Changing course to make clinical decision support work in an HIV clinic in Kenya

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ABSTRACT

Purpose: We implemented computer-based reminders for CD4 count tests at an HIV clinic in Western Kenya though an open-source Electronic Medical Record System. Within a month, providers had stopped complying with the reminders.
Methods: We used a multi-method qualitative approach to determine reasons for failure to adhere to the reminders, and took multiple corrective actions to remedy the situation.
Results: Major reasons for failure of the reminder system included: not considering delayed data entry and pending test results; relying on wrong data inadvertently entered into the system; inadequate training of providers who would sometimes disagree with the reminder suggestions; and resource issues making generation of reminders unreliable. With appropriate corrective actions, the reminder system has now been functional for over eight months.
Conclusion: Implementing clinical decision support in resource-limited settings is challenging. Understanding and correcting root causes of problems related to reminders will facilitate successful implementation of the decision support systems in these settings.

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1. Introduction

The HIV epidemic affects nearly 33 million people globally with two thirds of all HIV infected living in sub-Saharan Africa [1]. The large numbers of HIV-positive patients impose further strains to already overburdened healthcare systems [2]. In these settings, the few clinical facilities are often understaffed and under-resourced. Due to the vast shortage of doctors and other highly qualified personnel, care in many HIV-clinics is typically offered by a mid-level cadre of staff such as nurses and clinical officers. Further, there are high attrition rates of the healthcare providers [3]. For HIV-positive patients these systemic shortcomings usually translate to poor quality of care and adverse patient outcomes.

Approaches are needed to improve the quality of care offered to patients in resource-limited settings. It will take time for governments to train enough providers to adequately take care of all the patients. In the meantime, the many sick patients have to be cared for. The approach adopted should also be one that helps to specifically assist less-trained clinicians as they take care of patients. Electronic medical record systems (EMRs) have been shown to improve efficiency and quality of care offered. In fact, the Institute of Medicine identi-

fied EMRs as essential technology for care [4]. This report was not necessarily limited to industrialized nations, and could equally apply to the developing world.

Clinical decision support systems (CDSS) are among some of the most powerful tools in EMRs. In the developed world, CDSS have been shown to improve clinician behaviors and quality of healthcare [5,6]. In fact, a study conducted in the USA by Safran et al. demonstrated that computer-based alerts and reminders were effective in helping clinicians adhere to HIV care guidelines [7]. Despite an increasing number of EMRs being implemented in developing countries (partly because of the availability of robust Open Source EMR systems) [8], there is almost no evidence that CDSS are being used in these settings.

We set out to implement CDSS within an EMRs implementation in an HIV clinic in western Kenya. HIV care is highly algorithmic, and thus very amenable to decision support. As a proof-of-concept, we started by implementing reminders to providers when a CD4 count check was past due—CD4 counts are a marker of immune status for a patient, and thus highly relevant in the care of a HIV-positive patient. After programming of the CD4 reminders, the decision support system was implemented at one of the clinics. However, within a month, the clinic stopped using these reminders. We used a multi-method exploratory qualitative approach to determine reasons for failure to implement and adhere to the reminders, and took multiple corrective actions to remedy the situation. In this paper, we outline the real-world challenges to successful implementation of CDSS in a resource-poor setting and discuss generalizable lessons in addressing these challenges.

2. Methods

2.1. Setting

The Academic Model for Providing Access to Healthcare (AMPATH) is a collaborative initiative started in 2001 between Indiana University School of Medicine (USA) and Moi University School of Medicine (Kenya), which provides comprehensive care for patients infected with HIV [9]. The program currently cares for over 96,000 HIV-positive patients, with over 2000 new patients enrolling each month. Patients at AMPATH are taken care of at one of the 18 AMPATH clinics in western Kenya, or in an AMPATH satellite site. CDSS was implemented at one of the AMPATH clinics located in Eldoret, Kenya. This clinic, called Module 2, has a caseload of about 1300 patients per month. Most patients who visit the clinic are typically taken care of by one of the clinical officers (equivalent to a nurse practitioner).

