Benefits and Challenges of Implementing an Electronic Medical Record System in an Urban Slum in Kenya

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Abstract

This Thesis consists of two papers that explore the use of Electronic Medical Record (EMR) systems in resource-limited settings. The first paper (Chapter 2) comprises a State-of-the-Art review of the types of inquiry, settings, interventions and principal findings reported from studies of the benefits, challenges and impact of EMRs in resource-constrained environments in Sub-Saharan Africa. A systematically developed search strategy was applied to formal bibliographic databases and to grey literature retrieved with Internet search engines to yield 946 distinct communications. These were classified by literature type, method of inquiry, setting, interventions and outcomes. A subset of the most applicable articles was reviewed for principle findings from which an analytic framework was derived. This classified current knowledge into claims about the effects of systems (e.g., power, Internet, network infrastructure), people (e.g., recruitment and retention), processes (e.g., training, change management) and products (e.g., software features, user interface).

The second paper (Chapter 3) reports use of descriptive qualitative methods to explore perceptions of front-line staff about the use, benefits, challenges and impact of an EMR deployed in two primary care clinics in Kibera, one of East Africa's largest urban slums. Observations were categorized, then grouped into three major themes relating to matters of infrastructure, software, and social and organizational. One overarching theme, sustainability, permeated all categories. Although the diverse Kibera infrastructure and software challenges might have been anticipated from knowledge about conditions for successful EMR implementation, an unequivocal participant emphasis on organizational (social and cultural) considerations yielded specific observations about unique challenges to EMR use in slum settings. These and other

observations were combined to form a pre- and post-implementation checklist. The checklist summarize learnings from both the literature review and the field study.

Given the paucity of published reports about EMR effects in slum settings, this work will hopefully be of particular interest to clinicians and organizations working in resource-constrained settings. Many of the benefits and challenges found in this study resonate with observations originating in developed countries. Unique field findings reported here may facilitate the design and conduct of future studies about barriers and facilitators to EMR use in slum settings.

Preface

This MSc Thesis submission is the product of my independent work, with invaluable guidance, oversight and review by my thesis committee:

- Robert Hayward (RH) – Supervisor
- David Zakus (DZ)
- Louanne Keenan (LK)
- Dave Ludwick (DL) – Advisor

The idea for a study of Electronic Medical Record experiences in disadvantaged settings originates with my participation in philanthropic work in the Kibera slum of Nairobi, Kenya. The Thesis purpose, scope and conduct was led by me while benefiting from frequent review and input from my supervisor and thesis committee. The State-of-the-Art review (Chapter 2) was designed and conducted by myself, guided by my supervisor (RH) with input from committee members (DZ, DL and LK). The design and preparation for a field study in Kibera (Chapter 3) likewise originated with me and benefited from many adjustments recommended by committee members. The analysis of collected data particularly benefited from qualitative inquiry coaching (LK).

The field study was reviewed and approved by the University of Alberta Research Ethics Board (Pro00051485) and by AMREF Ethics and Scientific Review Committee (ESRC), in Kenya (AMREF-ESRC P162/2015). All participants provided written informed consent.

Some financial and in-kind resources supporting Kibera field work were provided by Innovative Canadians for Change. Other general financial support for thesis work was provided by Mitacs through the Mitacs Accelerate Program, the Division of General Internal Medicine in the Department of Medicine, University of Alberta, with the particular agency of the Patient Health Management (Sumit Majumdar) and Clinical Informatics (RH).

Dedication

To the strong women in my life who continue to inspire me: Naila Jawhari and Khaloud Jawhari. You are my rock, my strength, my everything.

To the women and peers in the health informatics and business disciplines: continue to persevere and support each other. Pave the way and create the ripple effect for those who come after you.

To all those living in slums, vulnerable environments and challenging situations around the world; remain strong and continue to advocate. The world will listen. *Pamoja tutashinda* (words in Kiswahili translated to English – "Together we shall overcome").

Acknowledgements

I would like to sincerely thank my supervisor, Dr. Robert Hayward, whose guidance, patience, and mentorship has been instrumental to my thesis journey and my emergence as a health informatics specialist. He supported me through diverse challenges and reassured me when I needed it. The nuggets of knowledge passed on will serve me well throughout life.

My committee members and advisor, Dr. David Zakus, Dr. Louanne Keenan and Dr. Dave Ludwick, are thanked for frequent and tireless feedback, for steadfast belief in the importance of this work, for encouragement and for continuing to challenge me through the thesis process. Their wisdom, advice, conversations and subject matter expertise were always appreciated and welcomed. ML, is thanked for supporting me through the peer check process prior to and during the field study.

My family (Mom, KJ, HJ, KJ) were an invaluable support and put up with me through a difficult yet fulfilling journey. Their patience and encouragement allowed me to follow my dreams. For believing in me, I will forever be indebted! Many dear friends (LR, DK, BR, JH, CP, SM, NR, AMJ, KB, KW, LJ, AB, NMB, JMG) are thanked for the jokes, meals, tears, laughter, runs, skype/viber dates, late night coffees and unconditional support. My mentors (DS, TO, MH) and all those who have walked this journey with me are sincerely thanked.

I thank my ICChange family for continuing to inspire me; fighting for what is right and overcoming some of the world's largest challenges. Their tenacity, intelligence and commitment is a constant reminder that giving up is never an option.

I owe special thanks to the health clinics and management teams in Kibera, whom I worked closely with throughout this study. Their support was invaluable; their belief in the

importance of the work was sustaining. I am grateful for the trust given to me when sharing thoughts, ideas and feedback. I hope that I was able to fairly represent these experiences in a kind, constructive and positive light.

Kibera's local partners and stakeholders are thanked for their commitment to the research study and for supporting EMR implementations in challenging environments. The broad Kibera community will forever inspire me with its resilience and energy. I am privileged to have been so generously welcomed.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

CHAPTER 1: Introduction

Enthusiasm for Electronic Medical Record (EMR) implementation is widespread in developed countries. The United States, Spain, Germany, England, France and Singapore all have national investment or incentive programs to drive expansion of EMR uptake.[1] Canada promotes EMR use at regional, provincial and national levels. Canada Health Infoway, a federal program promoting EMR uptake,[2] has invested over $2.1 billion since 2001 and has observed implementation rates increasing from 16% in 2004 to 64% in 2013.[3]

Although, it is widely recognized that EMR implementation can be difficult, there is also emerging consensus that successful adoption improves health care communication, enhances coordination of complex care, reduces adverse drug events, and speeds access to health information.[4] However, there remain doubts about whether benefits achieved in one context are transferable to other contexts; and there is growing realization that returns on investment are contingent upon a complex interplay of product, process and people considerations.[5] Resistance to change, insufficient training, and suboptimal post-implementation support can limit EMR use by clinicians.[6]

Interest in and support for EMR implementation is growing in developing countries. Kenya, Malawi, Haiti, Peru and Uganda all have formal EMR capacity-building initiatives.[7] They may be motivated by EMR benefits observed in developed countries and a hope that EMRs will ease their more complex coordination and communication problems. Benefits cited by those promoting EMR adoption in developing countries include better risk surveillance reports, improved health information access, reduced medication errors, increased clinic efficiency, better public health compliance, timely clinical decision support and better health care processes and outcomes overall.[7,8-12] However, it is also recognized that developing countries face added

barriers to successful EMR deployment. Known challenges include infrastructure (e.g., electricity and power), software (e.g., interoperability, privacy, confidentiality, security), people (e.g., failure to include local stakeholders and resistance to change) and organizational factors (e.g., absence of management support and insufficient training).[7,11,13] Enthusiasts are cautioned that EMR deployments in resource-limited settings require strategic planning and sustainable resource allocation in order to prevent abandonment by users.

Implementing an EMR in a slum may not seem like an obvious solution. They face extraordinary infrastructure and service challenges, but may also benefit disproportionately from the coordination and communication advantages of EMRs. According to UN-Habitat, slums form when rapidly increasing migration is associated with urban poverty, income inequality and unrecognized resident status.[14] Access to public health services is limited,[15] and crisis-driven out-of-pocket purchases reduce individuals' economic capacity for health, contributing to a "medical poverty trap."[16] Access to insurance is rare and continuity of care almost non-existent. At a community level, poor documentation of risks, diseases and deaths impedes effective health surveillance and planning.[17-19] With the number and size of urban slums continuing to grow, it is no surprise that EMR systems are offered up as a possible remedy for growing health information problems.[20,21] EMR use in slums could improve patient identification, information capture, disease tracking and drug distribution among a transient population.

