Experience Implementing Electronic Health Records in Three East African Countries

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Abstract

Introduction: Efficient use of health care resources in low-income countries by providers and local and national managers requires timely access to patient data. Objective: To implement electronic health records (EHRs) in HIV clinics in Kenya, Tanzania, and Uganda. Results: We initially developed and implemented an EHR in Kenya through a mature academic partnership. The EHR was then implemented in six HIV clinics in Tanzania and Uganda in collaboration with their National AIDS Control Programmes. All implementations were successful, but the system's use and sustainability varied depending on who controlled clinic funding. Conclusions: Successful EHR use and sustainability were enhanced by local control of funds, academic partnerships (mainly by leveraging research funds), and in-country technology support.

Keywords:

Computerized medical record systems, Developing countries, Africa South of the Sahara*

Introduction

Health care is an information business – most of what clinicians do is collect data (e.g. by history and physical exam), record data (in the patient chart), process data (choose treatments), and transmit information (via orders and letters). Information is necessary to provide and manage health care at all levels, from individual patients to health care systems to national Ministries of Health (MOH). The efficiency, effectiveness, accountability, and quality of health care at each of these levels depends on having accurate, timely data. In developed countries, electronic health records (EHRs) are becoming a necessary component of health care. For example, the U.K. and Sweden have national EHRs, and the U.S. has committed to wide use of EHRs by 2014 [1].

Developing countries trying to squeeze the most care from their limited health care resources have similar needs for timely health information. Yet being on the far side of the "digital divide" results in low-income countries having insufficient information to effectively manage their health systems. Since 2004, the U.S. Agency for International Development (USAID) committed more than $60 billion for HIV/AIDS care in developing countries. With more and growing HIV treatment programs, EHRs are becoming a necessity for managing and monitoring patients and health care systems while providing funders with data on the care provided and outcomes achieved. In this article, we describe our experience implementing OpenMRS [2], an open-source EHR, in three East African countries: Kenya, Tanzania, and Uganda. We evaluated each site and describe factors that led to successful implementation and sustainability of OpenMRS.

Implementing an Electronic Health Record System in Western Kenya

In 2001, Indiana and Moi Universities teamed with Moi

Teaching and Referral Hospital (MTRH) to form AMPATH (the Academic Model Providing Access to Healthcare) and opened HIV clinics at both MTRH and nearby rural health centres. Anticipating their data needs, AMPATH and developers from the Regenstrief Institute developed an EHR to capture data from clinical encounters and provide AMPATH with data for both clinical care, monitoring and evaluation, and quality improvement. Initially, the AMPATH Medical Record System (AMRS) was a series of MS-Access® spreadsheets linked by patient identifiers and visit dates [3]. Following USAID funding in 2004, AMPATH grew to more than 15,000 patients who made 50,000 visits by mid-2005, overwhelming MS-Access®. Using the Regenstrief model [4], in 2006 we reconfigured the AMRS as a Java web application atop a series of MySQL databases. Through 2009, the AMRS supports HIV/AIDS, primary care, and specialty clinics 23 sites (rural health centres, district hospitals and Moi Teaching and Referral Hospital) contains 60 million observations from 2 million visits to 23 AMPATH rural and urban clinics by almost 150,000 enrolled patients, more than 110,000 of whom have HIV/AIDS. Figure 1 below shows the cumulative patients and visits in the AMRS from 2001 through 2009.

