Electronic medical records and clinical Decision Support Systems in HIV care in resource-limited settings

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Chapter 5

The effect of electronic medical record-based clinical decision support on HIV care in resource-constrained settings: A systematic review


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Co-authors’ contribution

T. Oluoch, A. Abu-Hanna and N. de Keizer conceptualized the systematic review and formulated the search criteria. T. Oluoch and N. de Keizer conducted the literature review, scoring and classifying the articles included in the review. T. Oluoch, X. Santas, D. Kwaro and N de Keizer drafted the manuscript. M. Were, P. Biondich and C. Bailey edited the manuscript and provided input on studies resource-limited context. All co-authors edited and reviewed the final manuscript and consented to its publication.
Abstract

Background
It is estimated that one million people infected with HIV initiate anti-retroviral therapy (ART) in resource-constrained countries annually. This occurs against a background of overburdened health workers with limited skills to handle rapidly changing treatment standards and guidelines hence compromising quality of care. Electronic medical record (EMRs)-based clinical decision support systems (CDSS) are considered a solution to improve quality of care. Little evidence, however, exists on the effectiveness of EMR-based CDSS on quality of HIV care and treatment in resource-constrained settings.

Objective
The aim of this systematic review was to identify original studies on EMR-based CDSS describing process and outcome measures as well as reported barriers to their implementation in resource-constrained settings. We characterized the studies by guideline adherence, data and process, and barriers to CDSS implementation.

Methods
Two reviewers independently assessed original articles from a search of the MEDLINE, EMBASE, CINAHL and Global Health Library databases until January 2012. The included articles that evaluated or described the implementation of EMR-based CDSS that were used in HIV care in low-income countries.

Results
A total of 12 studies met the inclusion criteria, 10 of which were conducted in sub-Saharan Africa and 2 in the Caribbean. None of the papers described a strong (randomized controlled) evaluation design.

Guideline adherence: One study showed that ordering rates for CD4 tests were significantly higher when reminders were used.
Data and process: Studies reported on reduction in data errors, reduction in missed appointments, reduction in missed CD4 results and reduction in patient waiting time. Two studies showed a significant increase in time spent by clinicians on direct patient care.
Barriers to CDSS implementation: Technical infrastructure problems such as unreliable electric power and erratic Internet connectivity, clinicians’ limited computer skills and failure by providers to comply with the reminders are key impediments to the implementation and effective use of CDSS.

Conclusion
The limited number of evaluation studies, the basic and heterogeneous study designs, and varied outcome measures make it difficult to meaningfully conclude on the effectiveness of CDSS on quality of HIV care and treatment in resource-limited settings. High quality evaluation studies are needed. Factors specific to implementation of EMR-based CDSS in resource-limited setting should be addressed before such countries can demonstrate its full benefits. More work needs to be done to overcome the barriers to EMR and CDSS implementation in developing countries such as technical infrastructure and care providers’ computer illiteracy. However, simultaneously evaluating and describing CDSS implementation strategies that work can further guide wise investments in their wider rollout.
5.1 Introduction

The 2010 Progress Report “Towards Universal Access” for HIV services reported that 5.25 million people infected with HIV in low-middle income countries were receiving life-saving antiretroviral therapy (ART) at the end of 2009, representing an increase of 1.2 million people since December 2008 [1]. The greatest proportion of these patients (74%) were in sub-Saharan Africa. HIV/AIDS is a chronic disease and treatment guidelines require that patients on ART visit health care providers monthly, resulting in ongoing collection of longitudinal data to monitor treatment [2, 3, 4]. Case finding, enrolling in pre-ART care, tracking CD4 levels regularly, starting ART treatment, ensuring adherence and monitoring side effects are essential components of HIV care. The rapid annual increase in number of patients in a setting of overworked clinical staff with limited training potentially compromises quality of care and requires solutions that enable optimal care provision. Electronic medical record (EMR) systems are considered to be such a solution, especially when they support the implementation of guidelines through Clinical Decision Support Systems (CDSS) [5, 6].