Unfortunately, little is known about what really happens when EMRs are introduced to clinics operating in slum settings. The intent of this body of work is twofold: first to gather and describe what has been reported about unique benefits and harms associated with EMR

deployments in slum settings and, second, to directly observe the consequences of an EMR implementation in two clinics operating in Kibera, a large slum in East Africa.[1a]

This MSc Thesis report consists of two manuscripts, each the basis for papers submitted for publication in health informatics journals. The first manuscript (Chapter 2) describes how a "State-of-the-Art" literature review was conducted and what was discovered about the types of inquiry, range of objectives and outcomes described in published reports about the impacts of EMR implementations in resource-challenged Sub-Saharan settings. The second manuscript (Chapter 3) summarizes how a descriptive qualitative study explored perceptions about EMR benefits and harms among front-line primary care clinic staff in an urban slum. A practical outcome of the field work informing Chapter 3 has been the development of a pre-implementation EMR checklist optimized for slum settings.

Although the health informatics literature continues to grow, and reports about EMR implementations abound, meaningful direction for resource-challenged settings is relatively rare. Guidance that is sensitive to the unique challenges of urban slums is almost non-existent. It is hoped that this work will be directly helpful to clinics, organizations and governments contemplating EMR initiatives in the expansive slum settings of Sub-Saharan Africa and globally. The most specific applicability of this work may be to expose the unique benefits and challenges of implementing an EMR in Nairobi slum clinics. This pragmatic awareness could inform the design of future EMR intervention studies in similar contexts.

1a. Kibera is one of the largest slums in East Africa located in Nairobi, Kenya.[22] It encompasses a very densely populated environment and lacking basic necessities.[22]

REFERENCES

1. Accenture. Connected health: the drive to integrated healthcare delivery 2012. http://www.himss.eu/sites/default/files/Accenture-Connected-Health-Global-Report-Final-Web.pdf. Accessed May 13, 2014.

2. Canada Health Infoway. What we do. *Canada Health Infoway.* Published 2014. https://www.infoway-inforoute.ca/index.php/about-infoway/what-we-do. Accessed September 7, 2014.

3. Canada Health Infoway. Annual Report 2013-2014. 2014. https://www.infoway-inforoute.ca/en/component/edocman/1957-annual-report-2013-2014/view-document. Accessed September 21, 2014.

4. Adler-Milstein J, Daniel G, Grossmann C, et al. Return on information: a standard model for assessing institutional return on electronic health records. *Institute of Medicine of the National Academies.* 2014:1-21. http://nam.edu/wp-content/uploads/2015/06/ReturnonInformation1.pdf. Accessed May 13, 2014.

5. Shcherbatykh I, Holbrook A, Thabane L. Methodologic issues in health informatics trials: the complexities of complex interventions. *Journal of the American Medical Informatics Association.* 2008;15:575-580.

6. Zandieh SO, Yoon-Flannery K, Kuperman GJ, Langsam DJ, Hyman D, Kaushal R. Challenges to EHR implementation in electronic- versus paper-based office practices. *Journal of General Internal Medicine.* 2008;23(6):755-761. doi:10.1007/s11606-008-0573-5.

7. Fraser HS, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P. Implementing electronic medical record systems in developing counties. *Informatics in Primary Care*. 2005;13(2):83-95. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000002/art00002. Accessed March 13, 2014.

8. Blaya JA, Fraser HSF, Holt B. E-Health technologies show promise in developing countries. *Health Affairs*. 2010; 29(2):244-51. doi: 10.1377/hlthaff.2009.0894.

9. Edworthy SM. Telemedicine in developing countries: may have more impact than in developed countries. *British Medical Journal.* 2008;323:524–525. doi: http://dx.doi.org/10.1136/bmj.323.7312.524.

10. Rotich JK, Hannan TJ, Smith FE, et al. Installing and implementing a computer-based patient record system in Sub-Saharan Africa: the mosoriot medical record system. *Journal of the American Medical Informatics Association*. 2003;10(4):295-303. doi: http://dx.doi.org/10.1197/jamia.M1301.

11. Were MC, Emenyonu N, Achieng M, et al. Evaluating a scalable model for implementing electronic health records in resource-limited settings. *Journal American Medical Informatics Association*. 2010;17(3):237-44. doi: 10.1136/jamia.2009.002303.

12. Williams F, Boren SA. The role of the electronic medical record (EMR) in care delivery development in developing counties: a systematic review. *Informatics in Primary Care*. 2008;16(2):139-145. http://www.ingentaconnect.com/content/bcs/ipc/2008/00000016/00000002/art00008?crawler=true. Accessed March 13, 2014.

13. Matheson A, Baseman JG, Wagner SH, et al. Implementation and expansion of an electronic medical record for HIV care and treatment in Haiti: an assessment of system use and the impact of large-scale disruptions. *International Journal of Medical Informatics.* 2012;81(4):244-256. doi: 10.1016/j.ijmedinf.2012.01.011.

14. UN-Habitat. What are slums and why do they exist? *United Nations.* http://www.unhabitat.org/downloads/docs/4625_51419_gc%2021%20what%20are%20slums.pdf. Accessed March 26, 2014.

15. Chuma J, Okungu V. Viewing the Kenya health system through an equity lens: implications for universal coverage. *International Journal for Equity in Health.* 2011;10(22). doi:10.1186/1475-9276-10-22.

16. Whitehead M, Dahlgren G, Evans T. Equity and health sector reforms: can low-income countries escape the medical poverty trap? *The Lancet.* 2001;358(9284):833-6. doi:10.1016/S0140-6736(01)05975-X.

17. Kypbutungi C, Ziraba AK, Ezeh A, Yé Y. The burden of disease profile of residents of Nairobi's slum: results from a demographic surveillance system. *Population Health Metrics.* 2008;6(1). doi:10.1186/1478-7954-6-1.

18. World Health Organization. *Kenya Maternal and Child Health Data.* Countdown to 2015: Maternal, Newborn and Child Survival. 2014. http://www.countdown2015mnch.org/documents/2014Report/Kenya_Country_Profile_2014.pdf. Accessed July 2014.

19. Riley LW, Ko AI, Unger A, Reis MG. Slum health: diseases of neglected populations. *BMC International Health and Human Rights*. 2007;7(2). doi:10.1186/1472-698X-7-2.

20. Vlahov D, Galea S. Urbanization, urbanicity, and health. *Journal of Urban Health: Bulletin of the New York Academy of Medicine.* 2002;79(4 Suppl 1):S1-S12. doi: 10.1093/jurban/79.suppl_1.S1.

21. Jawhari B, Berenger B, Saleh A. Kibera Medical Record Initiative: barriers of implementing an electronic medical record system [abstract]. 26th Medical Informatics in Europe Conference (MIE2015). 2015; 210:1031-32. doi:10.3233/978-1-61499-512-8-1031

22. Ekdale B. Slum discourse, media representations and Maisha Mtaani in Kibera, Kenya. *Ecquid Novi: African Journalism Studies*. 2014;35(1):92-108. doi: 10.1080/02560054.2014.886277.

CHAPTER 2. Benefits and Challenges Associated with EMR Implementations in Low Resource Settings in Sub-Saharan Africa: A State-of-the-Art Review[1]

[1] *A version of this chapter has been submitted for publication.*

ABSTRACT

Objective: To discover the types of inquiry, range of objectives and outcomes described in published reports about the impacts of EMR implementations in slums and limited resource settings in Sub-Saharan Africa.

Methods: A State-of-the-Art overview was conducted as a step-wise and systematic process (concept mapping, optimization, filter results and key paper review). This approach emphasized description and classification of settings, methods and findings found in literature discovered from bibliographic databases, citations, and Internet-accessed grey literature. Key findings reported in relevant selected reports were analyzed.