For each adult and pediatric visit, AMPATH's nurses and clinical officers complete paper encounter forms that were developed by AMPATH clinicians and managers to capture data for day-to-day patient care. Because clinicians' have the greatest need for detailed patient information, a system that
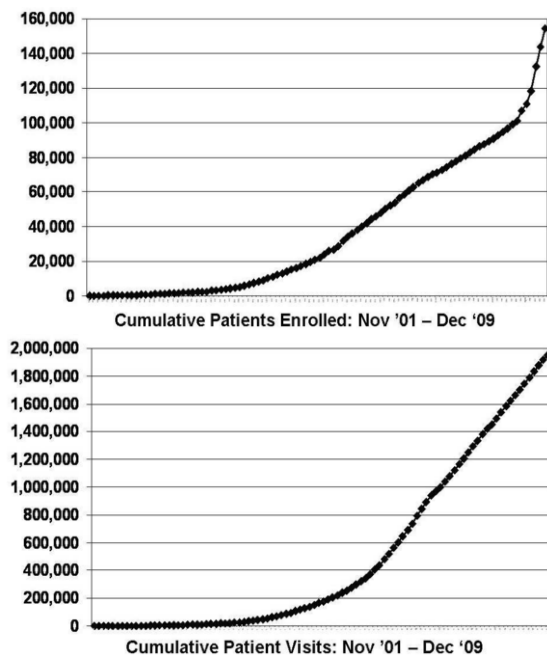
Table 1- AMPATH's electronic data collection

Clinics	Support Programs
HIV/AIDS – adults	Mother-baby register
HIV/AIDS – children	Social worker assessments
Primary care – adults	Outreach – patient follow-up
Primary care – children	Drug adherence assessments
Antenatal and postnatal	Nutrition assessments
Cardiovascular disease	Food supplement distribution
Pulmonary disease/tuberculosis	Microfinance program
Diabetes	Clinic pharmacies
Oncology	Clinical laboratories

captures sufficient data to serve clinicians' needs also serves the needs of local health system managers, national health programs, and international funding agencies [5]. Moreover, the same processes that capture clinical care can also capture data for non-clinical support programs. AMPATH provides care for HIV/AIDS and other conditions and collects clinical and non-clinical data as shown in Table 1. The AMRS currently employs 48 Kenyan data entry technicians, 10 data managers, 3 programmers, 3 information technicians, 2 biostatisticians, and 1 program manager.

Although all AMPATH care is delivered in Kenyan MOH facilities and mainly by MOH personnel, funding from USAID and other program-specific sources flows through Indiana University, Moi University, and MTRH. Investments by local AMPATH leaders in the AMRS to capture, manage, and analyze clinical data are recouped via enhanced provider and system productivity. Besides antiretroviral drugs (which are provided by USAID), care delivered by AMPATH cost only $175/patient/year in 2007 [6] and is now less than $100/patient/year in 2009.

In addition to the local monitoring and evaluation and routine and *ad hoc* reports required by funding agencies and the MOH, the AMRS also provides data to a robust multidisciplinary research program: researchers from Moi University and more than a dozen North American universities currently have more than 30 ongoing studies in East Africa, supported by >$40 million in grants from various U.S. federal granting agencies and foundations. Since 2006, Kenyan and North American AMPATH investigators have published >70 articles in peer-reviewed journals describing AMPATH care.

In early 2005, developers from Regenstrief and Partners in Health transformed the AMRS into OpenMRS [2,7] – a free, open-source EHR [8] and a community of developers who are creating a generalizable EHR to support health care delivery systems in developing countries [9]. To date, OpenMRS has been implemented in 25 countries, mostly low income, and supports HIV and a variety of other care programs.

The Rockefeller Foundation and the World Health Organization (WHO) observed that by having timely electronic data, AMPATH was able to deliver high-quality, evidence-based care. They then funded OpenMRS developers to test its usefulness to HIV/AIDS programs in other developing countries, specifically Tanzania and Uganda.

Figure 1- Cumulative patients enrolled and visit records

Implementing OpenMRS in Tanzania

In late 2005, leaders of the National AIDS Control Programme (NACP) of Tanzania expressed interest in participating in this OpenMRS demonstration. At the time, the NACP had implemented a paper-based HIV/AIDS registry that collected a core set of data on enrollment and at each visit, including vital signs, lab data, and treatments. The NACP had an electronic database for this registry, but few of these forms had been entered into the database or analyzed. Subsequently, there was scant information to support program management and strategic planning.

