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Using Electronic Medical Records for HIV Care in Rural Rwanda

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Abstract

Partners In Health (PIH) implemented an electronic medical record (EMR) system in Rwanda in 2005 to support and improve HIV and TB patient care. The system holds detailed patient records, accessible to clinicians through printed reports or directly via a computer in the consultation rooms. Ongoing assessment of data quality and clinical data use has led multiple interventions to be put in place. One such evaluation cycle led to the implementation of a system which identified 15 previously undiagnosed pediatric patients with HIV. Another cycle led to an EMR intervention which helped to decrease the proportion of completed critical CD4 lab results that did not reach clinicians by 34.2% (p=.002). Additionally an automated data quality improvement system reduced known errors by 92% by providing local data officers a tool and training to allow them to easily access and correct data errors. Electronic systems can be used to support care in rural resource-poor settings, and frequent assessment of data quality and clinical use of data can be used to support that goal.

Keywords:

Computerized medical records system, Developing countries, Information systems, HIV

Introduction

EMR in Rwanda

PIH has eight years of experience implementing EMR systems in resource-poor rural settings where meeting infrastructure, logistics and human resources needs is challenging [1,2]. The deployment of an EMR in Rwanda is a single intervention designed to meet multiple needs including improving direct patient care and decision making through access to summary chart data, printed summaries, using automated alerts and reports to ensure consistency of care and to aid follow-up. The system also allows the efficient production of aggregate data for administrative, monitoring and evaluation purposes, and to enable both research and reporting as required. Since the original implementation of PIH's EMR in Rwanda, the system has undergone numerous improvements and expansions. The current system is based on OpenMRS, an open source web-based EMR system that was co-developed by PIH and the Regenstrief Institute [3,4]. It is currently used in 16 PIH-supported health centers in Rwanda, as well as the government's HIV clinic in the capital city. By early 2010 the PIH Rwanda EMR held over 10,000 HIV, TB and heart failure patient records. This system is currently being expanded for general primary care use to support the Rwandan Ministry of Health's planned national implementation of OpenMRS across health centers.

Database setup

The EMR system is used in two provinces in Rwanda, and a separate database is maintained for each of these regions. In the Eastern Province, where solar power systems and internet access exist in the remote health centers, each health center runs a local server which is synchronized over the internet to the district hospital-based 'parent' EMR server. In the Northern Province, where electricity is not yet at all health centers, and only the district hospital has internet, data officers travel to the district hospital to enter the health center data into the shared database, and then return to the health centers with printouts of the upcoming week's consultation summaries.

Software Development

The PIH Rwanda EMR program currently employs two programmers who are based on site at one of the rural district hospitals, and develop modules and system improvements while immersed in the context in which the technology will be used. A key feature of OpenMRS is the modular nature of its architecture which allows programmers to develop and add additional functionality to the EMR without impacting on the code base of the system. This arrangement has allowed the software development to be adaptive, which is particularly beneficial in a complex low-resource environment.

Staffing

The organizational structure of the program is designed to maximize collaboration between PIH and the Ministry of Health (MOH) and build capacity within the MOH structures. All data officers who are based at the health centers, while currently funded by PIH because there is not yet a national EMR program, have employment contracts with the MOH. This allows the program to be part of the normal health center activities, which will increase the sustainability of the program. Employed by PIH centrally and providing support across all sites are a Data Quality Coordinator, Reporting Coordinator, Team Coordinator, Program Manager, Program Director, IT Officer and Software Programmers.

Data Collection

Almost all data collected by the EMR system is unambiguous, coded data. Collecting high quality data in the field is of critical importance to ensuring patient safety and quality of aggregate data. Input from clinicians, data managers, and researchers was incorporated into the design of the encounter forms that are currently in use in the field and are able to be updated to accommodate changing circumstances.

Clinical Use of Data

By prioritizing quality of care and placing an emphasis on clinician-oriented data tools, PIH's EMR program is currently working to maximize the amount of benefit from the system that flows back to clinicians, and therefore patients. In doing so, the system provides incentive for clinical staff to feel invested in the system and to prioritize accurate data collection as well as detection and correction of existing errors. Currently HIV clinicians at all 16 sites that use the EMR receive a printed consultation summary report each morning for patients scheduled for a visit that day. The summary sheet contains the patients' name, age, gender, program, three most recent recorded weights and CD4 counts, as well as their treatment regimen, and community health worker. An alert column indicates if the patient has a declining weight or CD4 count, and if their CD4 count is overdue. In addition to regular EMR reports, other data is provided to clinicians on request, such as lists of underweight patients, those at high risk requiring cervical screening, patients with renal failure. Lists of patients who are lost to follow up are provided to allow community health workers to make contact with the patients and encourage them to return to care.