The use of EMR-based CDSS has been shown to improve quality of health care. This has been demonstrated through better diagnosis, reduced medication errors [5, 7] and improved practitioner performance [8]. Studies conducted in the US and other developed countries have shown that CDSS can improve quality of HIV care through improved compliance with guidelines [9, 10]. On the other hand, a systematic review by Tawadrous et al. showed that many studies were often limited by the evaluation method used and benefits can only be reported selectively [11].

The increasing number of patients enrolling on HIV treatment has led to an increase in the number of EMRs developed to document, monitor and manage patient care in developing countries [6]. As with other health care innovations, EMRs and CDSS must be rigorously evaluated to establish their benefits before scaling up their use in clinical practice. Many systematic reviews on CDSS that have been conducted and published such as [8, 11, 12], describe experiences from developed countries. None has so far focused on resource-constrained settings where unique challenges and barriers to implementation of EMRs are encountered. To justify further investment of resources from a highly competitive funding environment for the development and implementation of EMRs with CDSS in resource-poor countries, evidence on their benefits, barriers and overall impact on health outcomes is needed.

We conducted a systematic literature review to identify published original studies on EMR-based CDSS describing process and outcome measures as well as reported barriers to their implementation in resource-constrained settings. We characterized the studies by adherence to clinical guidelines, data and process, and implementation barriers.

5.2 Methods

In this review, CDSS is defined as a computerized information system that matches individual patient characteristics to a computerized knowledge base or software algorithms to generate patient-specific and aggregate recommendations. The recommendations are delivered to the clinician via, for example, computer screen monitors, mobile phones, or printouts in patient notes as alerts or reminders.
We searched for original articles in English using MEDLINE, EMBASE, CINAHL and The Global Health Library (GHL) databases. All studies published prior to the search date (January 2012) were included. Figure 5.1 shows the two search strategies used and the corresponding profile for the searches. In strategy 1, keywords and Medical Subject Heading (MeSH) terms indicative of Electronic Medical Records (A) were combined with terms related to Decision Support Systems (B) and infectious or chronic diseases (F), including HIV and TB (D and E respectively). In strategy 2, keywords and MeSH terms currently used to refer to EMRs (A), Decision Support Systems (B) mobile systems (C) and infectious or chronic diseases (F) including HIV (D) and TB (E). The results of these two strategies were combined using the boolean operator “OR”.

The inclusion criteria were:

(i) The study must describe or evaluate an implementation of an EMR-based CDSS
(ii) EMRs must be used to provide care to persons with an infectious or chronic disease (including HIV or TB)
(iii) The study should have been conducted in a resource-constrained setting

Two reviewers (TO and NdK) independently examined the titles and abstracts to ensure they met the inclusion criteria. In case of discrepancies, a decision whether to include the paper or not was arrived at through consensus. Articles that did not have an abstract or the abstract contained insufficient information to inform the decision to include or exclude were retained and the full text articles were downloaded for more detailed review. Papers published in conference proceedings were considered, but only if there was no full journal paper on the same study available. A manual scanning of the references from identified review articles was conducted to complete the search.

5.2.1 Data abstraction

Full text articles from all studies that met the inclusion criteria above were scored. We developed a standardized data abstraction checklist containing 23 attributes/variables (see Table 5.1). The scores from the two reviewers were compared and discrepancies resolved by consensus. Cohen’s Kappa coefficient was used to measure the inter-rater agreement on the inclusion or exclusion of the articles. We sent the key variables abstracted to the corresponding authors of the articles included in the review for validation.

5.3 Results

5.3.1 Search

The initial scan based on our search strategies resulted in 2,020 articles, which included 1,981 original papers and 39 systematic reviews. The titles and abstracts for the 2,020 articles were scanned and 1,953 articles were excluded because the primary subject was not EMR/CDSS, the studies were not clearly associated with patient care or guidelines, the studies were conducted in a developed country or the study did not mention use of any clinical information system. Two additional studies were included following manual scanning of bibliographies of included articles. The remaining 69 articles were read for full text review.
Figure 5.1: Keywords and MeSH terms used in the search strategies.