Data Collection: MEDLINE, EMBASE, COCHRANE, GLOBAL HEALTH, GOOGLE and GOOGLE SCHOLAR were searched through January 2015.

Results: From an initial population of 946 papers, 32 were methods, setting and outcome filtered and underwent comprehensive full-text content analysis. The general literature scan was used to classify the available literature by type (secondary vs. primary), design (e.g., case study, case series, observational research, experimental research) and outcome focus (e.g., health care processes and health care outcomes). With most of the relevant communications appearing in the last five years, it is apparent that the literature about EMR implementations generally, and in resource-constrained environments specifically, is still developing. Experimental designs were rare. An analytical framework was developed synthesizing key messages from a subset of the literature selected for relevance and quality. This framework supports inter-study comparisons of matters of: 1. Systems (e.g., power, Internet and networks); 2. People (e.g., human resources and training); 3. Processes (e.g., change management); and 4. Products (e.g., software, user-interfaces).

Discussion: This review provided an overall impression of the health informatics literature that relates to EMR implementations in Sub-Saharan Africa. Little was found pertaining to EMR implementations in slum settings. Reports of experiences in resource-constrained settings emphasize the complexity of human factors which can outweigh product and system limitations. The available literature lacked practical aids to EMR deployment planners, especially pre- or post-implementation checklists or tools to support implementers when designing or executing EMR implementations to better support systems, people, processes, and products.

Conclusions: The future of EMR implementations in Sub-Saharan African is promising. This State-of-the-Art review revealed gaps in the available studies of EMR implementations in resource-constrained environments; and opportunities for research about how to improve EMR deployments and the study of their effects.

INTRODUCTION

Health Information Systems (HIS), including Electronic Medical Record (EMR) systems, show promise for facilitating health care improvements in developing countries. However, relatively little is known about whether this promise can be realized in resource-constrained settings, or about the applicability of evidence arising from well-resourced settings. This "State-of-the-Art"[1] overview examines published reports about how EMRs have been deployed in Sub-Saharan Africa, what type of attributes of EMRs correlate with deployment success, which categories of benefits and harms have been observed, what forms of inquiry have been employed, and where important uncertainty remains.

A preliminary search of mainstream bibliographic databases revealed few reports about experiences with EMRs in resource-limited settings. Most of these focused on *Human Immunodeficiency Virus (HIV) and Tuberculosis (TB)* patient management.[2-4] No reports examined EMRs impact on primary care outcomes in slum settings. Experimental inquiry is rare and the published reports do not provide detail about methods or findings sufficient for systematic review or meta-analytic synthesis. Accordingly, this overview expands the range of report sources considered, and adopts a systematic approach to describing what has been published, how insights were derived from observation, and which issues have been explored by what method.

State-of-the-Art overviews are well suited to the diversity of publications found on exploratory searching, and to the overarching study question: "What are the unique challenges and benefits of implementing an EMR in two health clinics that serve marginalized populations in Kibera, Nairobi?" This type of overview, which has not been previously communicated, could reveal patterns in EMR deployment research, and may provide a foundation for a future systematic review of an expanding and maturing literature.

METHODS

Review Process

A State-of-the-Art overview was conducted as a step-wise process. First, a general search strategy was iteratively derived from a concept map. Associated keywords were discovered from multiple search-review cycles in diverse databases. Second, specific search strategies were optimized for each of the source databases. Third, relevance filters were developed and applied to database search results to determine the prevalence of reports addressing settings, interventions and outcomes relevant to the study question. Fourth, methods descriptors were devised and used to classify the literature passing relevance filters. Finally, papers that were both relevant and methodologically credible were reviewed in detail (Figure 2.1). The overview results are expressed through description and classification of revealed literature, as well as analysis of the content of the selected literature.

Concept Map

Sub-Saharan African countries are actively adopting e-health technologies, including mobile health devices, electronic medical records, electronic health records, and risk surveillance systems. Despite their characterization as developing countries, Kenya, Uganda and Cameroon, for example, have demonstrated leadership through investment in recent-generation health information systems. They may ‘leap-frog’ technology barriers experienced in developed countries. For example, connectivity impediments are bypassed if wireless or smartphone towers replace expensive copper or fibre-optic infrastructure. Accordingly, literature relevant to the State-of-the-Art review might be associated with title, abstract or subject heading terms (e.g., “smartphone”, “wireless”, and “apps”) not commonly encountered in EMRs literature originating

in developed settings. For this reason, an initial inventory of search "concepts" was developed to reflect a wide range of technologies and possible EMR attributes.

A starter list of search concepts reflected key elements of the Thesis research question, literature review objectives and settings of interest. The list was modified as search cycles were conducted and new concepts emerged in retrieved reports. The list was subdivided into inclusion and exclusion criteria (Appendix 2.1). Examples of inclusion criteria include reference to EMRs implementations in resource-limited or slum settings in Sub-Saharan Africa: digital health record implementation reports that refer to human resource capacity, workflow, challenges and/or benefits, lessons learned, risks, user perception, and satisfaction. Examples of exclusion criteria include a focus on developed countries, hospital management systems or national health information systems; deployment limited to hospital settings; and use restricted to mental health, pharmacy or laboratory support.

After completing exploratory search cycles and developing an appreciation for how key concepts related to keywords found in titles, abstracts and subject, a list of standardized Medical Subject Heading (MeSH) terms was derived and used to build the search strategies for indexed bibliographic databases (Appendix 2.2). Publication dates were not incorporated into search strategies for two reasons. First, the relatively recent appearance of EMRs in the settings of interest makes publication date implicit in other selection criteria. Second, the paucity of relevant publications did not justify further limiting the population of reports to studies published in a particular time interval (Appendix 2.1).

Sources

Major North American (MEDLINE) and European (EMBASE) research citation databases, and one specialty citation database (GLOBAL HEALTH) were searched. In addition,

the Cochrane database of reviews and the Cochrane controlled trial library were searched for completed or pending systematic reviews. A general Internet scan was conducted using the Google search engine. The "grey literature," including conference proceedings, theses, websites, and government reports, was queried using Google Scholar and Google. This mix of indexed and full-text sources was selected to capture a wide range of publication types, while ensuring good representation of high impact journals. Reports not cited by any of these means are unlikely to have been supported by credible initiatives or to have influence with decision-makers. The above mentioned databases were searched from inception to January 2015.

Search Strategy

Concept Mapping

Optimized search strings, minimizing false positives while avoiding false negatives, were iteratively developed for each database (Appendix 2.2). Some key concepts were represented by different keywords in different databases. For example, MEDLINE, GLOBAL HEALTH and the COCHRANE LIBRARY used the term "Africa South of the Sahara" instead of "Sub-Saharan Africa" as used in EMBASE. Specific terms for different types of digital health records, such as "Electronic Health Record," "Electronic Medical Record," "Patient Health Record," etc., varied widely and had to be pooled as interchangeable. Whereas MEDLINE, EMBASE and the COCHRANE LIBRARY are indexed with controlled vocabularies, the available standardized terms are often new and inconsistently applied. Full text common-word searching proved important in all databases, having the greatest impact on GOOGLE and GOOGLE SCHOLAR performance.

Optimization

A systematic approach was followed to maximize the sensitivity (few false negatives) of the search for relevant reports. A search cycle was initiated by running a search with the current best Boolean combination of inclusion and exclusion criteria expressed as text words and index terms. From the retrieved citations, three to five reports were selected for closest match to the search concepts. The bibliography of each was reviewed for other high-value reports. Any cited reports not appearing in the search results were retrieved to determine how they were indexed and summarized. This information was used to seek keywords or text words that might enhance the next search cycle; a process repeated until few or no new false negatives were discovered. By this means, 13 reports were discovered that were not found by other means.

The results of optimized searches for database were combined to constitute the initial "population" of potentially relevant citations. This population was passed through a duplicate check, relevance filter and methods filter, using "RefWorks" citation manager software[5] to facilitate coding and classification. The relevance filter was applied to titles and abstracts in order to define a sub-population of papers constrained to the setting, country, practice type, interventions and outcomes of interest. A methods filter was then applied to the relevant sub-population to further subdivide by the type of literature (primary, secondary) and type of study (e.g., case report, case series, before-after study). The full texts of these reports were reviewed. Combined considerations of relevance and methods were used to identify a final distillate of reports most likely to address the study objectives in a valid, important and applicable way. The full text of these were analyzed for methods, results and themes; informing the development of an analytic framework describing the current state of knowledge, and knowledge generation, in the domain of interest.