Aim

The aim of this paper is to document the process of identifying areas within the electronic medical record program requiring improvement and implementing interventions to improve the quality of the patient data and to increase the usage of the clinical data for directly improving care in sixteen rural health centers in Rwanda. Brief case studies of four identified areas of need and the implementations and outcomes are described. These areas include decreasing errors in electronic data used by clinicians, improving transmission of CD4 results to clinicians caring for HIV patients, increasing clinician direct access to electronic patient summary data and increasing detection and program enrollment of HIV positive children.

Materials and Methods

Program auditing and process analysis were used to determine areas of the EMR program which could be modified to improve clinical care. The process in each case was the identification of needs through discussion with clinicians and the data team and analysis of existing data and workflow. Following identification of need areas the technical aspect of the intervention was undertaken, which included drafting necessary software tool requirements, and designing, developing and implementing the software though an iterative process between program manager, data team, clinicians and software developers. Other aspects of the intervention were also undertaken including provision of equipment, data officer training, clinician training and workflow adjustment. Each area identified for intervention was then evaluated.

Data Quality

This assessment focused on data which was directly used by clinicians for decision-making. In response to the identified needs, an automated data quality tool with emailed data quality report was developed for and implemented in OpenMRS. The developed tool allowed for customized definitions of data errors, for example people currently registered in the TB program that do not also have a current anti-TB drug regimen prescribed in their record. Each health center had a separate link to a data error report, which provided a real time list that linked to all patient files with a known data error. Additionally a weekly report was sent to the Data Quality Coordinator and data officers which listed the progress of data error correction in each site. Eight data errors types were defined and programmed in July 2009, and data officers and managers were trained to utilize these software tools to efficiently identify errors and initiate processes to correct them in collaboration with clinical staff when necessary. Incorporating input from data officers, a second round of error types were identified and automated lists were created.

To evaluate the impact of this intervention, the total number of errors detected was tracked on a monthly basis beginning with the implementation of the first automated lists. The total number of errors corrected was also tracked.

Access of laboratory results

The current process in place to support clinical decision making is based on patient summary data being available to clinicians along with alerts and reminders. Among the key variables for decision making for the clinicians that we support for HIV are patient drug regimen, weight, height, and CD4 count. CD4 count testing is a critical measurement to gauge the state of the patient's immune system and for clinicians to initiate antiretroviral HIV therapy (ART) or to identify treatment failure. Measurement of CD4 levels indicates how far the disease has advanced and the risk to the patient of complications or opportunistic infections. This test is usually performed every six months and is critical that clinicians be able to access the results of this test during a patient's consultation.

The existing method of communicating CD4 laboratory results to clinicians was identified as requiring improvement. The Rwinkwavu District Hospital laboratory processes CD4 count tests for two district hospitals and all health centers in the Kayonza, Kirehe and Ngoma districts in eastern Rwanda. CD4 count test result follow-up visits are scheduled a minimum of seven days after the test sample is obtained to allow sufficient time for transport of the test sample from the health center to the laboratory site and for sample processing and result return.

Before the introduction of the OpenMRS laboratory system, these paper-based laboratory results were entered into a static database on the laboratory workstation, which was stored locally and not integrated with the EMR system. Test results were then printed and transported back to the health center by hand or emailed to those health centers with internet connectivity available. At worst, printed test results were delayed in transit, and at best, clinicians were required to cross-reference

an individual patient's record with multiple laboratory result reports during the clinical visit to be recorded on the encounter paper form. Patients with lost ID cards often had a new patient record created in the laboratory system due to an inability to easily cross patient data in the EMR, making their CD4 data difficult to access.

Problems identified from this nonintegrated system were that clinicians did not always receive the most recent CD4 result on patient summary sheet printed from the EMR. The solution devised was to develop and implement a laboratory order and entry system in OpenMRS tailored to the clinic workflow, and to conduct a quality improvement evaluation. Based on a detailed requirements document, a new module for OpenMRS was developed to allow laboratory orders and results to be entered directly into the EMR system by data officers based in the Rwinkwavu laboratory and these results are being recorded directly into the patient's electronic record.

The usefulness of migration to the OpenMRS-based laboratory information system in reducing use of outdated CD4 count test results in assessments for HIV patients was also evaluated. Laboratory CD4 count test result data was collected from laboratory paper register logs for a 30 day period in January 2008, prior to the implementation of the OpenMRS laboratory system, and for an additional 30 day period in June 2009 following the completion of the implementation period. A period of one month was chosen based on power calculations which indicated a sample size of 474 would be sufficient for 80% power based on a 2 sided test with alpha = .05.