2.2. Electronic medical record—AMRS

Since 2006, AMPATH clinics have used an open-source medical record called the AMPATH Medical Record System (AMRS) [10]. AMRS is an implementation of OpenMRS, which is an open-source EMR deployed in resource-limited settings, including Eastern and Southern Africa and in the Skid Row area of Los Angeles, USA (http://www.openmrsla.org) [11]. OpenMRS is designed to be an enterprise quality data repository modeled

upon the lessons learned in the 30-year history of the Regenstrief Medical Record System [12]. All data in AMRS are stored as coded concepts to allow for easy retrieval and analysis [13]. The data model is patient-centric and conforms fairly well to standard HL7 representations.

AMRS runs on a server in Kenya accessible securely via the Internet with proper authorization. The system is set up to allow duplication of such a medical record system with as little effort as possible, thus maximizing the ability to be deployed in as many settings as is required [14].

Since most clinicians in resource-limited settings are not able to use computers directly during patient-care, OpenMRS allows clinicians at AMPATH to complete data-driven, pre-printed AMPATH encounter forms (which contain coded choices) during patient visits. These forms are based on a template with a mix of checkboxes and blanks for free text entry. The forms are filled in for both new and returning patients during or just following the encounter. Data-entry personnel, hand-enter the information contained in the encounter forms into AMRS. Free text entries are matched to known concepts in the database, thus assuring that patient data is always entered in coded form. Occasional free text that is not already a concept in the dictionary goes through a moderation process before being entered into the dictionary. The forms are later returned to the clinic, where they are placed in the patient's paper chart.

2.3. Clinical summary module

OpenMRS functionality can be expanded through programming modules without the need to modify the core system [15]. Modules are packaged java code that can be installed into a running OpenMRS instance and are able to modify almost all aspects of the system. These modules are designed to be highly flexible and expandable.

The team behind OpenMRS developed and made freely available a clinical summary module, which generates a clinical summary that includes select fields from the patient record for a quick reference to the patients' most recent information. The clinical summary module ultimately creates a PDF file, which is printed for use. We then added decision support functionality to this clinical summary module. The decision support functionality checks for CD4 count results, and alerts the provider when a CD4 count check is overdue by having a reminder printed at the bottom of the clinical summary.

The specific reminders we implemented are outlined in Table 1. These reminders appeared in printed form at the bottom of the clinical summary sheet (Fig. 1).

The CD4 testing algorithms used had been adapted by AMPATH based on recommendations by World Health Organization [16] and the Kenyan Ministry of Health [17]. To generate the reminders, data about CD4 results were derived from the database by looking at individual CD4 observations, and getting the value and datetime for each; these were compared against programmed logic to see if the patient met any of the reminder criteria.

Workflow: The augmented clinical summary module with CDSS to generate CD4 count reminders was loaded into the AMRS system and turned on for Module 2 clinic. Clinical summaries were initially programmed to be generated in

Table 1 – CD4 count reminders.	
Indication for reminder	Reminder generated
No previous CD4 count result or order	Please order CD4 count now (no CD4 in system)
Only one CD4 result or order, done more than six months ago	Please order CD4 count now (last CD4 over six months ago)
Only two prior CD4 results, with at least one less than 400, and no new CD4 order or result for more than six months	Please order CD4 count now (one of first two CD4s was less than 400, repeat should be in six months)
More than two CD4s, last one was less than 400, and no new CD4 order or result for more than six months	Please order CD4 count now (last CD4 was less than 400, repeat should be in six months)
More than two CD4s, last one was more than 400, and it has been more than twelve months since this one ordered	Please order CD4 count now (last CD4 was ordered over twelve months ago)

electronic format as new information about a patient was entered into the encounter form. The generated clinical summaries, now including reminders when appropriate, would then be saved using Batch and Print Pro (Traction Software), and printed in batch format from a dedicated computer and printer. Printed summaries were then put into each respective patient's chart.

