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Experience Implementing a Point-of-Care Electronic Medical Record System for Primary Care in Malawi

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Abstract

Due to the fact that health care professionals in Malawi are often overstretched, the use and quality of health data can be compromised. The Malawi Health Management Information System (HMIS) has streamlined data collection and reporting and increased the use of data to improve care. Obstacles remain, including incomplete reporting and low staff morale. With the Baobab Health Trust and the Malawi Ministry of Health, Partners In Health piloted an innovative point-of-care data system for primary care that functions alongside OpenMRS, an open source medical record platform. The system has given access to a patient-level primary care dataset in real time. Initial results highlight some of the benefits of a point-of-care system such as improved data quality, emphasize the importance of sharing data with clinical practitioners, and shed light on how this approach could strengthen HMIS.

Keywords:

Point-of-care systems, Primary health care, Malawi

Introduction

Background

The convergence of falling information technology costs, improved computer literacy and greater availability of open source software platforms has increased access to electronic medical record systems in resource-poor settings. Early successes in some locations include timely delivery of lab results, tracking of drug supplies [1] and easier aggregate reporting [2]. The potential to improve patient care through better compliance with standardized guidelines, clinical decision support and other measures is promising. While such initiatives are in early stages with less documented successes, a preliminary evaluation of the Malawi Ministry of Health's (MOH) use of an electronic data system for antiretroviral therapy suggests the results are positive [3].

Malawi has poor health and economic indicators relative to other countries in Southern Africa and the world in general. In 2005, 41.7% of a population of 12,884,000 lived below the poverty line. The life expectancy at birth was 41 for both males and females, compared with averages of 47 and 49, respectively, in nearby countries [4].

Human resources in Malawi's health sector are scarce. A 1998 estimate indicated that 36.3% of physician posts and 18.4% of nurse and/or midwife posts were vacant [5]. As of 2002 the coverage rate of physicians and nurses per 1,000 patients was 0.022 and 0.589, respectively, compared with averages of 0.217 and 1.172 in other nearby countries [4]. Staffing shortages have resulted in increased reliance on health professionals with only two or three years of training [6], and task-shifting of some activities, such as data capturing, to staff with little or no formal training [7].

In 1999, the health information system in Malawi was restructured into a new Health Management Information System (HMIS), with the goal of overcoming the lack of reliable data and inadequate use of data in healthcare planning. A small set of indicators was chosen to minimize the burden of data collection. The system was primarily paper-based, including client health booklets, facility-based registers, data aggregation and monitoring workbooks and annual planning and review tools [2]. District-level HMIS Coordinators entered data into an electronic system which was then aggregated at a central level. As of 2002, facility-level information was available on a monthly basis for the first time. Obstacles remain in spite of the successes, including [2]:

- inadequate reporting from some facilities,
- staffing shortages for qualified personnel,
- data aggregation by clerks with little formal training [7],
- low motivation of HMIS personnel,
- insufficient data use at the local level, and
- low data use where quality is perceived to be poor [7].

Partners In Health (PIH) began a partnership with the Malawi MOH in early 2007 in rural Neno District. Building on its experience in Rwanda, Lesotho and elsewhere, PIH implemented OpenMRS, an open source electronic medical record system designed to support the delivery of healthcare in developing countries [8], by collecting HIV and TB data. PIH

saw potential in the Baobab ART system (BART), a point-of-care electronic data system developed by the Baobab Health Trust [9], but this system was not fully compatible with OpenMRS. Primary care data collection was not a part of PIH's initial electronic medical record system, so data from HMIS had to be relied upon.

Goal

To address some of the shortcomings of the HMIS dataset and improve access to data at the point of care, PIH sought to work with the Baobab Health Trust to develop a point-of-care data collection system for primary care. It would be based on the Baobab ART system (BART) and be fully compatible with OpenMRS. It should improve the quality of patient-clinician interactions and increase the use of the data for planning purposes in Neno District. It was also hoped that collecting this dataset at the point of care could demonstrate the feasibility of the approach in addressing some of the challenges affecting HMIS. Finally, the integration could pave the way for a full integration of BART with OpenMRS, bringing the benefits of the OpenMRS community [10] to existing Baobab implementations.

Challenges

Internet access is very important to the development and piloting of a new electronic medical record system, but connectivity from local Internet Service Providers (ISPs) was not available in Neno District. Finding an alternative source for Internet connectivity was key to PIH's operations as a whole and the development of its electronic medical record systems in particular.

Power supply in Malawi is unreliable. While most of the health facilities in Neno District are connected to the grid, power outages ranging from a few hours to an entire working day are common. Utility line power surges are a problem, as are lightning strikes. A point-of-care electronic data system must work when the power is off for long periods of time and must be resistant to power surges and lightning strikes.

