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Implementing OpenMRS for patient monitoring in an HIV/AIDS care and treatment program in rural Mozambique

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Abstract

We have adopted the Open Medical Record System (OpenMRS) framework to implement an electronic patient monitoring system for an HIV care and treatment program in Mozambique. The program provides technical assistance to the Ministry of Health supporting the scale up of integrated HIV care and support services in health facilities in rural resource limited settings. The implementation is in use for adult and pediatric programs, with ongoing roll-out to cover all supported sites. We describe early experiences in adapting the system to the program needs, addressing infrastructure challenges, creating a regional support team, training data entry staff, migrating a legacy database, deployment, and current use. We find that OpenMRS offers excellent prospects for in-country development of health information systems, even in severely resource limited settings. However, it also requires considerable organizational infrastructure investment and technical capacity building to ensure continued local support.

Keywords:

Computerized medical record systems, Developing countries, Mozambique, Rural health, HIV

Introduction

Mozambique, a country in sub-Saharan Africa, has a severe generalized HIV/AIDS epidemic with a national HIV prevalence rate of 16% and roughly 1.5 million persons living with HIV/AIDS, including 100,000 children [1]. The national health care system is subject to severe resource limitations, in large part a consequence of both a struggle for independence from colonial rule, and a subsequent civil war. In recent years, Mozambique has received substantial international development support, with the reconstruction of a national health system as a major focus area.

In response to the severity of the HIV epidemic, the Mozambique Ministry of Health (MOH) began an intensive ART expansion program in 2004. With support from international donor organizations, including the United States' President's Emergency Plan For AIDS Relief (PEPFAR) program, most urban centers and large hospitals now provide a range of HIV related services. Human resource capacity as well as infrastructure to support a care and treatment program for a large number of patients is much improved. However, the vast majority of Mozambicans live in rural areas, and implementing HIV care and treatment services in these areas remains very challenging.

Vanderbilt University Institute for Global Health and its affiliate non-governmental organization (NGO) Friends in Global Health, LLC (FGH) have been working in Zambézia province, Mozambique, since February 2007. The province is the largest in population size, with almost 4 million inhabitants, and second largest geographically (approx 100.000 km^2)[1]. It is a predominately rural area, with the provincial capital city as the only real urban center. The HIV prevalence is slightly higher than the national average, at 19%. The overall aim is to develop a comprehensive model for rural HIV services provision that integrates health and social services. The program currently provides technical assistance to local health authorities in 12 out of 17 districts in the province, with direct support at the principal health facility in each district. Major program elements include adult and pediatric care and treatment, prevention of mother to child transmission, and child-at risk services.

All MOH health facilities that provide HIV services use a standardized paper based patient monitoring system. It includes a facility register and a patient based paper chart, as well as a patient card that is issued on enrollment in a care program. The system suffers from redundancy due to a large number of forms and many form fields that do not correspond well with a compact data set suitable for resource constrained settings [2]. In a recent assessment, the number of data elements in the current system was found to exceed the WHO recommended set of HIV specific data elements by more than

[1] Data from the 2007 census, available online at: http://www.ine.gov.mz/censo2007/rdcenso09/zambezia/q1

a factor of two[2]. Furthermore, there is extensive use of non-coded data fields in the forms, which in general decreases the usability of data for analysis. A review and revision of the complete paper based system is included in the strategic information plan for HIV.

The rapid expansion of HIV services has already resulted in high patient enrollment numbers, and further growth is anticipated. A high patient volume inevitably results in a documenting and reporting burden on already heavily taxed human resources in the health facilities. Avoiding this scenario is a primary motivation for pursuing an electronic patient monitoring system. A growing body of evidence from case studies suggests that the use of electronic medical records in developing countries can contribute to improving the health care system [3-7]. The World Health Organization, in its recent progress report on universal access to HIV treatment, reiterated its position on the importance of strategic information, and the building of systems that improve data quality [8]. In assessing potential impact of the overall technical assistance program from FGH in Mozambique, we identified the implementation of a health information system as a key opportunity in strengthening the integrated HIV care and support program.

This paper describes our implementation of an electronic patient monitoring system for the setting described above. It includes the choice of the Open Medical Record System [9] framework, its adaptation to the local context, the actual implementation and deployment of the application, creating a local support team, information technology challenges, and current use.