### Electronic Medical Records:
1. Electronic Medical Record
2. Electronic Health Record
3. Patient Monitoring Systems
4. Computerized Medical Record

### Decision Support Systems:
1. Decision Support Systems
2. Clinical Decision Support Systems
3. Computerized Decision Support Systems
4. Computerized Alert systems

### Mobile Services:
1. Handheld
2. Cell phone
3. Mobile phone
4. SMS
5. Short message service
6. 1 or 2 or 3 or 4 or 5

### HIV:
1. AIDS Virus
2. Human Immunodeficiency Virus
3. Human T Lymphotropic Virus Type III
4. Human T-Cell Leukemia Virus Type III
5. Lymphadenopathy-Associated Virus
6. Acquired Immune Deficiency Syndrome Virus
7. Acquired Immunodeficiency Syndrome Virus

### Infectious or chronic Diseases:
1. Infectious Diseases
2. Communicable diseases
3. Chronic illness
4. Chronic disease
5. 1 or 2 or 3 or 4

### Search Strategy 1:
(A1 OR B1) AND (D2 OR E1 OR F5)

### Search Strategy 2:
(A1 OR C6) AND B1 AND (D2 OR E1 OR F5)

Bold texts indicate the keywords, MeSH terms or combination of keywords used in the search. For example: using the MeSH term **Decision Support Systems (B1)** in the search engine also searches for other the keywords in the same box (i.e. Clinical Decision Support Systems and Computerized Decision Support Systems).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Valid values</th>
<th>Variable</th>
<th>Valid values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Location</td>
<td>Sub-Saharan Africa, Latin America, Asia, Europe/N. America</td>
<td>13 Data entry(^a)</td>
<td>Clinicians, nurses, data clerks, other</td>
</tr>
<tr>
<td>2  Point_of_use</td>
<td>Inpatient, outpatient, in/outpatient</td>
<td>14 EMR users</td>
<td>Clinicians, nurses, other</td>
</tr>
<tr>
<td>3  Patient population</td>
<td>adults, children, adults and children</td>
<td>15 Duration of CDSS use</td>
<td>&lt;6 months, 6 months – 1 year, 1 – 2 years, 2 – 5 years, 5 – 10 years, &gt;10 years</td>
</tr>
<tr>
<td>4  Type of health facility</td>
<td>Government, private, faith-based</td>
<td>16 CDSS use(^a)</td>
<td>Diagnosis, medication, appointments, other</td>
</tr>
<tr>
<td>5  Year of study</td>
<td>&lt;1995, 1995-2011</td>
<td>17 CDSS implementation</td>
<td>Alerts, reminders, complex DSS, other</td>
</tr>
<tr>
<td>6  Developer(^b)</td>
<td>In-house, third party, vendor</td>
<td>18 Type of CDSS(^c)</td>
<td>Active, passive</td>
</tr>
<tr>
<td>7  Implementation</td>
<td>Standalone, networked</td>
<td>19 Type of data</td>
<td>Individual patient level, aggregate, individual/aggregate</td>
</tr>
<tr>
<td>8  Data collection</td>
<td>Paper, electronic, paper/electronic</td>
<td>20 Type of study</td>
<td>Evaluation, EMR description</td>
</tr>
<tr>
<td>9  Data collection by</td>
<td>Clinicians, nurses, clinicians/nurses, other clinical staff</td>
<td>21 Study design</td>
<td>RCT, pre-post, descriptive, cross-sectional, qualitative, other non-randomized</td>
</tr>
<tr>
<td>10 EMR Deployment</td>
<td>Paper, electronic, paper/electronic</td>
<td>22 Evaluation indicators</td>
<td>Process indicators, system performance, data quality, system usability</td>
</tr>
<tr>
<td>11 Duration of EMR use</td>
<td>&lt;6 months, 6 months – 1 year, 1-2 years, 2-5 years, 5-10 years, &gt;10 years</td>
<td>23 Outcome measures</td>
<td>Free text response</td>
</tr>
<tr>
<td>12 EMR use(^c)</td>
<td>Patient management, information management, national reporting, research</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) More than one category can be selected
\(^b\) We defined third party systems as those that were developed by another institution than the one hosting the system
\(^c\) We defined active alerts as those that launched proactively as soon as a pre-defined condition was encountered, while passive alerts were described as those that the user had to find.
**Figure 5.2: Search strategies and search results**

