the hospital enters data on a server in Durban remotely using Microsoft Terminal Services or Internet and SSL (Figure 1).

The entire system was developed by a single implementer in a few weeks. Minor issues relating to setup of the application were effectively addressed by posting questions to the OpenMRS implementer list server and occasionally escalating to the developer’s list server. Similar systems will be implemented at other TB clinics in South Africa.
Figure 1. OpenMRS in South Africa.

**Pilot Implementations of OpenMRS**

Morogoro Regional Hospital, Tumbi Hospital and Ocean Road Cancer Institute, Tanzania

These three sites are in the process of implementing OpenMRS as a pilot project. The National AIDS Control Programme of the Ministry of Health and Social Welfare of Tanzania chose the sites as they are different sizes and would show the relative successes in different settings, and because they are all within three hours drive of Dar es Salaam, allowing easier coordination of the pilot project.

Ocean Road Cancer Institute will pilot OpenMRS to monitor patients with both HIV/AIDS and cancer. The pilot project is being implemented with financial support from the World Health Organisation and the United Nations Development Programme. The University Computing Centre Ltd (UCC) of the University of Dar es Salaam is performing a technical support role.

The three sites have developed common data forms and concepts have been developed to match these forms in the OpenMRS concept dictionary. In addition, the necessary hardware is in the process of being installed and inspected at the three sites.

**Other**

Cell-Life (South Africa), the Millennium Village Project (various sites in Africa) and the Baobab project (Malawi) have active pilot implementations.

**CONCLUSION**

The OpenMRS Implementers network is growing at a rapid pace, in terms of the number of implementations sites and plays an important role in supporting new and existing users using the Wiki, e-mail server and meetings and also helps forge the OpenMRS application itself by providing real world implementation experiences to guide development.

Based on the experiences in South Africa and other countries, OpenMRS is fulfilling its potential as a low cost, rapid development, open source shareware application for developing HIV and TB patient and treatment management systems in resource-poor settings. It is feasible for implementers with limited programming expertise to rapidly develop robust, scaleable EMR applications to collate forms-based data and, through the OpenMRS Implementers group, receive support. Other benefits are the data interchange standards and, with careful planning, simplified data integration.

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