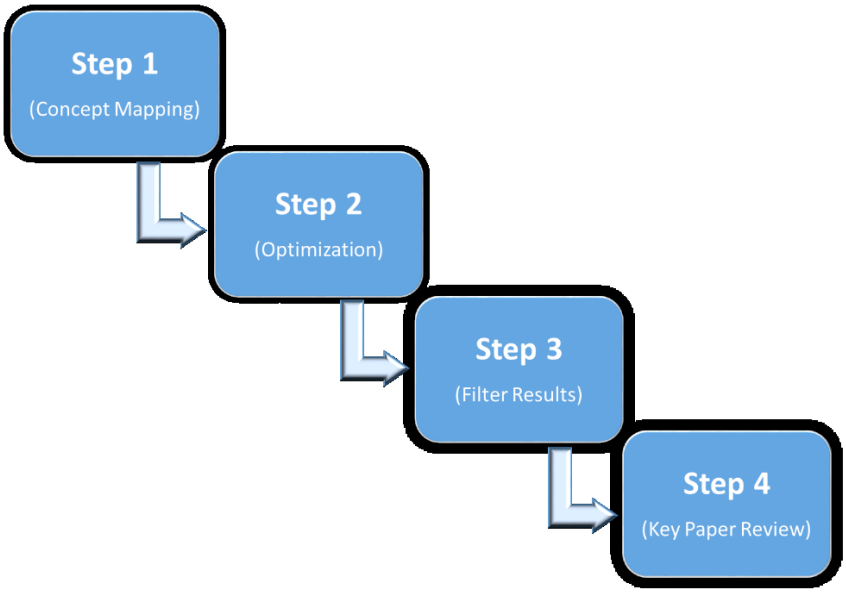


FIGURE 2.1: LITERATURE REVIEW SEARCH PROCESS

Filter Results

At total of 946 reports were pooled from the optimized search strategy yields from all bibliographic databases. Of these, 251 were removed in the duplicate check, leaving 695 reports subjected to the relevance filter (Figure 2.2).

Full-text Internet searching (GOOGLE databases) generated a large number of hits and was purposefully left until bibliographic database search strategies had been optimized. The Internet search strings were made more specific (fewer false positives) by concatenating many terms in one search, with the highest frequency of keyword matches represented in the first hits listed. Multiple combinations of terms, and different orderings of terms, were used to ultimately discover 18 possibly relevant GOOGLE reports and 36 GOOGLE SCHOLAR reports not found by bibliographic searching (Appendix 2.2). Of these 54 new findings, 24 were not typical publications and would not have been included in bibliographic databases. They included project websites (8), government reports (4), books (3), thesis dissertations (6), a PowerPoint

presentation (1), a conference paper abstract (1) and a news article about an unpublished study (1). Citations appearing in these communications were reviewed, with no discovery of significant reports not found by other means. Combining the pertinent Internet search results with the post-duplicate bibliographic pool resulted in 749 citations, of which 738 were papers or articles. Application of inclusion and exclusion criteria to this set reduced the population of citations to 323.

Screening article abstracts reduced the total number of relevant and acceptable reports to 96. Papers about digital health records that did not address implementation or adoption challenges, benefits, advantages, or failures were excluded from the search. For example, some papers focused on retrospective secondary uses such as estimation of the prevalence of disease. In some cases, the filters would exclude an article that appeared important; triggering minor adjustments to the filters. For example, growing appreciation of inconsistent reporting of geographic considerations motivated the addition of "Sub-Saharan Africa" to the synonyms with the result that two more papers were included.[2,6] Abstract review also revealed subsets of EMRs that should be excluded. For example, a few reports referred to digital health record systems that do not have interfaces for clinicians or patients; such as the District Health Information System (DHIS) and National Health Information Systems (NHIS).

The introduction, objectives and methods sections of the 96 filtered reports were reviewed to re-apply relevance filters to a more detailed exploration of study context and methods. This excluded 54 more reports. The most common reason for exclusion was discovery of EMRs restriction to use within an institution and not within a clinic setting. Although lessons learned are appreciated, hospital information system implementations are associated with complexities not commonly encountered in community-based health clinics. A total of 32 reports remained after

comprehensive full-text review (Figure 2.2) and were subjected to methods filtering (Table 2.2 and 2.3).

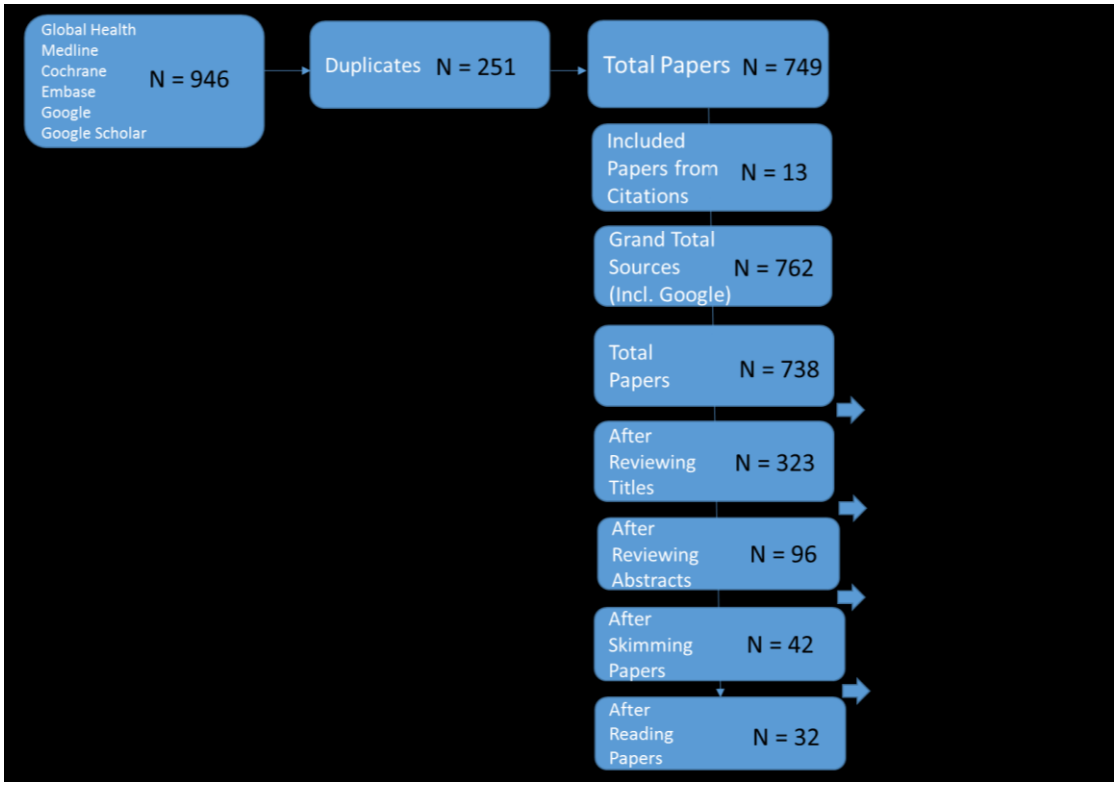


FIGURE 2.2: SUMMARY OF THE FINDINGS AND NUMBER OF PAPERS IN THE LITERATURE REVIEW PROCESS

Key Paper Review

Of the reports remaining after all relevance and method reviews, seven were a clear best fit to the research topic.[7-13] The outlined papers had EMR implementations in Kenya and Cameroon, using a software relatively similar to the software used at the two clinic sites of the research study. Even so, none of these specifically concerned EMR implementations in slum settings. The identified key papers did not reveal important indexing (Medical Subject Heading) terms not already encountered. Some terms, such as "medical informatics" had been considered and tested but excluded from search strategies for being implicit in other terms. Overall, the key

paper review did not reveal significant gaps in bibliographic database search strategies. The bibliographies of key reports were also reviewed. No new significant citations were found.