When a patient presented for their clinic visit, this chart, along with the summary containing the reminders was available to all the providers, who could then act on the reminders if they agreed with them. Providers could put in new CD4 orders by filling a laboratory requisition form for a 'CD4 panel'. They would also record on the day's encounter form under 'Plan' that they had ordered a 'CD4 Panel'. A data-entry clerk then

Fig. 1 – Clinical summary with CD4 reminder at bottom.

entered encounter form information into AMRS, with CD4 order information stored as a response to the concept 'TESTS ORDERED', with the answer being 'CD4 panel.' Patients typically went to the laboratory with the lab requisition form, and had the laboratory drawn on the same day.

3. Identifying causes of failure of reminder system

The clinical summaries with reminders were implemented in Module 2 clinic in October 2008. Clinicians were made aware of the CD4 reminders prior to implementation. However, within a month of introducing the reminders, the clinic had completely stopped using the decision-support system. In effect, clinicians reverted back to manual review of the chart and their own understanding of the testing algorithms to determine if there was deficiency in care. We set out to determine reasons for failure to comply with reminders using a multi-method approach.

The techniques employed are outlined below:

(a) *Clinician feedback and interviews*: When clinicians received printed summaries with reminders, they had the option of either following the advice or ignoring it. If they decided to ignore the reminder, they were asked to document their reason(s) on the printed summary. The summaries with comments were collected and the written feedback formally reviewed. In addition, during December 2008 and January 2009, one of the authors (MW) conducted semi-structured interviews with providers in Module 2 to further elicit reasons for non-compliance with reminders. Providers were interviewed initially as a group and later one-on-one using open-ended questions. The feedback from providers helped to determine the direction of the subsequent evaluations.
(b) *Manual review of data and printed reminders*: Patient data stored in the EMRs was reviewed against information contained in paper-based encounter forms and lab results to check for inconsistencies. All reminders identified by providers as having problems were formally analyzed, and the cause of the problem identified.
(c) *Workflow analysis*: We conducted several site visits to Module 2, and observed the process of printing and delivering of summaries with reminders to providers. We were particularly interested in barriers to successful and efficient generation and printing of the summaries.
(d) *Dictionary maintenance and code review*: The AMRS concept dictionary was reviewed to look for out-of-date terms and any additional concepts that could affect the logic used in generating the reminders. In addition, we re-reviewed the programmed decision-support logic to ensure that it truly reflected the intended CD4 testing algorithms.
(e) *Assessment of providers' knowledge*: As part of the group interviews for providers, we assessed knowledge and understanding by providers of the approved CD4 testing algorithms. Feedback was also sought on adequacy of the training received before the reminders were implemented.
(f) *Examination of physical infrastructure*: Computers, printers, network equipment, and the general physical infras-

tructure needed to generate and print summaries were inspected. Infrastructure factors affecting this process were analyzed.

4. Results

Our analysis revealed several factors that led to failure of the reminder system. These factors can be broadly broken into three categories: (a) unreliable generation of summaries and reminders; (b) generation of inaccurate reminders; and (c) failure by providers to comply with accurate reminders.

4.1. Unreliable generation of summaries and reminders

Causes: There were multiple days when the summaries did not get printed because there was no power, the printer ran out of ink or paper, or a virus had infected the dedicated machine used to generate and print the summaries. On occasion, the nurse charged with printing the summaries was too busy performing other duties, and did not have time to print the clinical summaries. Over time, providers simply learned not to rely on having reminders available to them.

Remedies: Simply having a well-designed CDSS system does not guarantee its success. The system has to be placed in context and obstacles anticipated. In our new iteration, we budgeted for paper and ink for the printer, and ensured that the antivirus software was frequently updated – this required part of an IT personnel's time. We have also installed backup uninterrupted power supply connected to the computer and printer used for the clinical summaries. Instead of having nurses print the summaries, we will assign this task to lower caliber staff, like clinic assistants – this will relieve the nurses who have many other pressing responsibilities. The clinic assistants responsible for printing summaries will be given very limited privileges into the EMRs.