To keep costs low and reduce downtime, equipment for the point-of-care system would need to be low cost, easy to use, and reliable. It should fit smoothly within the existing workflows of the hospital. Given the power issues mentioned above, the equipment should have low power consumption. A reliable supply chain for IT hardware and consumables, such as printer labels, must also be established.

Integrating BART and OpenMRS also required a technical solution. The OpenMRS application is programmed in Java and runs on the Apache Tomcat web server with a MySQL database [8]. PIH started its implementation in Malawi at version 1.3 of OpenMRS, and has since migrated to version 1.4.4. BART is programmed in Ruby on Rails and uses version 1.0.18 of the OpenMRS data model, making it incompatible with the OpenMRS implementation used by PIH. Due to the different programming languages of the applications, integration was not trivial.

Inconsistent spellings of names and addresses are common in the HMIS dataset. To avoid unnecessary patient duplication, the system needed an easy way to find a patient record, and an ability to compare slightly different spellings of a name. Data validation would be crucial to avoid common entry errors.

With high patient loads and overstretched staff, the system would need to be as easy-to-use as possible. Given that most staff at the hospital were not familiar with computers, it would need to be intuitive in order to require a minimal amount of training. Time-saving measures would have to be adapted wherever possible, and the new processes would need to be easily integrated into existing workflows. To encourage adoption and consistent use of the system, it would need to be immediately useful to clinicians while also providing a perceived benefit to the local MOH management team.

Materials and Methods

Hardware and power

PIH purchased a VSAT Internet connection for its program activities in Neno District Hospital but could not install connections at other sites due to the high cost. The Internet network was extended around the hospital with low-cost wireless technology, but the rugged topography of Neno District prevented point-to-point connections between the hospital and any of the other health centers in the district. Faced with these connectivity limitations, PIH decided to pilot the point-of-care system exclusively at Neno District Hospital.

PIH benefited from advances in the implementation of BART in addressing power problems. Four 12-volt deep cycle batteries in series provided backup power. A 48V, 10 Amp charger was protected from voltage spikes by a surge arrestor. The system was connected to the main building ground to prevent surges and lightning strikes from damaging the equipment. A Low Voltage Disconnect (LVD) device was installed after the batteries and the load to prevent them from being drained too low, preserving their lifespan. As a sum of its parts, the system functioned like a large online uninterruptible power supply. The computer and network hardware chosen were generally low-power DC equipment to enhance the battery life.

Table 1 - Summary of power supply equipment

Item	Number	Unit	Total
13A Surge Arrestor	1	$70	$70
10A 48VDC Charger	1	$133	$133
102 Ah 12V Battery	4	$200	$800
48V LVD	1	$160	$160
Total			**$1,163**

PIH also utilized the experience of Baobab in the selection of hardware. The data collection devices were low-power (13 Watts) thin client touchscreen computers modified by Baobab receiving Power Over Ethernet (POE) from a special network switch wired to the batteries. The thin-client approach precluded potential problems of computer viruses. A label printer was used to print a unique patient identifier as a barcode and summaries of encounters for the patient passports. A barcode scanner was used to quickly find patient records. The printer was powered directly off of the batteries, and used rolls of

labels and thermal transfer ink ribbon. The application and OpenMRS were installed on a single low-powered server (30W idle, 60W peak load).

Table 2 - Summary of point-of-care equipment

Item	Number	Unit	Total
Baobab touchscreen	5	$400	$2,000
Barcode scanner	5	$60	$300
Thermal label printer	5	$410	$2,050
Custom POE power supply for printer	5	$100	$500
24 port POE switch	1	$375	$375
Linux server	1	$1,670	$1,670
Ethernet cabling	1	$200	$200
Total			**$7,095**

Table 3 - Summary of consumables purchased in first year

Item	Number	Unit	Total
Box of 12 label rolls	3	$310	$930
Box of 12 ink rolls	3	$60	$180
Total			**$1,110**

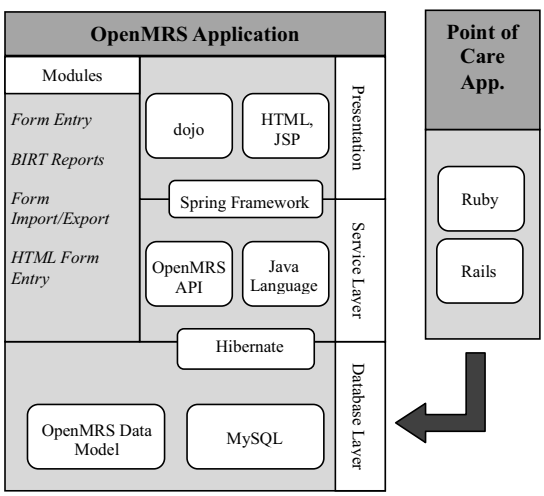

Figure 1 - Linking the OpenMRS web application with the new point-of-care system

Software

Options considered for integrating the Baobab technology with OpenMRS included working together at the database layer, using a java ruby bridge to allow the Baobab application to write to the OpenMRS Application Programming Interface (API) [8], or rewriting the entire application in Java. In the end the database layer was chosen for its simplicity and potential for adoption by Baobab at other sites (see Figure 1).