Each HIV patient encounter at the clinic required the clinician to complete a paper initial or return visit encounter form for the patient's chart – which included a space for recording the patient's most recent CD4 count. A CD4 result from the January 2008 and June 2009 date range was included in the sample if the patient with the test result also had a return visit encounter in the EMR and did not have an initial visit (where finding the initial CD4 is crucial to conducting the encounter) within 60 days after the test result. The clinical data was collected from the paper return visit encounter forms in the patient chart. For the purpose of this exercise, successful receipt of an up-to-date CD4 count test result was confirmed by a matching CD4 count value in the laboratory paper register as entered by the lab technician and on the return visit encounter paper form as entered by the clinician. Assuming the laboratory result registers are correct, this frame of analysis allows for the capture of all possible errors occurring throughout the transmittal process that could prevent successful delivery of the result. All cases of non-matching CD4 count values were investigated to attempt to identify the source of the error.

Data for all sites and for both pre-ART as well as ART patients were included in the evaluation. Exclusion criteria for patients with a CD4 result during either examination period were if a follow-up visit did not occur between 7 and 60 days following the test sample date, if the laboratory register recorded "no result," and if the patient had multiple CD4 counts in the 30 day period. The data was collected by EMR data staff with existing full access to patient medical records as part of their employment, and names were removed for analysis. Data officers were unaware of the CD4 count result from the lab register when recording the CD4 count that the clinician had written on the form.

Clinical Decision Making

After the conclusion of the intervention to improve access to laboratory results, the assessment was made that while an integrated laboratory system can help to improve the transmission of the data, relying on paper copies to be produced from the EMR still allows room for lost results. Patient consultation summaries were already being produced from the EMR that included brief pertinent information that could fit across a page and accommodate data for all patients scheduled to attend the clinic that day. This however did not account for patients who arrived at the clinic for an unscheduled visit. It was also limited to only providing a minimal set of information due to the format and space available. To expand clinician access to data for decision making, including access to graphs of key care indicators like CD4 count and weight, direct access to the system was required.

Training for HIV clinicians was conducted in June 2009 on how to log in to the EMR, look up patients, and use the data in patient summary. The training was led by data officers from several of the sites in which the clinicians work, so that they could serve as the onsite trainers when needed. Another required step for implementing direct look up was the purchase of laptop computers specifically for this purpose and configured and supported by the EMR IT officer for low maintenance (i.e., running Ubuntu, unneeded audio/visual componentry removed, locked to the desk). Due to a delay in acquiring the equipment, laptops were unable to be placed in all consultation rooms until September 2009.

A need was identified within the EMR program to assess if clinicians and data team were using the system to access patients files, how the system was being used, and to examine periods of heaviest system use. A usage auditing module was developed for this purpose, and deployed on one EMR server.

Targeted High Risk HIV Testing

A key benefit of the EMR system is the ability to automate real-time reports that would take many hours of work to compile under a paper-only system. A need was identified in enabling the EMR to support earlier identification of pediatric HIV cases in children of known HIV infected adults. The impetus for this is that early initiation of HIV care and ART in pediatric patients is associated with decreased mortality [5].

In April of 2008, an automated report was created to track untested children of HIV positive parents who were newly enrolled in the HIV program at any of seven PIH-supported health centers in Rwanda. If a parent's test result was positive, they are enrolled in an HIV treatment program and their paper intake form is entered into the EMR system. On a weekly basis, an automated report is produced that lists all children of HIV positive parents enrolled in the program who have not been tested for HIV as reported by their parent. This report is automatically emailed to the pediatrics department where the Pediatric Coordinator manages the database and the then work with the social workers and village-based community health workers to contact the family and have the child attend the health center for HIV testing.

Children who test positive are immediately enrolled in the pediatric HIV program, through which they are provided with comprehensive HIV care. To evaluate the impact of this intervention, the total number of children identified has been tracked on a weekly basis beginning with the implementation of the first automated lists. Of these children, the number tested and the number that tested positive was also tracked.

This study was approved by the Brigham and Women's Hospital Investigational Review Board

Results

Data Quality

The development and implementation of the automated data quality improvement tools, along with the training of data officers, led to a 92% decrease in eight pre-defined data quality errors (1064 errors corrected) in the first four months of implementation (Figure 1). Limits and ranges applied to concepts within the EMR identified existing errors including over 9,000 observation dates in the future, and will prevent such errors in the future. Feedback regarding use of the data quality OpenMRS tools was positive, and the training was well received by data officers. A user-friendly interface and automated weekly reminders have helped keep these tools in use.