* - Search Strategy 1
** - Search Strategy 2
Based on full paper review, 17 articles were excluded because they did not describe an EMR or CDSS. This included 4 papers describing the use of cell phone reminders to enhance adherence to medication but the cell phone use was not linked to an EMR. Three other articles were excluded because the EMR/CDSS were not described or evaluated in the articles although the articles described studies in which EMRs were used to provide data. An additional 11 studies were excluded as they did not indicate a link between CDSS use and patient care or implementation of clinical guidelines. Finally, we excluded 21 studies conducted in developed countries as well as 4 systematic reviews and commentaries. The inter-rater agreement on the inclusion or exclusion of the 69 articles that we read for full text review was substantial (κ=0.696). Figure 5.2 shows a flowchart of the inclusion process. Table 5.2 shows a list of the 12 articles included in our review.

5.3.2 Study settings

Ten of the twelve studies included in the review were conducted in sub-Saharan Africa (Kenya – 4, Rwanda – 3, Uganda – 2, Botswana – 1) and two in the Caribbean (Haiti). Five of the studies described EMRs implemented in inpatient and outpatient departments while another five articles described systems that were only implemented in outpatient departments. In many of the studies, the EMR supported care and treatment for all HIV patients (pediatric and adult) except in 3 cases which were based on adult HIV clinics and two where the population of the patients served was unclear. All selected studies were conducted between 2003 and 2011.

5.3.3 EMR deployment and use

Nearly all systems (10 out of 12) were developed by a third party entity (see footnote in Table 5.2) and deployed in a computer networked environment. Regenstrief Institute (n= 5) and Partners In Health (n=5) were key implementers in the studies included in this review. Both institutions were involved in developing the OpenMRS [13] which succeeded the AMPATH Medical Records Systems (AMRS) [14]. Although the core data model for OpenMRS is the same, the implementation of the system at different study sites varied. Data capture was mainly on paper (8 out of 12). Direct data entry by clinicians at the point of care was described in only one study [15]. The majority of data entry was conducted after patient encounters by data clerks (n=9). Data capture was occasionally done by clinicians (3 out of 12), and in a few cases by nurses. The deployment of EMRs is a combination of paper-capture and computer entry for electronic storage and manipulation.

The systems were used predominantly by clinicians (12 out of 12) for patient management, information management (9 out of 12), for reporting to ministry of health or donors (9 out of 11) and for research (5 out of 11). Other EMR users mentioned in the studies were nurses, researchers, laboratory staff, outreach/social workers, pharmacists, clinic managers and counselors. All, except two studies [16, 17], described an EMR installation at government-owned health facilities. Systems had different levels of maturity when the studies were conducted. The duration of system installation ranged from 6 months to 5 years.

5.3.4 Clinical decision support systems deployment and use

The CDSSs’ feedback was implemented as alerts (5 studies) or reminders (6 studies). One of the studies did not explicitly indicate how CDSS was implemented. In studies conducted by
institutions collaborating with The Regenstrief Institute (n=5), all using OpenMRS, the Arden syntax [18] was used to implement the decision support functionality. In 5 out of 11 cases the alerts and reminders were active, i.e. they were launched proactively as soon as a pre-defined condition was encountered. In the other 5 cases the alerts and reminders were passive, i.e. the user had to request advice. One study [19] did not describe how the CDSS was implemented and could therefore not be classified.