Patients sometimes need to be looked up by name if the passport is not available or the barcode is unreadable. To avoid patient duplication due to inconsistent spelling, a soundex algorithm was developed that matched similar sounding letters (eg, r's versus l's and c's versus k's), counted double letters as a single letter, and ignored vowels. Unlike classical soundex algorithms, the first letter was also accounted for, allowing names such as 'Kathleen' and 'Catherine' to be compared:

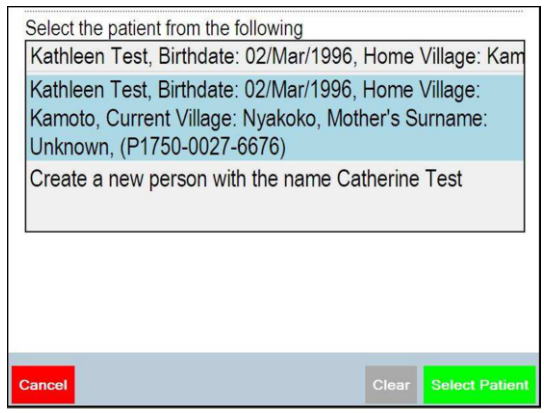

Figure 2 - Example results from soundex algorithm

The new system maintained conventions of the BART user interface designed to make it easy to use, displaying one question per screen and using large buttons to facilitate data entry.

Figure 3 - Example user interface

Data validation was also used where possible to prevent data entry errors (eg, unrealistic patient weights).

The data collected by the point-of-care system included basic demographics, height, weight, diagnoses and treatment prescribed, and was consistent with the data collected by HMIS. However, HMIS collects diagnosis data on a set of only 63 indicators and some broad definitions (eg, 'All other non-communicable diseases') are not conducive to a patient-level dataset. The new system allows clinicians to select from a list of more than 530 diagnoses allowing for explicit answers be-

fitting a patient-level dataset. In the future, these diagnoses will need to be mapped to the HMIS indicators and to an established coding system such as SNOMED.

Various time-saving measures were put in place. The system shows a list of common treatments for a particular diagnosis in order of frequency (see Figure 4). An encounter label can be printed, summarizing information entered electronically to avoid writing it out by hand. A patient summary screen displays recent information about the patient for easy reference. Reports were programmed using the Eclipse Business Intelligence Reporting Tool (BIRT) for the OpenMRS BIRT rendering module. These included a weekly summary of clinical activity and a summary for a single diagnosis including most common village (an epidemiological value), and most common treatment combinations (to address prescribing habits). These reports were delivered each Monday during the morning report at Neno District Hospital.

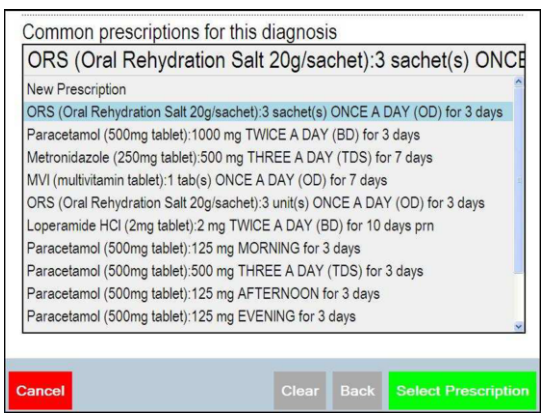

Figure 4 - Common prescriptions for gastroenteritis

The implementation of the point-of-care primary care system was done in a phased approach, allowing key elements of the process to be fine tuned (see Figure 5). Starting with patient registration in June 2008 allowed many of the hardware and networking issues to be worked out without impacting the clinical workflow and registered many patients before new data collection was added. Diagnosis was captured by clerks in September 2008 and by clinicians in January 2009. Capturing of treatment was added in May 2009 once the "suggested prescription" feature had been implemented. Weight and height were added in July 2009.