Methods

Choosing the OpenMRS framework

To determine a suitable implementation path for an electronic patient monitoring system we evaluated several such systems in use both in Mozambique, and elsewhere. While we found electronic data capture relatively common, applications are typically only used internally by each organization. Within Mozambique an exception was the electronic patient monitoring system created by the *International Centers for AIDS Care and Treatment Programs* (ICAP, affiliated with Columbia University, USA). While limited in functionality or options for feature extensions, this Microsoft Access desktop database application included essential Portuguese language support, and a reasonable correspondence to the Mozambique patient monitoring system. ICAP graciously allowed FGH to use this system as an interim solution in the health facilities supported in the early phases of our program while we developed our own approach.

As the most suitable candidate for a system that will provide long term growth in supporting a range of health services, as well as facilitate eventual needs to support health services research, the Open Medical Record System (OpenMRS) emerged with the broadest set of necessary features. OpenMRS is an electronic medical record (EMR) system framework [9]. The framework is under continuous development to expand capabilities towards an increasingly comprehensive set of EMR functions [10-11]. It is also characterized by a collaborative development model, and the emergence of an "implementers' network" [12] that provides a community oriented mechanism to support new adopters, disseminate lessons learned, and establish best practices. Most deployments to date are in low or middle income countries. While larger scale or multi-facility implementations of OpenMRS typically depend on technical support from external partners, there is a strong trend towards locally sustainable development models. When an implementation incorporates a technology transfer and health information systems capacity building aspects, the implementation can increasingly be supported through local or in-country technical staff.

Electrical power and telecommunication infrastructure

The electrical power grid in Zambézia benefits from the proximity of a reliable source of electric power, a hydro-electric dam. As a result, those health facilities connected to the grid also have relatively reliable electrical power. Power infrastructure limitations still exist in three districts, but the implementation of a permanent solution for each of these sites is already in progress.

Internet connectivity at a health facility is another important objective both for general Internet access, and also to enable a health information exchange with other sites or with a regional data repository. A national telecommunications infrastructure project is underway expanding a terrestrial fiber optic network that will eventually reach all districts in the country. In Zambézia, broadband subscriber services (dedicated circuit or DSL) are gradually becoming available. We consider this to be the most promising infrastructure for long term sustainability and are adopting this service in each district where it is provided. Wireless data services based on GPRS or better are also expanding coverage area, but real world availability and data rates in rural areas remain limited. As an overall strategy we anticipate heterogeneous connectivity options for the supported health facilities.

Scope of the initial implementation

Both power and communication infrastructure concerns dictate a key macro-level architecture decision. We implement an independent EMR server at the primary district health facility, provided the facility is connected to the power grid. Access to the system is provided through a local area network and data entry terminals. This approach, while requiring more IT infrastructure is more robust than a centralized implementation. In addition, a program in multiple districts crosses administrative boundaries. Without MOH approved policies on data sharing in place we opt to keep the individual EMR repositories unconnected. Where grid power is not yet available we implement for a laptop based solution, with corresponding constraints on data availability.

While we aim to implement an electronic patient tracking system we also expect that paper based record systems will re-

[2] Patient Monitoring System Assessment, Technical report prepared by the University of California, San Francisco, for the Mozambique Ministry of Health, 2009.

main in place for the foreseeable future. Electronic systems used for retrospective data entry can provide easier access to information for the health care worker and thereby lead to improvements in providing care. True evaluation of the impact of a health information system on patient outcomes is much more challenging because the use of a health information system is rarely an isolated intervention [13]. Our direct objectives therefore are focused on improving the health care process by making clinical data available and useful.

Results

Customizing the OpenMRS framework

The OpenMRS concept dictionary, the representation of all clinical knowledge in the system, has been created to match the paper based system, and has been fully translated into Portuguese. The web based user interface has also been translated into Portuguese (although internationalization support of the web based interface remains somewhat incomplete), and localization of the patient registration section supports a structure for providing rural patient addresses.

The *de facto* application for form data entry in OpenMRS is through the use of Microsoft InfoPath. An electronic form was created to correspond to each of the paper forms with improvements in data coding and with implementation of data validation logic. OpenMRS report building functionality, available as extension modules, lacks some desired features, e.g. archiving persistent reports. However, creating an interim reporting solution has been relatively straightforward, and we expect to replace it with standard capabilities in due course.