CDSS was mainly implemented to provide alerts and reminders for laboratory orders. In 7 out of 12 studies, reminders and alerts were related to CD4 ordering. Only two studies described the use of CDSS on medication prescription [16, 20]. Fraser et al. describe an alert based CDSS implementation that doctors can use to check the drugs and their doses, allergies and incompatible drug combinations [15], while Sika et al. describe how they have used their system to track medication history, including past and current use of highly active antiretroviral therapy (HAART) [20]. Three studies explicitly described CDSS use for appointments and follow-up of patients who missed scheduled appointments (i.e., defaulting patients) [19, 20, 21]. Decision support systems were implemented at the individual patient level as well as an aggregate level. At the individual level, trends in physical examination, signs and symptoms, and laboratories results were monitored. Although 5 out of 12 articles indicated that aggregate level summaries were produced by the respective systems, they did not describe the indicators generated and how they were used to improve quality of care.

5.3.5 Outcome measures

The majority of the studies (6 out of 12) were descriptive studies and outcome measures were not used or clearly stated. None of the papers described a randomized controlled design to evaluate the impact of CDSS in providing care to HIV patients. In the few cases where they were explicitly mentioned [4, 22, 23, 24, 25], the main outcome measures were error reduction, CD4 ordering rate and time taken by providers to see patients. Table 5.3 summarizes the key outcome measures.

5.3.5.1 Guidelines adherence

Were et al. showed significantly higher ordering rates for CD4 tests in the CDSS intervention clinic compared to the control clinic (53% vs. 38%, OR=1.80, CI 1.34 to 2.42, p<0.0001) [25].