<table>
<tr><td>Month</td><td>Reg.</td><td>Wt/HT</td><td>Diagnosis</td><td>Treatment</td></tr>
<tr><td>May 2008</td><td>Not done</td><td rowspan="3">Clerk(p)</td><td>Clerk(p)</td><td rowspan="3">Clerk(e)</td></tr>
<tr><td>Jun 2008</td><td rowspan="4">Clerk(e)</td><td rowspan="2">Clerk(e)</td></tr>
<tr><td>Sep 2008</td></tr>
<tr><td>Jan 2009</td><td rowspan="3">Phys(e)</td></tr>
<tr><td>May 2009</td><td rowspan="2">Clerk(e)</td></tr>
<tr><td>Jul 2009</td><td>Clerk(e)</td></tr>
</table>

Figure 5 – Phased implementation of paper (p) and electronic (e) data capturing at Neno District Hospital

Results

Implementing a point-of-care data collection system at Neno District Hospital has given PIH and its MOH colleagues access to a rich set of data. Nationally-unique patient identifiers, (more than 1,000,000 of which have been issued at Baobab sites), have been assigned to patients at Neno District Hospital, and demographic information has been collected.

Table 4 - Summary of cumulative patient registrations at Neno District Hospital as of September 30th, 2009

Gender	Under 15	Over 15	Total
Male	5,171	5,942	11,113
Female	6,065	8,734	14,789
Total	11,236	14,676	25,912

The real time dataset is easier to make use of than the HMIS dataset. By integrating data entry into the point-of-care, data accuracy should increase due to reduced transcription. The collection of diagnoses and treatment information by clinicians also obviates the need to have staff with limited training and limited supervision enter the data.

Table 5 - Five most common diagnoses, January through September 2009

Diagnosis	Number	%
Upper respiratory tract infection	7,773	26
Malaria	7,608	25
Musculoskeletal pain	4,482	15
Dyspepsia	674	2
Gastroenteritis	658	2
Remaining diagnoses	9,057	30
Total	30,252	100

Producing a list of common treatments for a diagnosis helps save the clinicians' time and provides suggestions for reference in unfamiliar cases.

Table 6 - Top five most common treatment combinations, Upper Respiratory Tract Infection, September 2009

Treatment	Number	%
Paracetamol 1000mg TDS	98	18
Ibuprofen 400mg TDS	76	14
Chlorphenamine 4mg OD + Ibuprofen 400mg TDS	63	11
Paracetamol 1000mg TDS + Cotrimoxazole 2 tabs BD	37	7
Chlorphenmine 4mg BD + Ibuprofen 400mg TDS	28	5
Other treatment combinations	252	45
Total	554	100

The patient-level dataset is linked with electronic HIV and TB data, unlike the HMIS data. Retrospective data entry of patient-level data from HMIS registers is generally not practical due to difficulties in comprehending the handwritten text.

The power backup system continues to function during extended power outages. The first set of batteries installed lost their charge capacity in November 2008, but a Low Voltage Disconnect has prevented this problem from occurring again. The touchscreens occasionally have calibration issues, causing unresponsiveness. PIH does not have the capacity to correct this problem so the units have to be sent to Baobab to be fixed. A more reliable off-the-shelf solution with an extended warranty will be desirable.

Discussion

The biggest challenge to the new system has been its adoption by MOH clinical staff. Initially, minor technical problems might cause a clinician to stop using the system. Likewise, they were unlikely to use it if their patient loads were too high, and unplanned staff shortages are common. A series of focus group meetings helped to identify common problems and increased user confidence in the system. Equally important, the weekly reports have become popular with the local MOH management team. Their enthusiasm has trickled down to the clinicians using the system and has increased its use over time, as a comparison of patient registrations and diagnoses shows:

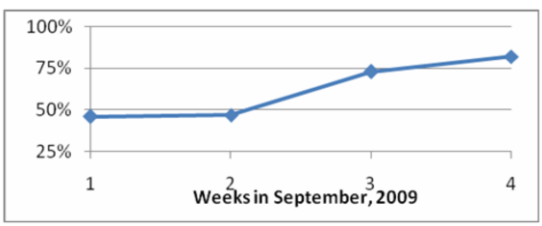

Figure 6 - Percent of patients registered electronically at Neno District Hospital with a diagnosis recorded

Not all of the patients who are seen at the registration desk visit an outpatient clinician, so the figures from the final two weeks of September in Figure 6 represent a high proportion of the patients who actually saw a clinician.

Conclusion

Malawi's Health Management Information System (HMIS) has provided decision makers at the district and central level with monthly access to facility-level data. Persistent problems such as a lack of qualified staff, low morale among data collectors and poor training and supervision among those responsible for aggregating the data have adversely affected data quality. Together with the Baobab Health Trust and the Malawi Ministry of Health (MOH), Partners In Health (PIH) has piloted an innovative electronic system for collecting primary care data at the point-of-care. Since clinicians creating the data are actively involved in capturing it, common data entry mistakes are reduced. The amount of time required to use the system has been minimized by integrating it into the general workflow of the clinic. Summary reports in OpenMRS have increased the overall use of the data and have had a positive effect on the use of the system as a whole. Political will on the part of MOH management will be essential if the system is to continue being adopted successfully. This early success highlights the potential for such an approach to address problems in the HMIS dataset and the general collection and use of medical data in resource-poor settings.

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