Migration of legacy databases

The adoption of an interim database presented both an opportunity and a challenge. The databases enabled for data mining of the content, which revealed that clinicians were using their own (mostly) consistent coding schemes in some of the plain text fields on the paper forms. This provided us with an easy opportunity to improve the field values in the corresponding OpenMRS forms. The challenge came in mapping the source database model onto the OpenMRS data model to automate the data migration. A utility was created to automate the migration of all patient records from the legacy databases to OpenMRS, but the accidental complexities of the source database made creating this mapping a labor intensive process.

Deployment

Standardized Information Technology setup

For ease of maintenance and support, we select only COTS hardware in a standardized configuration. An uninterruptible power supply (UPS) can provide backup power for two hours, and a power conditioning unit protects against intermittent power quality problems. For the OpenMRS server, we employ a low-voltage and small form-factor hardware platform that has much lower power consumption than conventional server class hardware. The default configuration is a rackmount server enclosure but to accommodate very dusty conditions we can also select a fanless enclosure, at the cost of performance. High reliability data storage is realized through redundant hard drives. The server runs an open source operating system and does not require any proprietary software.

Space constraints are a consideration in all health facilities, and it is in general not possible to allocate a dedicated space to host a server. As a solution, we install a self contained system in a compact (approx 50 cm tall) rack-mount cabinet. The cabinet ensures basic physical security and effectively provides a "server room in a box" (see Figure 1). The cabinet is wall mounted, and raised to conserve floor space. For any site, the cabinet is grounded for electrical safety, and in addition to the equipment mentioned above also contains a basic unmanaged switch to create the local area network (LAN) for the data entry terminals. For sites with internet access the cabinet further contains the broadband modem, which is paired with a Cisco router.

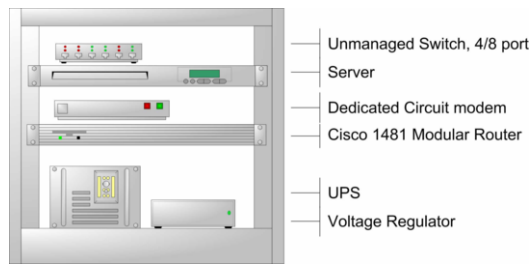

Figure 1 - "Server room in a box." A compact rack-mount system holds the OpenMRS server, and peripheral equipment for networking and power conditioning.

For data entry, standard configuration laptops are used but they rely on their own batteries for backup power as opposed to the UPS. In all current setups the LAN is a wired configuration, although wireless connectivity has also been tested when the LAN switch is extended with a wireless access point.

Management

In a distributed setting with facility based servers, the ability to reduce technical support overhead of the operational systems is critical. A web based server administration tool is configured with simple modules so that facility staff can handle database backups and basic server management. For networked facilities, it is also possible to remotely monitor the installed systems with a network resource monitoring application[3]. The application registers network resources that support the Simple Network Monitoring Protocol (SNMP). The status of the server, managed networking hardware, the UPS equipment, and the status of the OpenMRS database can be monitored centrally, and continuous link monitoring indicates when connectivity is lost.

Using the system

Data management

The quality of the information in an EMR has been shown to have real impact on the use of the data, and training of the data

[3] We employ the Zenoss product: www.zenoss.org

management staff has been identified as a critical factor in maintaining good data quality [14]. In the FGH program each health facility is supported by two data entry staff. A regional supervisor oversees data entry in three districts, and a centrally located coordinator oversees the complete team and process. We consider the data entry staff as an integral part of a comprehensive approach to data quality. Prospective candidates for data entry staff positions are screened on problem solving ability. If accepted, a two week training program follows. The first week is primarily classroom based, with an introduction to the entire patient monitoring and tracking process. This includes training in location of missing information and resolution of anomalies in the paper chart by directly contacting the health care providers. This is followed by classroom training on using the actual data entry tools. The second week occurs in the field, where they are immersed in the actual environment of the health care facility, with close supervision from trainers, more experienced data entry staff, and supervisors. During the first weeks of actual field work new staff are monitored by supervisors until considered experienced.