4.2. Inaccurate reminders

Causes: Providers complained that in some cases the reminders generated were inaccurate. Our analyses revealed multiple factors that contributed to inaccurate reminders. First, generation of reminders relied on data stored in the EMRs. Unfortunately, on occasion, as was typical of laboratory results, there were delays in entering this information into the EMRs. Typically, laboratory results were sent in paper form to the provider, and a copy also sent to dedicated data-entry clerks tasked with entering the result into the EMRs. The data-entry group was grossly understaffed and they were months behind in entering results into AMRS. As such, our CDSS which queried the EMRs for CD4 results frequently found only older results – consequently, reminders were generated based on inadequate data.

Second, our initial decision support module did not take into account pending test results. In cases where a result was not out, our system would still generate a reminder to check CD4 studies, even though the test had already been ordered. Third, we faced the problem of keeping up with concept dictionary changes that would affect what elements we needed to query. As an example, new concepts were sometimes cre-

ated without the knowledge of CDSS developers who needed these terms to develop the appropriate rules. Fourth, on several occasions inaccurate data had been stored in EMRs. Errors in the data stored in the system were due to (a) inaccurate documentation by clinicians on paper encounter forms, and (b) errors by data-entry clerks in transferring information from encounter forms into AMRS.

Remedies: We reprogrammed our CDSS module to look both at completed CD4 results, but also at the 'TESTS ORDERED' concept with 'CD4 PANEL' as an answer. If there was a 'CD4 PANEL' order that occurred after the last CD4 result in the EMRs, we took it that the result was still pending. The last date on which the 'CD4 PANEL' was ordered was then be used to determine whether a reminder should be generated or not. To improve the utility of the concept dictionary, we facilitated communication between the staff tasked with maintaining the concept dictionary and the CDSS developer group. We also created a wiki page for new concepts related to our reminders. Delays in entering laboratory results into EMRs were solved by hiring additional data-entry clerks who helped to catch up on results for the Module 2 clinic. More importantly, we have now implemented a laboratory information system, which automatically transfers laboratory results via HL7 into our EMRs. This has alleviated problems related to delayed entry of results and possible errors related to data entry.

We know to 'err is human' and thus it is anticipated that some errors will occur at multiple steps in the data-acquisition and data-entry process. A way to reduce this problem is to cut down the number of steps it takes for data to be entered into the system. This could involve using handheld devices, or touch screen devices, or having providers directly interact with the computers. These options were not feasible in our setting, and we ended up having a manual data-quality checking and feedback mechanism. Clinicians could mark all errors they found on reminders, and data-entry clerks could note errors found on encounter forms. A dedicated data manager then made corrections in the EMRs, and communicated the action to all involved providers and data-entry clerks. In essence, we started using our CDSS as a way to improve the quality of data stored in our system.

4.3. Providers ignoring accurate reminders

Causes: On several occasions, providers indicated that they simply did not agree with the reminders or did not want the computer to dictate to them what they should do. Some providers had rote practice patterns which they were unwilling to change. Others were simply unaware of the approved algorithms for CD4 testing, and thought that the computer had made a mistake. This was paradoxical—the deficiency of knowledge among providers, which was one of the main reasons for implementing CDSS, turned out to be one of the main reasons why the reminders were subsequently ignored.

Remedies: We learned that simply implementing CDSS without adequate training of providers could cause problems. At the end of the day, providers should have the final say about clinical decisions. However, for them to comply with the reminders, they need to be informed about the rationale behind each reminder. In fact, having reminders provides the perfect opportunity to educate the providers on standards of care. We have since conducted aggressive training to make our providers aware of the CD4 testing algorithms. In the future, as we incorporate more reminders, we will create a dedicated resource to provide as-needed information about any of the reminders. We will also incorporate infobuttons into our CDSS [18].