RESULTS

Methods and topic concepts were used to categorize relevance-filtered reports. The frequency (number of reports fitting a category) and intensity (subjective closeness of fit of reports to the concept) of concept-associations is summarized in Table 2.2 and 2.3. These categories inform the description of relevant and sound literature – the "State-of-the-Art" – in two domains: method of inquiry ("Literature Type") and observations reported ("Literature Topic").

Table 2.1 orders the final set of key papers by publication date. Over half of the key reports appeared in the last four years. Of the final set of papers, most reports reveal using open-source software such as OpenMRS, iSante, OSCAR, World Vista.[14] The most prominent software of choice is OpenMRS which is widely used throughout Sub-Saharan Africa. Other open-source software include OpenEMR. The OpenEMR EMR software, which figures prominently in the settings of interest, first appeared in 2001, became Health Insurance Portability and Accountability Act (HIPPA) compliant in 2002 and was released to the general public in early 2003.[15] However, it was not until 2010 that the system was optimized for ambulatory care, for which it received certification in 2011. It is likely that the appeal, accessibility, ease of support, availability of customization services and sustainability of installed code-sets for the most common EMRs in resource-constrained community settings accelerated from 2010 onwards. Reports published between 2000-2009 were more exploratory in nature, using EMR technology relatively new to low resource settings, and did not appear to have been associated with long-term sustainable initiatives. Accordingly, it appears that the most relevant

literature is also the most recent. Greater weight was given to findings reported in the last five years.

Reports	Frequency	Year
Hannan, et al.	1	2000
Hannan, et al.	1	2001
Tierney, et al.	1	2002
Rotich J. K., et al.	1	2003
Fraser, et al.; Kamadjeu, et al.	2	2005
Mamlin, et al.; Simbini	2	2006
Allen, et al.; Tierney, et al.	2	2007
Williams & Boren	1	2008
Braitstein et al.; Kalogriopoulos et al.; Nucita, et al.; O'Mahony	4	2009
Amorosoet al.; Blaya et al.; Fraser & Blaya; Manders E.-J. , et al.; Moster-Phipps et al.; Thompson et al.; Were, et al.,	7	2010
Mohammed-Rajput, et al.,; Were & Meslin	2	2011
Akanbi, et al.,; Alamo, et al.; Castelnuovo, et al.; Johnson, et al.; Moster-Phipps et al.; Talisuna; Millard et al.	7	2012
Sheikh	1	2014
Total	**32**	

TABLE 2.1: YEAR OF PUBLICATION OF PAPERS INCLUDED IN THE LITERATURE REVIEW

Literature Type

The relevance-filtered publications were grouped by whether they reported original observations or interpreted the observations of others. The primary literature was further subdivided by the type of inquiry used to generate observations (Table 2.2).

Literature Type	Number of Papers
Primary Literature	**28**
Case Reports	**21**
- Single	0
- Series	21
Implementation Processes	16
Adoption (Rationale)	5
Observational Studies	**16**
- Qualitative Inquiry	0
Acceptance of EMR by Users and Patients	2
Patient Satisfaction towards to the EMR	0
Patient Perceptions of the EMR	1
- Program Evaluation	15
Data Quality/Error Rates	3
Missed Appointment	2
Wait Time for Patients (Reduced/Increased)	4
Same Day Patient Tracing	2
Time Motion Study	2
Experimental Studies	**23**
- Uncontrolled Trials	1
- Controlled Trails	0
- Benefits/Challenges/System Design	22
Secondary Literature	**17**
- Commentary and Editorial	6
- Position Statements and Guidelines	2
- Narrative Reviews	7
- Systematic Reviews	2

TABLE 2.2: RELEVANCE-FILTERED PUBLICATIONS GROUPED BY LITERATURE TYPE

Primary Literature

Case Studies

No case reports about single EMRs implementations appeared in the final population of studies. There were 21 descriptions of case series, where a common intervention crossed multiple EMR implementations (Table 2.2). Foci of description included paper-to-digital record

transformation challenges,[16] clinician distraction by user interfaces,[17] training effects, and determinants of user acceptance.[17] One case series explored hardware and software barriers to implementation, including very specific impediments like corrupted files and server failures.[17] Many case studies shared experience-based recommendations about best training practices, with a common theme that user involvement increases buy-in before, during and after implementation.

Case studies tended to be rich descriptions of phenomena affecting implementation processes and outcomes. For example, it is suggested that EMR adoption rates can be enhanced by loss of paper storage space and that EMRs reduce record misfiling, improve stock control[17] and increase acceptance of reports filed to government or funding agencies.[12,13,18] A key study shared experiences about different open-source EMRs and what they might mean for groups contemplating adoption in resource-limited settings.[14] The study also emphasized the importance of EMR customization, sustainable funding and access to a digitally-capable workforce.[14]

Observational Studies

Of the observational studies selected for relevance, none used rigorous qualitative research methods. Some were reports of the results of surveys administered to users or patients,[19-21] but these did not describe a-priori objectives, how survey question concepts were developed, how instrument validity was established, or how results were interpreted in light of an analytic framework. Thompson et al. (2010) conducted an observational study using data gathered in ethnographic field notes, but did not report an explicit approach to data-abstraction, coding or purposeful analysis of the recorded observations.[22] Another study analyzed interview transcripts (EMR implementers) rather than users or patients.[11] Other studies did not capture observations pre-implementation or in comparator non-implementation settings. Where observational studies claimed overall user satisfaction with EMRs, the authors often did not reconcile this with their

own report of user complaints respecting training burdens, loss of productivity and difficulty finding key information.[21]

Program evaluations were a common form of observational study. These tended to focus on the quality and application of data accrued by EMRs and commenting on operational considerations: like error rates, visit duration, appointment no-shows, wait times, clinic efficiency, and fulfillment service delivery expectations.[20,21,23,24] One study included a formal time-motion study and noted a patient visit duration reduction of about 10 minutes.[20] Apparently, productivity improvements were associated with less staff time socializing with colleagues.[20] Another program evaluation reported a 30% reduction in missed appointments, 24% reduction in erroneous appointments, and an overall reduction in wait times for nurse and lab technician access.[23] A Castelnuovo et al. (2012) program evaluation claimed a reduction of scheduling error rates from 66.5% to 2.1%.[19]

Three studies emphasised the lessons learned from observed EMR implementations.[2,18,25] However, readiness assessments were not reported and measures before and after implementation were not done or not consistent. Lessons learned were not expressed in the form of tools or checklists that might guide future implementations.

Some observational reports provided detailed descriptions of EMR designs and pilot implementations, focusing on things like system design, data models, software architecture and performance specifications.[2,14,18,19,26,27] A common theme related to the use of open-source systems in resource-limited settings, presumably because lower up-front software costs make these easier to acquire and deploy. OpenMRS[28] is an open-source EMR that has seen multiple iterations since it was first developed in the early 2000s. Supported by a multi-institutional collaboration that includes Indiana University, Partners in Health and Academic Model Providing Access to Healthcare (AMPATH),[18] OpenMRS has become the software of choice for

organizations operating in resource-limited settings. Implementations are active in over 40 countries.[28] This may explain the prevalence of descriptive reports that focused on feature customization, local adaptation and costs (e.g., tangible and value-based) of adoption.[13,14,17,18]

Experimental Studies

No formal clinical trials, where an EMR-exposed group is compared to a suitable control group, were found among relevance-filtered studies. However, a number of before-after time-series were found (Table 2.2). These tended to examine impacts on resources and barriers to sustainability, such as staffing requirements, employee retention, training needs, hardware reliability and infrastructure requirements.[8,10,11,16,18,22,25,29,30] There was a tendency to report positive impacts, with unintended negative effects possibly not included in the data captured. Positive effects included increased access to Internet information resources, quicker retrieval of patient records, timely access to clinical data, more legible documentation and improved quality and safety of care.[2,7,16,29,31]

Secondary Literature

Whereas primary literature reports results from investigators overseeing, describing or comparing original EMRs interventions, secondary literature reviewed or opinioned about work reported by others. Seventeen secondary reports appeared among relevance-filtered literature (Table 2.2). These included editorials, general commentary, best practice advisories, narrative reviews and a few systematic reviews.