NACP leaders selected three sites OpenMRS for that varied in size, location, and experience with electronic data: Morogoro Regional Hospital (a large referral hospital, located 3 hours west of Dar es Salaam, that had prior experience with an electronic national hospital data system), Tumbi Special Hospital (a district hospital located on the outskirts of Dar es Salaam), and Ocean Road Cancer Institute (the site of care for AIDS-related malignancies) located near the NACP offices in Dar es Salaam). Neither of the latter two sites had any experience with electronic records of any kind.

In April of 2006, clinicians and data managers from each site and the Director of Epidemiology for the NACP met with OpenMRS developers in the AMPATH Centre in Eldoret, Kenya to learn about OpenMRS and develop adult and pediatric HIV/AIDS encounter forms. These forms included data required by the NACP plus additional information the clinicians thought would be useful for ongoing care. For guidance they used the AMRS encounter forms and a minimum dataset for HIV/AIDS care developed in 2004 at a WHO-sponsored meeting in Nairobi [5]. Also included in this 2006 meeting in Eldoret were computing and communication technology (IT) consultants from the University of Dar es Salaam who were contracted to program encounter forms and reports into OpenMRS and install and support it at each site. The United Nations Development Program provided computers and network hardware for all Tanzanian OpenMRS sites. The NACP supported data entry and management, aided by an epidemiologic research grant to Indiana University.

Because of high printing costs the desire for consistency with past data collection efforts, NACP leaders decided to forego the encounter forms developed by the Tanzanian clinicians and instead use their existing HIV registry forms. The computing consultants created a Patient Summary Report containing identifying data, diagnoses (HIV-related and others), drug allergies, HIV-relevant lab test results, and HIV/AIDS treatment data. This report was printed for clinicians before each patient visit to each demonstration clinic.

OpenMRS was first implemented at Morogoro in January of 2008 (Table 2). By the demonstration project's end in December of 2008, OpenMRS had been successfully deployed at all 3 sites, more than 11,000 patients had been enrolled, and OpenMRS had captured data from more than 58,000 visits. Patient Summary Reports were printed for most visits.

Reception of OpenMRS was generally positive. The university computing consultant independently maintained the system and generated reports for the NACP. Because OpenMRS was used to provide a database for the NACP's used to provide a database for the NACP's HIV/AIDS registry, implementing OpenMRS resulted in no fundamental changes in local clinic workflow and data management. However, by June of 2009 Morogoro had ceased to use OpenMRS.

Table 2- Implementation of OpenMRS in Tanzania with patients enrolled and visits stored through 31 December 2008

Tanzanian Site	Date EHR Initiated	Patients Enrolled	Visit Records
Morogoro	January 2008	5,204	23,436
Ocean Road	March 2008	621	3,707
Tumbi	July 2008	5,220	31,088
All Sites		**11,045**	**58,231**

Morogoro ceased its use of OpenMRS because its computer system failed and the consultant's contract ended. Subsequently, support was reestablished, and Morogoro is back using OpenMRS as a vehicle for capturing HIV registry data. Clinicians at Tumbi and Ocean Road Cancer Institute have continued to use their local versions of OpenMRS for all patients, sending electronic data to the NACP rather than paper HIV-register forms. Both Tumbi and the Ocean Road Cancer Institute continue to use the Patient Summaries.

Implementing OpenMRS in Uganda

The NACP and MOH in Uganda also participated in the demonstration project, choosing three sites differing in size, location, and university affiliation: Mbarara Regional Hospital (5 hours SW of Kampala, affiliated with the Mbarara University of Science and Technology), Masaka Regional Hospital (2.5 hours SW of Kampala), and Mbale Regional Hospital (4 hours NE of Kampala). HIV clinicians from these hospitals attended the April 2006 meeting in Kenya. Mbarara already had an MS-Access database (for data copied from patients' clinic notes) to support collaborative research with the University of California, San Francisco (UCSF). We contracted with a computing consultant at Makerere University in Kampala to install and maintain OpenMRS at all three Ugandan sites.