A data quality assurance process is implemented using a data quality assessment instrument. For a group of measurements critical to the current reporting requirements, we compare the electronic and paper based data. Errors are categorized according to missing data elements on the paper record or in the electronic record, or actual mismatch in values between the paper and electronic record. Early sample runs of the tool have already allowed us to use the results to improve training for those fields where common errors occurred. We do not employ a double data entry scheme.

Reporting

The FGH program generates reports in three formats, reports for the MOH each month, reports for PEPFAR, and reports for the US based HIVQUAL quality improvement program. For the MOH, any discrepancies between the reports generated from the EMR, and a corresponding report using only the paper based system must be adequately explained. In a recent audit of the patient monitoring system for multiple sites a formal process was followed to resolve discrepancies. Here the power of the EMR presented a clear advantage because most discrepancies were found to be the result of a lack of analysis on the paper record data to correctly identify patients in lost-to-follow-up status, and the report generated from the electronic system proved more accurate.

Use by the program clinical and technical teams

The main use of the data outside of reporting is by the district and regional community health teams which use the data to find patients who do not appear at the health facility in time to obtain their medication. The “active follow-up” teams use custom reports to identify patients that should be tracked down and reminded or encouraged to return to the clinic for treatment. In some locations, clinicians with an active (volunteer) interest in health information technology are using the system for ad-hoc analysis of patients in their care. There is no institutionalized use of the data for direct patient care at the moment.

Current Status

The first OpenMRS installation for FGH was put in use in November 2008, only weeks after the first dedicated health information systems staff member joined FGH in Mozambique. The initial OpenMRS sites were in districts where the legacy database was never used, and at the time of writing some legacy sites remain to be migrated. Per July 2009, the number of patients ever in care in all districts is 26893, ranging from 567 to 4469 patients for individual facilities.

Conclusions and Discussion

The current work represents the (near) completion of the first phase in adopting OpenMRS for the FGH program in Zambézia. Throughout the process we have been able to take a long term perspective, focusing on building capacity in Zambézia province to ensure our continued ability to evolve the application.

To determine the actual impact of timely and accurate data, the data will ideally be used in routine clinical practice which can be used to evaluate real improvements in health care delivery and, ultimately, improved patient outcomes as a result of improved care. Several installations of OpenMRS described in the literature have illustrated how this can be done, and we intend to follow these examples to demonstrate utility. Initially we will be providing patient specific alerts or reports at the time of a patient visit.

There is also an increasing focus on building sustainable health information systems. As metrics for determining sustainability emerge, we will be evaluating our approach by comparing against these metrics [15]. The emerging capacity within FGH will be applied to engage the regional health officials in defining a strategy to improve the access to and use of health information for decision and policy making within Zambézia, and to use this strategy to guide ongoing development efforts.

In the development of regional capacity in Zambézia new opportunities are also emerging. In recent years, health information systems have been of great interest at national planning levels of the Mozambique MOH. The department of health information systems within the MOH is evolving a national policy for building a health information infrastructure and an e-health strategy. Key aspect of the strategy is to balance the adoption of health information technology with the capacity to use it within all levels of a health care system [16]. There is also a deeper understanding on the reasons why information systems may fail in a given context [17]. In Mozambique, there are no large scale implementations of commercial enterprise solutions for facility-based health information systems. However, for some applications for aggregate level information, in-country developed systems have been deployed.

Recent changes to national policy include a restructuring of the interaction with partner organizations. An organization that wants to develop a data collection or analysis instrument (paper or electronic), is required to describe and document the instrument, as well as disclose findings resulting from its use

to the MOH. This process will improve transparency on informatics related activities in the country, while at the same time encouraging innovation in the context of specific regional constraints. The other key element is the development of national expertise on health system strengthening through linkages between the MOH and academia in Mozambique that are also considering OpenMRS and other open source technologies for health information systems.

As an implementing partner for the PEPFAR program in Mozambique tasked with the provision of technical assistance to the MOH both at the national level and at the local level, we are faced with an opportunity to investigate solutions that benefit the HIV services in particular, and the health system as a whole. The current work represents in-country capacity development, harmonization with emerging e-health policies at a national level, and creation of a system that fits the needs of Zambézia province. In turn, a successful demonstration of health information technology in Zambézia may benefit others seeking to follow a similar approach.

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