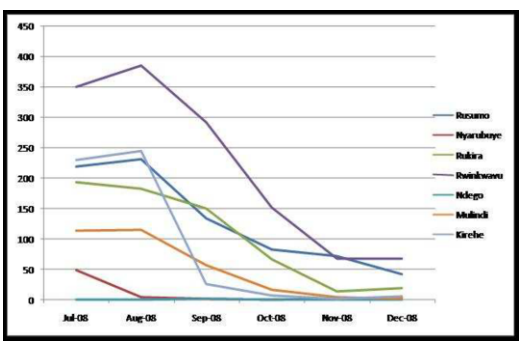

Figure 1 –Defined Data Quality Errors by Health Center Before and After August 2008 Data Quality Tool Implementation

Access to laboratory results

After patients who did not have a visit within 60 days of their CD4 test were excluded there were 457 patients in the January 2008 sample, pre-intervention and 545 in the June 2009 post-intervention sample. Exclusions due to incomplete charts and multiple CD4 counts in the same month decreased the sample size to 412 for and 493 respectively. The proportion of patients who completed CD4 counts within 60 days prior to their visit whose recent result was unknown to the clinician at the time of consultation was 24.7% pre-intervention and 16.7% post intervention, representing a 32.4% reduction in CD4 loss, a change which was found to be statistically significant ($p=.002$, $\chi^2=9.146$). There was no statistically significant difference for either sample period between lost CD4 counts and the age, gender or CD4 count range of the individual patients.

Clinical Decision Making

The response to clinician training on the EMR was positive, with over 30 HIV clinicians attending. In addition to this training, data officers at each health center were instructed to provide ongoing clinician support for computer and EMR use.

The equipment was successfully placed at each site and clinicians were able to access the EMR providing electricity and the local network were functioning. Prior to any additional formal training for clinicians, the usage audit tool was launched, showing that over a 21 week period between October 2009 and March 2010, 18 HIV and TB clinicians directly accessed the electronic records of 1752 patients. The number of patient records accessed ranged between two and 520 per clinician, with seven clinicians accessing over 100 records.

Targeted high risk HIV testing

In an assessment period covering six months the automated report of untested children with HIV positive parents resulted in 178 children being tested, with 41 currently awaiting results, 122 testing HIV negative and 15 who were found to be HIV positive. Due to their identification through the EMR, the HIV positive children are all now receiving comprehensive care, with seven of them receiving ART.

Table 1 – Summary of Audit Case Study Findings

Issue	Description	Intervention Method	Outcome
Data quality	Data errors existed in variables used for clinical care	Developed automated data quality tool and report and provided training	92% reduction in defined data errors
Access to laboratory results	Clinicians not having access to patients' most recent CD4 count during consultation.	Developed an integrated laboratory system in the EMR	32.4% decrease in CD4 counts that did not reach clinicians
Issue	**Description**	**Intervention Method**	**Outcome**
Clinical decision making	Clinicians not having direct access to comprehensive electronic patient summaries	Improvement of a patient summary module, development of an EMR-use audit tool, placement of laptops in consultation rooms	1752 patient records looked up by 18 HIV/TB clinicians in a 21 week period
High risk screening	Missing opportunity to used medical record data from HIV+ adults to ensure screening at their at-risk untested children	Developed an automated email report alerting weekly of any new untested at-risk	15 patients found to be HIV positive and enrolled in pediatric HIV program

Discussion

Each of the four areas of intervention led to a change in behavior and practice in the health centers. Efforts in training and changing workflows were very important in accomplishing this. In particular in each of these cases it was key to understand the user's needs, and ensure that a technological solution alone was not implemented. Data problems decreased sharply once data officers were aware of the existing problems. From this experience we learned that what is needed to continue to improve quality is to add additional pre-defined data errors to the data quality tools, and to increase automation of error reporting as well as primary prevention of data errors. Similarly with increasing detection of the pediatric HIV patients we saw that this type of report being automated from the EMR, with a documented process of what actions are taken when the report is received, can lead to improved program quality and have real clinical impact. Automated high risk patient screening reports are likely to have a clinical impact, provided that the processes and workflows surrounding them are sustainable.

Clinician access to information was addressed in both increasing access to laboratory results and allowing direct lookup of patient data. In this regard many of the hardware and software challenges have been overcome, but training clinicians on using the system and ensuring it is designed to respond to the clinician's needs remain the challenges. In particular there was a long unintended gap between training clinicians on looking up patients in the EMR and in providing the equipment for them to be able to do so. Some clinicians used the system only infrequently, and discussion with them will be required to better understand if there are hardware, software, training or workflow changes that could increase the usefulness or ease of use of the system. Due to the development of the audit module as part of this process, it is now possible to observe if there are changes following trainings or after the addition of clinician-requested features to the EMR. An additional need for a re-evaluation of clinician access to CD4 counts will take place after the clinicians have had further training on direct access to the system. Establishing a cycle of audit and quality improvement in the EMR program will allow for faster progress towards having the most effective and useful system possible.

Conclusion

Multiple strategies have been employed to improve EMR data quality and use of the data to improve patient care. Experience from the capture of HIV, TB and chronic care patient data has shown that as the PIH OpenMRS program in Rwanda continues to expand, in particular to include capture of all primary care data, the need for automated and user friendly tools to assist in data quality and clinical care will increase.

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