5.3.5.2 Data and process

Although data accuracy is not explicitly included in clinical guidelines, it is an important aspect that contributes to quality of care because providing accurate information about the patient’s diagnosis, medications, and vital signs are essential for monitoring response to treatment and key health outcomes [26, 27]. Amoroso et al. concluded that the implementation of OpenMRS in Rwanda resulted in a 92% reduction in defined data errors and a 32% reduction in the number of CD4 cell counts that did not reach the clinician [22]. Allen et al. also reported a reduction in data errors although the proportion was not stated [23]. A clinical summary generated by an EMR was shown to improve the quality of data stored in the EMRs [4]. Alamo et al. showed a significant reduction in the mean number of missed appointments from 21 pre-EMR to 8 post-EMR (t_{100} = 15.31, p<0.001). They also showed a reduction of missed appointments as a result of loss to follow-up from 10.9% to 4.8% (p= 0.001) [17].
<table>
<thead>
<tr>
<th>#</th>
<th>Author</th>
<th>Location</th>
<th>Patient population</th>
<th>Study design</th>
<th>Type of CDSS</th>
<th>Outcome measures</th>
<th>Results/Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Noormohammad <em>et al.</em>[28]</td>
<td>Sub-Saharan Africa, Kenya</td>
<td>96,000</td>
<td>Qualitative</td>
<td>Reminders</td>
<td>Reasons for not using reminders for decision support</td>
<td>Essentials for a successful EMR are: adequate infrastructure, dictionary maintenance, data quality and staff training.</td>
</tr>
<tr>
<td>2</td>
<td>Tierney <em>et al.</em>[21]</td>
<td>Sub-Saharan Africa, Kenya</td>
<td>45,000</td>
<td>Descriptive</td>
<td>Reminders</td>
<td>None</td>
<td>The main incentive for clinicians to complete encounter forms is if it meets their information needs. EMRs contribute positively to HIV patient care. Inadequate skilled staff hinders implementation of EMRs.</td>
</tr>
<tr>
<td>3</td>
<td>Siika <em>et al.</em>[20]</td>
<td>Sub-Saharan Africa, Kenya</td>
<td>4,000</td>
<td>Descriptive</td>
<td>Reminders</td>
<td>None</td>
<td>Standardized patient data collection, faster data retrieval, evidence based decision making and patient care are essential to success EMR implementation.</td>
</tr>
<tr>
<td>5</td>
<td>Amoroso <em>et al.</em>[22]</td>
<td>Sub-Saharan Africa, Rwanda</td>
<td>10,000</td>
<td>Pre-post</td>
<td>Alerts</td>
<td>Error reduction (data quality), trends in CD4 and weights</td>
<td>Multiple strategies are needed for EMR data quality. Automated and user friendly tools assist data quality and improved clinical care.</td>
</tr>
<tr>
<td>6</td>
<td>Allen <em>et al.</em>[24]</td>
<td>Sub-Saharan Africa, Rwanda</td>
<td>800</td>
<td>Descriptive</td>
<td>Alerts</td>
<td>None</td>
<td>Describes flexible configuration, extensibility and multiple language implementations.</td>
</tr>
<tr>
<td>7</td>
<td>Allen <em>et al.</em>[23]</td>
<td>Sub-Saharan Africa, Rwanda</td>
<td>3,400</td>
<td>Descriptive</td>
<td>Alerts</td>
<td>Error reduction (data quality), timely data access</td>
<td>Combining functionality for patient data recording and display, reporting, and quality control in one system reduces the cost and complexity of setting up and maintaining the data management processes.</td>
</tr>
<tr>
<td></td>
<td>Authors</td>
<td>Location</td>
<td>Study Type</td>
<td>Summary Type</td>
<td>Summary</td>
<td>Time for patient care and length of patient visit.</td>
<td>EMR-based, patient-specific clinical summaries were associated with improved clinic efficiency and shorter patient visits.</td>
</tr>
<tr>
<td>---</td>
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<td>-------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8.</td>
<td>Were et al. [4]</td>
<td>Sub-Saharan Africa, Uganda</td>
<td>Pre-post</td>
<td>Clinical Summary</td>
<td>Pre-post</td>
<td>Time for patient care and length of patient visit.</td>
<td>EMR-based, patient-specific clinical summaries were associated with improved clinic efficiency and shorter patient visits.</td>
</tr>
<tr>
<td>9.</td>
<td>Alamo et al. [17]</td>
<td>Sub-Saharan Africa, Uganda</td>
<td>Pre-post</td>
<td>Alerts</td>
<td>Missed appointments, patients lost to follow-up</td>
<td>CDSS contributed to a significant reduction in number of appointments missed as well as the number of patients lost to treatment follow-up.</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Jazayeri et al. [16]</td>
<td>Caribbean, Haiti</td>
<td>Descriptive</td>
<td>Alerts</td>
<td>None</td>
<td>EMRs aid clinical and operational research.</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Fraser et al. [15]</td>
<td>Caribbean, Haiti</td>
<td>Descriptive</td>
<td>Reminders</td>
<td>None</td>
<td>Lack of infrastructure, including ICT remains a major challenge to the implementation of EMRs in resource poor settings. However, innovative solutions can be used to track clinical outcomes, laboratory tests and drug supplies.</td>
<td></td>
</tr>
</tbody>
</table>
Table 5.3: Outcome measures of evaluations in included studies.