The secondary literature was most likely to tally facilitators and barriers to successful EMR use. Commonly reported success factors include stakeholder engagement in pre-implementation design, building trust among stakeholders, supporting emergence of local leadership, nurturing embedded champions, and avoiding major change to staffing. Additionally,

implementers are encouraged to use existing systems and software, collaborate with other organizations (leveraging resources), investing in data backup capacity, auditing user actions, providing on-site training and declaring and tracking effectiveness measures.[11,13,18,20,25]

A unique secondary report explored the ethical ramifications of EMR implementations. The authors lamented a lack of ethically grounded EMR policies in developing countries.[32] The authors caution to heed the principle of "do no harm" when managing change for stakeholders (clinics, staff and patients). The ethical implications of implied consent, data security, inflexible operating procedures and sustainability were raised as important considerations pre-implementation.[32]

Literature Topics

Considered together, the filtered literature addressed recurring themes about EMR design, implementation and impact. The topics covered by both primary and secondary literature were categorized into matters of health processes, health outcomes and geographic considerations (Table 2.3 and 2.4).

Literature Topic	Number of Papers
Health Process	**22**
- Patient identifier	5
- Pharmacy/Drug management	2
- Laboratory management	2
- Integration between other systems	1
- Efficiency of human capacity (HR)	7
- Continuity of care	1
- Communications and team relations	2
- Patient management	8
- Clinic efficiency	3
- Timely and accurate data/Data quality	3
- Information management	7
- Government reporting/Administrative report	3
- Auditing	1
Health Outcomes	**22**
- Chronic disease treatment compliance	2
- HIV/AIDS management	17
- Tuberculosis management	1
- Accurate medication list/Legible prescription list	2
- Reduction in medical errors	0
- Improved quality of care	1
- Maternal newborn and child health management	1
- Clinical decision support	1

TABLE 2.3: CATEGORIZATION OF LITERATURE TOPICS

Health Processes

A common focus of EMR implementation reports relates to impacts on health care delivery. Given the effort associated with EMR implementation, there is a tendency to emphasize how returns on investment can be realized. The most commonly emphasized return is improved efficiency of time-consuming or error-prone health care processes.

Resource-constrained settings often have difficulty consistently identifying patients from visit to visit and from clinic to clinic, with negative impacts on continuity of care. In Sub-Saharan African countries, particularly in Kenya, there is a lack of standardized national identifier.[8,9,20]

Perhaps for this reason, the retrieved literature frequently referred to the efficiency value of unique identifier management in EMRs. For example, provision of robust unique identifiers to patients and providers,[2,7,8,12,20] increased patient encounters per clinic, improved utilization of human resources,[9,17,21,22,27,33,34] reduced chart filing times, improved continuity of care,[31,34] reduced data integrity issues,[16,26,35] and improved the accuracy of reports.[20,22,26]

Five papers highlighted collateral benefits of unique identifiers in EMRs, allowing patients to more easily flow through the health system, track exposures and outcomes, reduce inappropriate test duplication and provide more consistent care[2,7,8,12,20] all contingent on the ability to retrieve and compare multiple episodes of care for the same patient.[13]

Effective communication is a common challenge in resource-constrained settings. Even improved legibility of communications can make a difference. One study reported improved legibility and clarity of orders and lists post EMR implementation, with overall improvement in prescription management.[17] Other reports noted the value of increased health data quality associated with the structured data entry associated with EMR use.[19,36,37]

Clinics operating in resource-constrained settings commonly have to report to diverse government programs, donor organizations and disease-specific grant programs. An important EMR-associated process improvement relates to automated reporting capabilities that significantly reduce the time taken to comply with agency reporting requirements.[9,10,20,22,26]

Resource-constrained settings also have difficulty attracting, training and retaining experienced staff; process problems compounded by the need to up-skill and up-manage for transitions from paper to digital processes. The retrieved literature reflects the importance of these challenges. There are frequent references to EMR impacts on human resources. Were et al. (2010) suggested a unique approach to mitigate human resources constraints in Uganda, proposing a centralized group of software developers, implementers and informatics experts to

support EMR implementations.[21] This "Technical Expertise Centre" (TEC) would provide consultation services to clinics on an as needed basis. For example, if the clinic needed a certain EMR data collection form or custom report, TEC would be consulted. The model appears to presume infrastructure and communication norms that may not be transferrable to all settings, particularly slums.

Developing EMR-permissive skills, attitudes and knowledge within a clinic setting is a commonly reported challenge. Involving users early on in the process development is often cited as an effective strategy for enhancing buy-in (overcoming attitudinal barriers) and increasing systems awareness.[10,22] One study reported that user empowerment can increase self-esteem and positive views about the health facility, with spin-off benefits for the community.[10]

Health Outcomes

Health outcomes that may be affected by EMR implementation can be difficult to track for slum clinics. They typically have short-term interactions with clients and little opportunity for follow-up. The outcomes may be hard to measure or may take time to develop. Accordingly, the retrieved literature rarely discusses true health outcomes, and tends to emphasize surrogate outcomes like immunization rates and medication dispensing as surrogates for guideline compliance. Seventeen retrieved reports focused on HIV/AIDS management, a priority of global granting agencies, and tracking of medication dispensing and select blood test results (Table 2.3).

Little in the retrieved literature addressed chronic disease outcomes,[7,10] usually related to TB management.[2] One paper made reference to a maternal and child health focused EMR and guideline compliance.[22] The effect of clinical decision support[33] on surrogate outcomes, including medication tracking,[16,17] were not widely explored in the filtered literature.

Geographic Considerations

Table 2.4 summarizes the distribution of relevance-filtered literature by the primary country of EMR implementations. Secondary literature aggregating observations from many settings were categorized as "multi-regional." The geographic associations observed among retrieved literature reflects well-described geographic differences in information systems investment. Kenya, South Africa and Uganda have various digital records implementations underway with relatively reasonable and positive support from government and various stakeholders. Of the seven selected key papers, six related to Kenya and one reported work done in Cameroon.

Countries	**Number of Articles/Papers**
South Africa	3
Kenya	6
Nigeria	1
Uganda	3
Cameroon	1
Mozambique	1
Zimbabwe	1
Rwanda	2
Multi-regional (Developing Countries)	9
Multi-regional (Sub-Saharan African countries)	5
Total	**32**

TABLE 2.4: COUNTRY OF IMPLEMENTATION

ANALYTIC FRAMEWORK

A theoretical framework (Figure 2.3) was developed to summarize and synthesize key messages appearing in the retrieved and filtered literature. The framework highlights four categories of influences that determine which success factors most affect outcomes. These

influences relate to matters of 1) Systems 2) People, 3) Processes; and 4) Products. The Systems context for an EMR implementation includes things like access to a reliable power source, suitably located and protected server computers, availability of backup systems and the speed and reliability of telecommunications and Internet services. The People context relates to the types of human resources available, how they are trained and supported, how they interact with technology and how they are influenced by workplace attitudes and leadership. Processes affecting EMR implementations include change management at the time of deployment and operational supports post-deployment. Product influences are unique to the specific electronic medical record software in play and how it inter-operates with other clinic information applications. Success factors are those things that authors emphasize as determinants of EMR implementations and outcomes are the changes sought from EMR implementations.

The analytic framework posits that there is no generic set of success factors applicable in all resource-constrained settings. Rather, the interplay of local systems, people, process and product considerations determine which success factors best predict effective EMR use. The framework is consistent with what the retrieved literature has to say about facilitators and barriers to effective EMR implementations in resource-constrained settings; and it may suggest an approach to planning future interventions. One might start with a clear statement of desired outcomes, then consider how known success factors must be adapted and prioritized to fit with the local product, process, people and systems opportunities and challenges that will shape the implementation experience.