With the remedies outlined above, the new CDSS has now been in use for over eight months (since January 2009). All providers within the clinic rate the reminders very highly, and are asking for even more reminders/alerts to be included in clinical summaries.

5. Discussion

We have successfully implemented a CDSS system that generates reminders for overdue CD4 count checks in a clinic in the resource-limited setting of Western Kenya. While this might be one of the few successful CDSS implementations in a developing country setting, this success did not come very easily. In fact, to make this system work, we had to backtrack on our initial approaches, and adapt to the constraints within our environment.

To implement CDSS well in a resource-limited setting, technology is but one small part of a larger equation. The technology used has to be right for the setting and has to conform to the workflow. We are forced to use paper-based reminders since our providers have little interaction with the computer system. The team developing CDSS has to be in close touch with those maintaining the concept dictionary and versions of encounter forms—this will ensure that the CDSS system is programmed to meet the exact format with which the data is being stored.

Having a clinician champion and leader who works closely with the CDSS group and is respected by colleagues can help to improve uptake of reminders [19]. There is also a major role for constant feedback with providers, so that even after implementation, problems get addressed in good time. Despite having piloted our intervention initially with a limited group of providers, it became evident that new errors and scenarios emerged once the system was in wider use. Clinical summaries and reminders offer the opportunity to improve care for patients and serve as a tool to improve the quality of data stored in EMRs. A well-established feedback mechanism is needed to ensure that errors identified are expeditiously corrected.

The difficulties experienced implementing clinician-directed decision support demonstrate that other approaches for delivering care suggestions need to be strongly considered when implementing CDSS. These approaches could include patient-directed reminders and decision aids [20,21] or care-alerts delivered in batches to a dedicated provider responsible for dealing with them. Reminders could also be displayed on a computer terminal or delivered to a mobile device. In addition, there needs to be further elaboration of the logic infrastructure within OpenMRS to make it easier to develop and maintain rules within this system. The use of reference terminologies like SNOMED should also be considered to facilitate easier maintenance of the rules.

Summary points
What was already known on the topic

- Electronic Medical Record Systems and Decision Support Systems have the potential to improve efficiency and quality of care offered.
- More electronic medical record systems are being implemented in resource-limited settings.

What this study has added

- Implementing clinical decision support systems in resource-limited settings comes with unique challenges.
- Iterative improvements with constant feedback are useful tools for successful adoption of decision support systems in resource-limited settings.

The findings from our failure analysis informed the changes that were needed in our CDSS implementation. By addressing the problems discovered, we now have a stable CDSS system that has been in use at the clinics for over eight months. We are currently evaluating the impact of the reminders on adherence to CD4 testing guidelines as a way to determine success of the CDSS implementation. Demonstrating the value of EMRs through CDSS will go a long way in helping these systems effectively compete for the limited financial resources in resource-poor settings.

6.   Conclusions

Successfully implementing CDSS in resource-limited settings requires the ability to recognize and adapt to the special needs of these settings. Attention has to be paid to infrastructure issues, dictionary maintenance, time-lapse before data makes it to the system, errors within the database, and interpersonal interaction and training of the staff targeted by the decision-support intervention.

Author's contributions

Sheraz F. Noormohammad: Acquisition of data, analysis and interpretation, drafts and revision of article, and final approval for submission.

Burke W. Mamlin: Critical revisions, development of intervention, and final approval for submission.

Paul G. Biondich: Critical revisions, development of intervention, and final approval for submission.

Brian McKown: Data acquisition, analysis and interpretation, and final approval for submission.

Sylvester Kimaiyo: Development of intervention, revisions of article, and final approval for submission.

Martin C. Were: Study design, acquisition of data, analysis and interpretation, drafts and revision of article, and final approval for submission.

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