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Article</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Guideline adherence:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Clinical compliance with CD4 testing</td>
<td>Were et al [25]</td>
<td>Increased CD4 ordering rate from 42% to 63%.</td>
</tr>
<tr>
<td>• Loss to follow-up</td>
<td>Alamo et al [17]</td>
<td>A reduction in loss to follow-up of patients from 10.9% to 4.8%.</td>
</tr>
<tr>
<td><strong>Data and process:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Data errors</td>
<td>Amoroso et al [22]</td>
<td>92% reduction in defined data errors.</td>
</tr>
<tr>
<td>• Data access</td>
<td>Allen et al [23]</td>
<td>Reduction in data error rate not quantified.</td>
</tr>
<tr>
<td>• Patient visit time</td>
<td>Allen et al [23]</td>
<td>Reduction in data access and communication time not quantified.</td>
</tr>
<tr>
<td>• Missed appointments</td>
<td>Alamo et al [17]</td>
<td>10 minute (23%) reduction in patient visit time.</td>
</tr>
<tr>
<td>• Patient waiting time</td>
<td>Alamo et al [17]</td>
<td>11.5 minute reduction in patient visit time.</td>
</tr>
<tr>
<td>• Providers' free time</td>
<td>Tierney et al [21]</td>
<td>Daily missed appointments reduced from 21 to 8.</td>
</tr>
<tr>
<td>• Providers' time on direct patient care</td>
<td>Were et al [4]</td>
<td>Patient waiting time to see nurses reduced from 56 min to 38 min.</td>
</tr>
<tr>
<td>• CD4 result not reaching clinician</td>
<td>Amoroso et al [22]</td>
<td>Increase in provider free time from 15% to 46% of workday.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26% increase in time spent on direct patient care (from 2.3 min to 2.9 min).</td>
</tr>
<tr>
<td><strong>Barriers to Implementation:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reasons for failure of reminder systems</td>
<td>Noormohammad et al [28]</td>
<td>Delayed data entry and pending test results, wrong data inadvertently entered, inadequate training of providers and resources-related issues.</td>
</tr>
<tr>
<td>• Challenges to EMR implementation</td>
<td>Fraser et al [12]</td>
<td>Lack of infrastructure, including ICT.</td>
</tr>
</tbody>
</table>
Were et al. reported a statistically significant increase in time spent by providers on direct patient care after the installation of EMR-based clinical summaries (2.9 min vs. 2.3 min, \( p < 0.001 \)) [4]. Returning patients spent 11.5 min less time per visit after implementation of the Patient Summary Reports compared with the pre-intervention period when the OpenMRS encounter forms were used but no summaries were printed (197.7 min before vs. 186.2 min after, \( p < 0.001 \)) [4]. Alamo et al. showed significant reductions in waiting time to see the nurses (38 min post-EMR vs. 56 min pre-EMR; \( Z = -5.13, \ p < 0.001 \), and the time to see the pharmacy technician (11 min post-EMR vs. 45 min pre-EMR; \( Z = -7.25, \ p < 0.001 \)). However, there was an increase in waiting time to see the laboratory technician (42 min post-EMR vs. 15 min pre-EMR; \( Z = 4.35, \ p < 0.001 \)) [17]. The computerized reminder system identified encounters with overdue CD4 tests (21%) [25].

5.3.5.3 Barriers to CDSS implementation

Infrastructural obstacles were reported as barriers to the implementation of EMRs and hence CDSS. These include unstable electrical power, loss of Internet connectivity, and access to mobile phones. Humidity, dust, and security concerns were also indicated as barriers [15, 16, 19, 21].

Low literacy and poor training of health workers on use of computerized information systems including EMRs remains a major challenge. Skills to extract and analyze data for patient care and research were limited [15, 20]. Tierney et al. noted that inadequate training on medical informatics to EMR developers and health managers remains a major problem [21].

Clinicians often fail to adhere to reminders and alerts for various reasons. Noormohammad et al. reported some factors that are potential barriers to clinician’s using CDSS, specifically, unreliable generation of summaries and reminders, generation of inaccurate reminders, and failure by providers to comply with accurate reminders [28]. Were et al. reported that some clinicians simply disregarded reminders. However, educating them on reminders improved acceptance rates [25].

5.3.6 Quality of study methodology:

Eight of the twelve studies were descriptive and the remaining four had a quasi-experimental study design conducted in single sites. The studies had several limitations such as small sample size, short follow-up period, potential systematic bias, and the majority had no explicit outcome measure.