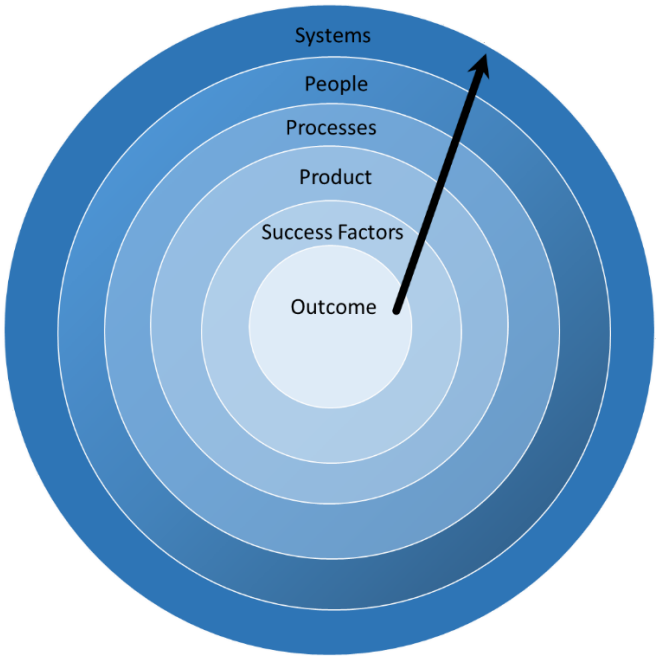


FIGURE 2.3: UNDERSTANDING EMR IMPLEMENTATIONS IN LIMITED RESOURCE SETTINGS

Systems

Many reports highlight the importance of appropriate information systems infrastructure, such as reliable power, connectivity and networking capabilities where the EMRs are deployed.[8,9,12] Some authors recommend remedies for the challenges of resource-constrained settings, including installation of multiple power supplies of different types (e.g., generator, solar, battery, uninterrupted power supply) to ensure hardware and software function when most needed.[8,9,12,25] Where mobile EMR products link to centralized information systems backed by robust infrastructure, it may be that the location of telecommunications towers and service centres become more important considerations.

People

Socio-technical factors – interactions between patients, providers, staff and their digital environment – are frequently highlighted as powerful determinants of EMR uptake and impact.

Typically cited barriers to implementation include high staff turnover, absence of local technical support, and low levels of computer literacy. Organizational barriers include lack of local information system leadership or coexistence of multiple co-deployed systems without coordinated leadership.[7,10,11,25]

Processes

Description of process changes, whether intentional or unintentional, whether part of the EMR intervention or a result of the intervention, figure prominently in the filtered literature. A number of authors observe that EMR implementations does not, by itself, improve the efficiency or effectiveness of health care. Digital systems can bring dysfunctional processes into focus, even aggravating bad workflows. One report suggested optimization of a good paper-based system as a pre-requisite to an EMR implementation.[10] Another study suggests that development of structured data collection with paper based forms can help bridge the gap between paper and EMR workflows.[8] Additionally, retention of some kind of supplemental paper-based workflow can reassure staff that their job will not be replaced or drastically changed.[8]

Some positive process change claims are common. For example, many authors emphasize the importance of user and leadership engagement and how training and support can protect against negative reactions to inevitable changes to familiar workflows. Achieving such user engagement requires investment both pre and post-deployment. Although usually effortful, sometimes engagement is facilitated by relatively simple interventions. These can target patients, providers or staff. For example, two reports suggested that providing patients with an identification card (ID) allows them to feel involved in the EMR process, even increasing buy-in because they feel valued having gained visible association with a prestigeous clinic.[9,12]

Some process changes are initially difficult, but easier once embedded in normal clinic practice. Financial incentives can help overcome the implementation hurdle for some types of staff.[13] Details about how the incentives might be matched to performance, for how long, are scant.

Products

One report emphasized how limitations to currently available EMR software contribute to user resistance, typically citing bugs, missing features and poor performance.[11] Some commonly maligned software features are mandated by government, especially in Kenya. For example, complex security associated with sign-on processes, unrealistically complex reporting requirements, or backup rules can be beyond the means of clinics in resource-constrained settings.[8,9] One study suggests that challenged clinics back up data to paper rather than other IT systems.[8] Given the frequent referrals to product-related factors, consensus appears strong. Health clinics in resource-constrained settings require well-designed, easy to use EMR software that can be easily customized to the needs of clinic and staff.[8]

Success Factors

The proposed analytic framework suggests that the success of a particular EMR implementation effort will be influenced by how well local systems, people, process and product factors are discovered and leveraged. Improving end-user engagement might, for example, require extraordinary effort to establish rapport with clinic staff, use of multiple site visits to fully understand how workflows and operations must change, strengthen relationships with local partners, find and involve stakeholders, customize product to better fit local needs, and build reliable methods for data collection to track user behavior change.[7,10,11,13]

Outcomes

Different changes, or outcomes, from an EMR implementation are implied by the intervention reports appearing in the filtered literature. While it is commonly assumed that EMRs should improve health care processes and health outcomes for patients and populations, some authors contend that this is more likely when research, quality improvement and disease surveillance are explicit goals even an effective public health agenda that assures health for individuals.[12,13,16]

Some EMR implementation outcomes are quite basic, but impactful given a particular mix of system, people, processes and product factors. In some resource-limited settings, for example, implementing unique identifiers and improving patient tracking can be sufficient for meeting improved care coordination goals. Improved continuity of care is commonly cited as a critical success factor for communicable and chronic disease management.[7,8]

Other settings seek more complex changes, including the shaping of provider decisions (including medication choices). EMR clinical decision support capacity becomes an important product-influenced success factor.[7,33] Some EMR implementations are credited with tracking patient outcomes, access to a shared medical record, and reduction in medical errors.[2,16] Others are credited with improved clinic productivity. Rotich (2003) suggests that staff are more productive when patient waiting times are reduced. They may have up to 46% more free time to focus on important daily tasks.[20] Accordingly, schedule and appointment management may be the outcome that optimizes systems, people, processes and product factors.

DISCUSSION

An overall impression of the health informatics literature most directly relevant to EMR implementation in resource-constrained community settings is that it is methodologically weak

and at an early stage of development. Some of the authors wrote various papers that reported similar information about their projects, creating a redundancy of information. The most relevant reports appear in the last four to five years; there are no controlled comparison studies to date; and most communications are descriptive in nature. Hypotheses about factors affecting EMR implementations in slums can be inferred, but they have not been tested. Clear evidence-based recommendations are rare and the available recommendations are often inconsistent. This is understandable as there is wide variation in the systems, people, process and product factors at play in the EMR implementations described or studied in settings of interest. To the extent that fundamental infrastructure (e.g., move to wireless and mobile devices), cost (e.g., available open-source EMR software), and support (e.g., emerging information literate workforce) challenges are being overcome, an acceleration in the quantity and quality of relevant literature is anticipated.

Since completing the literature review, two new papers have come to light. [38,39] Fritz et al. (2015) focused on EMR success factors in limited resource settings, neglecting barriers to implementation.[38] The findings were similar to our review confirming that this topic is not widely reported: most articles were published in the last ten years with a peak after 2009. Additionally, most EMR implementations focused on HIV care which was also confirmed by our review. They reported organizational (e.g., human resource), technical (e.g., infrastructure, Internet and power), functionality (e.g., data quality and reporting) and training, as critical success factors which were consistent with our findings. However, the paper also considered "political" and "ethical" as success factors,[38] which differed from our review. Although, there was one paper that did refer to ethical factors of EMR implementations in this review,[32] we did not classify it as a critical success factor. The study by Tierney et al. (2015) was built upon previous studies[8,12,20] already mentioned in our review. The time motion study conducted rendered longer time spent at the clinic by patients post-EMR.[39] The survey provided to clinical and administrative staff

highlighted a strong need for more training with general satisfaction of the EMR.[39] However, due to the use of a Likert scale, the survey lacked the ability to include participant's comments on improvements that could be made to EMR utilization, confirming the need for more qualitative research in this area.

Given the methodological state of the available literature, and the types of questions raised by that literature, it would appear that reputable qualitative studies are in great need. The human factors affecting EMR impacts in resource-constrained environments are complex. These need to be better characterized before good implementation impact measures are designed, assessment methods are developed, evaluation frameworks validated and comparative studies are doable.