Each Ugandan site developed local encounter forms that captured data required by the Ugandan NACP and data that local clinicians needed to manage HIV-infected patients. The computing consultant installed OpenMRS at each site and programmed it to capture data from encounter forms and produce Patient Summary Reports and required reports to the NACP and MOH. Neither the Ugandan NACP nor the MOH required patient- or visit-level data from its HIV/AIDS clinics and as a result provided no support for OpenMRS. Research grants to UCSF and Indiana University paid for OpenMRS computer hardware, programming, and data entry.

Mbarara was first to initiate OpenMRS in January of 2007 (Table 3), employing seven Ugandan data entry technicians, a data manager, and one technologist, all with prior experience with their electronic chart abstracting database.

Ugandan Site	Date EHR Initiated	Patients Enrolled	Visit Records
Mbarara	January 2007	9,854	12,869
Mbale	November 2007	1,601	,493
Masaka	January 2008	9,714	1,811
All Sites		**21,169**	**147,173**

Mbale had fewer HIV/AIDS patients and required one data entry clerk and one data manager. Masaka had three data entry technicians and one data manager. By the end of 2008, 21,169 Ugandan patients had been enrolled in OpenMRS at the Ugandan demonstration sites, with more than 145,000 visit records stored. Almost half of the patients and three-quarters of the visits were at Mbarara.

Care processes differed at the three Ugandan sites, and hence OpenMRS' effects on workflow varied. We assessed the effects of OpenMRS on workflow via a formal time-motion study [10]. At Mbarara, with experience with EHRs, patient visits after OpenMRS were slightly shorter (186 minutes pre-OpenMRS vs. 198 pre-OpenMRS, (p<0.05), with significantly less time spent waiting (88 minutes vs. 122 minutes) and more time spent with pharmacists (12 vs. 2 minutes) and non-clinical staff (61 vs. 42 minutes). There was no impact on provider time spent in various activities. At Masaka, which had no EHR experience, total visit time when up post-OpenMRS (102 vs. 77 minutes), all of which was due to increased waiting time (88 minutes increasing to 51 minutes). Yet there was a significant drop in time spent with pharmacy (1 vs. 3 minutes) and non-clinical staff (5 vs. 11 minutes). There was a statistically significant reduction in percent of the day clinicians (physicians, clinical officers, nurse practitioners) spent in patient care (43% of the workday pre-OpenMRS vs. 60%) and more time spent in administration (23% vs. 14%). At Mbale, a small clinic working out of two rooms, there were no significant changes in practice patterns.

Because only the Ugandan sites had fully implemented OpenMRS, we sent questionnaire Ugandan OpenMRS users (and not Tanzanian users) to assess their satisfaction with various aspects of the system. Respondents included clinicians, clinical support staff, and medical record clerks. As shown in Figure 2 below, users were highly satisfied with OpenMRS, finding it to be reliable and useful for performing their duties.

Currently, OpenMRS use continues at all three Ugandan sites. But Masaka has had problems paying for printing encounter forms, and data managers at all sites are being paid with research funds from Indiana University as part of an NIH-funded global HIV/AIDS epidemiology network [11]. Research grant funds from UCSF support OpenMRS data entry clerks and data managers at Mbarara.

Discussion

OpenMRS was initially, developed, implemented, and successfully supported rapidly expanding care in AMPATH clinics in western Kenya, aided by a long-standing partnership between Moi University, MTRH, Indiana University, and es-
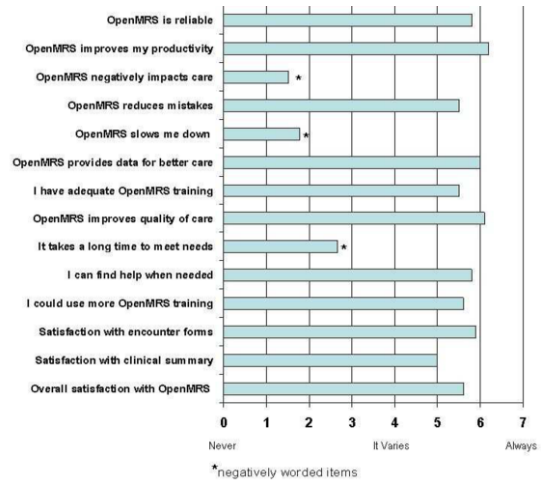

Figure 2- Results of OpenMRS user survey in Uganda

pecially the Regenstrief Institute, one of the world's oldest and most active academic medical informatics institutions. Three decades of experience allowed Regenstrief investigators to replicate their data model into a new software platform (MySQL) that is able to support what is likely the largest clinical informatics enterprise in sub-Saharan Africa.