5.4 Discussion

Our systematic literature review identified twelve studies meeting our inclusion criteria, 10 of which were conducted in sub-Saharan Africa and the other two in the Caribbean. The three studies that reported quantitative evaluation of the effect of CDSS on quality of care showed statistically significant improvement in compliance with ordering critical laboratory investigation (CD4 tests), an increase in time spent directly with patients in health care provision, and a reduction in missed appointments, respectively [4, 17, 25]. The majority of the studies showed that data capture was mainly on paper by clinical staff. Direct data entry into the EMR by
clinicians during consultations was only reported in one study [15] possibly indicative of the very limited use of CDSS at the point of care in resource-constrained settings.

Adherence to clinical practice guidelines is essential for quality provision of health care. Despite efforts and resources invested in developing and disseminating these guidelines, practitioners still ignore them [29]. We found effects of EMR-based CDSS on improved adherence to guidelines related to CD4 ordering and results reaching the clinician, reduction in data errors, and reduction in missed appointments [4, 17, 22] are consistent with work done in the US and other developed countries [9, 30, 31]. Garg et al. showed that CDSS can potentially improve practitioner performance in developed countries [8]. Studies in our review described an increase in the amount of time spent on direct patient care and a reduction in time spent by patients waiting to see the nurse and pharmacists [4, 17]. Alamo et al. indicate an increase in waiting time to see the laboratory technologists. It is not clear from the paper whether laboratory orders were made electronically using a computerized physician order entry (CPOE) hence it is difficult to assess the extent to which the EMRs negatively impacted the waiting time. Published work done elsewhere shows that the use of CPOE generally improves waiting time at the laboratory [32].

Several barriers to CDSS implementation were mentioned in our included articles. Infrastructure problems, clinicians' limited computer skills, and failure by providers to comply with the reminders are key impediments to implementation and effective use of CDSS. These are quite different from the reasons for not using CDSS in developed countries which include inability to type quickly, reduced eye contact with patients, false alarms and preference to write in long prose [33, 34]. Health facilities in resource-constrained settings encounter unique human resources and infrastructure challenges that are not necessarily experienced in developed countries [35, 36]. This underscores the need for innovative solutions such as power backup and “offline” systems that are appropriate for resource-limited settings [15, 16].

The small number of evaluation studies and the basic evaluation designs show the premature status of implementation and evaluation studies on EMR and CDSS in resource-limited settings despite an annual investment of nearly $1 billion globally on health systems through global health initiatives such as the US President’s Emergency Plan for AIDS Relief (PEPFAR) [37] and the Global Fund to fight against AIDS, TB and Malaria (GFATM) [38] since 2003. Implementation of CDSS in developing countries is still uncommon. Two recent systematic reviews by Bryan et al. and Fraser et al. reiterated the need for comprehensive evaluations of CDSS as the use of EMRs in resource-limited settings continues to expand in a standards-based, sustainable manner based on appropriate technologies [39, 40]. More work needs to be done to overcome the barriers to EMR and CDSS implementation in developing countries – including capacity building on health informatics, and simultaneously evaluating and describing CDSS implementation strategies that work in order to inform wise use of limited resources.

Our review was limited by several factors. The studies included in our review were conducted in single sites and the findings may not be easily generalizable. Although we used an extensive search strategy on multiple literature databases we found a small number of evaluation studies meeting our inclusion criteria. Ten of the twelve studies evaluated OpenMRS thereby limiting the generalizability of the findings. The heterogeneity in terms of study designs and outcome measures made it impossible to meaningfully conclude on the effectiveness of CDSS on quality
of HIV care and treatment in resource-limited settings. High quality evaluations grounded on solid scientific principles such as those described in Good Evaluation Practice in Health Informatics (GEP-HI) [41] should be conducted to inform decisions on the most appropriate implementations of systems that work in the developing world. Clear clinical care process and outcomes measures should be defined when conducting such studies.
Reference list


32. Baron JM, Dighe AS. Computerized provider order entry in the clinical laboratory. *J Pathol Inform* 2011; **2**:35.