In Tanzania and Uganda, OpenMRS was successfully installed and used at all six sites. The most substantial and effective use was at Mbarara in Uganda, likely for several reasons: (1) Mbarara had previous experience managing electronic medical records via a small MS-Access research database. Thus they had both information technology in place and existing trained data entry clerks and data managers who could support the IT infrastructure, data entry, management, and reporting with minimum instruction. The local data manager was highly capable in programming as well as data management. Hence, problems with OpenMRS got solved quickly, usually by local staff able to work either alone or with help from Makerere University, Indiana University. (2) Mbarara University had a strong existing partnership with a sister university in the U.S. (UCSF). This led them to be friendly towards innovations and actually depend on data for both clinical care and research, even before OpenMRS was implemented. (3) Mbarara's clinicians and investigators had an incentive to perfect data collection to support future research. (4) And finally, a new clinic building was built just prior to implementing OpenMRS which was configured to accommodate OpenMRS' information technology infrastructure. Mbarara is a good example where a multi-disciplinary, multi-sector partnership was leveraged to enhance the implementation and rapid rise in use of an EHR. Such partnerships may be key to success in implementing health information technology in low-income countries.

Three factors influenced OpenMRS use in all three East African countries: local budgetary control, academic partnerships, and in-country IT support. AMPATH's local fiscal control and

global budgeting allowed it to pay for OpenMRS because it could recoup the cost through enhanced efficiency of care [12]. Pulling charts for scheduled patients facilitated patient flow while recording clinic data on a single form via tick boxes, numbers, and coded text (e.g., diagnoses). AMPATH could anticipate its personnel needs and avoid drug and lab stockouts. If control of local health care budgets resides in national MOHs, a local health care provider organization cannot pay for an EHR by increasing efficiency of care and lowering local personnel costs unless there is a national plan for installing and maintaining health information technology. Even then, EHRs will still need to be customized to serve local needs while serving the data needs of the government's national health care management and strategic planning.

EHRs that support local care can also provide sorely needed support for investigators and care programs in low-income countries. Research grants between North American and East African investigators helped implement and sustain OpenMRS in AMPATH [12] and all three Ugandan sites. Long-term sustainability and optimal use of EHRs to improve health care in developing countries, both locally and nationally, could therefore be enhanced by collaboration among academic, public, and private stakeholders [13,14]. Moreover, the resulting research could help identify strategies for more efficient and effective health care in low-income countries while supporting careers of local academic investigators.

Expertise in information and computing technologies, especially health informatics, is scarce in many low-income countries. Due to lack of medical informatics training in Kenya, the Regenstrief Institute trained all of AMPATH's local IT support staff and data managers. University IT consultants from the University of Dar es Salam supported OpenMRS in Tanzania while consultants from Makerere University in Kampala supported OpenMRS implementation in Uganda. These consultants participated in the OpenMRS collaboration and were thus backed by the global OpenMRS developer community which helped train them at annual OpenMRS Implementer Conferences and through online consultations. Such global developer communities can thus be a free and effective source of support for computing organizations that can then provide support to multiple EHR users in developing countries.

In conclusion, we successfully implemented a sophisticated EHR in HIV clinics in three East African countries. The locus of funding and oversight dictated the range of data captured, whom the EHR served, and how data were used to monitor, evaluate, and improve care. Local control of funds, academic partnerships, and enhanced local technical support bolstered developing countries' ability to implement and sustain EHRs to help low-income countries deliver, monitor, manage, and improve health care.

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