Practical tools for conducting environmental profiles or needs assessments were not found in this State-of-the-Art literature review. The development of pre-implementation checklists – to better characterize local systems, people, process and product factors – appears justified by gaps in the current literature. Such a checklist, iteratively improved with experience in multiple implementations, could also facilitate the development of a more informative literature about EMR use in resource-constrained environments. The analytic framework offered here can inform checklist development and also help map the field study findings to the experience of others.

Strengths and Limitations

The literature search supporting this State-of-the-Art review was conducted by one researcher, without opportunity for checks of inter-rater or intra-rater reliability in the development of relevance and methods filters. As a result, there may be both unquantified bias and error affecting the search, filter, review and categorization processes. Only papers written in the English language were captured during the review, possibly missing important

communications. Although potentially important research databases, such as CINAHL and INEEX Explorer, were not searched, careful checks of the bibliographies of retrieved papers, and the use of broad search engines like GOOGLE and GOOGLE SCHOLAR, suggest that the English language literature retrieval was comprehensive.

Limiting the literature search to Sub-Saharan African countries may have limited opportunities to capture papers that may have discussed EMR implementations in slum areas in other countries. Given the breadth of the initial search strategy, and the size of the initial population of studies scanned, the impression is that any missed literature about EMRs in slum settings elsewhere would not be more methodologically mature or likely to yield significantly different insights.

CONCLUSION

The future for EMRs in Sub-Saharan Africa is promising. Increased investment and deployment of digital health records throughout Sub-Saharan Africa are likely given growth in multi-institutional collaborations, government support and funding opportunities. Diversification in areas of study is necessary to further expand the literature. Historically the informatics discipline has focused primarily on EMR implementations for HIV/AIDS management with little focus on primary care or chronic disease management. However this trend seems to be shifting due to global commitments, funding and changing disease trends. Although most reports highlighted pilot projects, achieving sustainability remains a challenge.[30] In resource-limited settings, sustainability expands much further than financial investment: cultural and contextual (e.g., Health clinic, community, and environment) factors need to be considered as well.

The systematic approach to this unique State-of-the-Art review has identified both gaps and opportunities for research about EMR use in resource-limited settings. More consistent and

informative reporting about implementation studies could improve our ability to discover the most important determinants of success, and the most important harms to avoid. There is a need for rigorous qualitative research and pre-implementation checklists that focus attention on a determinative framework: system, people, process and product considerations could be particularly helpful.

Although the literature review focused on diverse resource-limited settings throughout Sub-Saharan Africa, lessons learned from the reports and topics discussed can be transferred to the slum setting of interest to this Thesis. The over-arching study question was answered effectively, revealing patterns and areas that have already been explored through a categorization process. This review has created a foundation for other researchers to build upon.

REFERENCES

1. Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*. 2009;26(2):91-108. doi: 10.1111/j.1471-1842.2009.00848.x.

2. Fraser HS, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P. Implementing electronic medical record systems in developing counties. *Informatics in Primary Care*. 2005;13(2):83-95. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000002/art00002. Accessed March 13, 2014.

3. Fraser HS, Thomas D, Tomaylla J, et al. Adaptation of a web-based, open source electronic medical record system platform to support a large study of tuberculosis epidemiology. *Medical Informatics and Decision Making*. 2012;12(125):1-10. doi:10.1186/1472-6947-12-125.

4. Ekouevi DK, Karcher S, Coffie PA. Strengthening health systems through HIV monitoring and evaluation in Sub-Saharan Africa. *Current Opinion in HIV and Aids Journal*. 2011;6(4):245-50. doi: 10.1097/COH.0b013e3283479316.

5. RefWorks. *RefWorks*. https://www.refworks.com/. Published 2009. Accessed December 2014.

6. Azubuike MC, Ehiri JE. Health information systems in developing countries: benefits, problems, and prospects. *The Journal of Royal Society for the Promotion of Health*. 1999;119(3):180-4. http://rsh.sagepub.com/content/119/3/180.long. Accessed January 6, 2015.

7. Braitstein P, Robert M. Einterz JES, Kimaiyo S, Tierney W. "Talkin' about a revolution": How electronic health records can facilitate the scale-up of HIV care and treatment and catalyze primary care in resource-constrained settings. *Journal of Acquired Immune Deficiency Syndromes*. 2009;52:S54-7. doi: 10.1097/QAI.0b013e3181bbcb67.

8. Hannan TJ, Rotich JK, Odero WW, et al. The Mosoriot medical record system: design and initial implementation of an outpatient electronic record system in rural Kenya. *International Journal of Medical Informatics*. 2000;60(1):21-28. doi:10.1016/S1386-5056(00)00068-X.

9. Hannan TJ, Tierney WM, Rotich JK, et al. The MOSORIOT medical record system (MMRS) phase I to phase II implementation: an outpatient computer-based medical record system in rural Kenya. *MEDINFO 2001, Studies in Health Technology and Informatics*. 2001;84(Pt1):619-22. doi: 10.3233/978-1-60750-928-8-619.

10. Kamadjeu RM, Tapang EM, Moluh RN. Designing and implementing an electronic health record system in primary care practice in Sub-Saharan Africa: a case study from Cameroon. *Informatics in Primary Care*. 2005;13(3):179-86. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000003/art00003?crawler=true. Accessed September 13, 2014.

11. Mohammed-Rajput NA, Smith DC, Mamlin B, Biondich P, Doebbeling BN, OpenMRS Collaborative Investigators. OpenMRS, A global medical records system collaborative: factors influencing successful implementation. *AMIA Annual Symposium Proceedings 2011*. 2011:960-68. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243141/pdf/0960_amia_2011_proc.pdf. Accessed January 6, 2015.

12. Tierney WM, Rotich JK, Smith FE, Bii J, Einterz RM, Hannan TJ. Crossing the "digital divide:" implementing an electronic medical record system in a rural Kenyan health center to support clinical care and research. *AMIA Annual Symposium Proceedings*. 2002:792-5. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2244335/. Accessed January 6, 2015.

13. Tierney WM, Rotich JK, Hannan TJ, et al. The AMPATH Medical Record System: creating, implementing, and sustaining an electronic medical record system to support HIV/AIDS care in Western Kenya. *MEDINFO 2007: Proceedings of the 12th World Congress on Health (Medical) Informatics*; *Studies in Health Technology and Informatics*. 2007;129(Pt 1):372-6. Accessed January 6, 2015.

14. Millard PS, Bru J, Berger CA. Open-source point-of-care electronic medical records for use in resource-limited settings: systematic review and questionnaire surveys. *BMJ Open*. 2012;2:e000690. doi:10.1136/bmjopen-2011-000690.

15. Wikipedia. OpenEMR. *Wikipedia*. https://en.wikipedia.org/wiki/OpenEMR#cite_note-2. Published June 26, 2015. Accessed July 17, 2015.

16. Williams F, Boren SA. The role of the electronic medical record (EMR) in care delivery development in developing counties: a systematic review. *Informatics in Primary Care*. 2008;16(2):139-145. http://www.ingentaconnect.com/content/bcs/ipc/2008/00000016/00000002/art00008?crawler=true. Accessed March 13, 2014.

17. O'Mahony D. Implementing an electronic medical record system in a rural general practice. *South Africa Family Practice*. 2009;51(4):346-7. doi:10.1080/20786204.2009.10873878.

18. Mamlin BW, Biondich PG, Wolfe BA, et al. Cooking up an open source EMR for developing countries: OpenMRS - a Recipe for Successful Collaboration. *AMIA Annual Symposium Proceedings*. 2006:529-33. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1839638/pdf/AMIA2006_0529.pdf. Accessed June 12, 2014.

19. Castelnuovo B, Kiragga A, Afayo V, et al. Implementation of provider-based electronic medical records and improvement of the quality of data in a large HIV program in Sub-Saharan Africa. *Plos ONE*. 2012;7(12):e51631. doi: 10.1371/journal.pone.0051631.

20. Rotich JK, Hannan TJ, Smith FE, et al. Installing and implementing a computer-based patient record system in Sub-Saharan Africa: The mosoriot medical record system. *Journal of the American Medical Informatics Association*. 2003;10(4):295-303. doi: http://dx.doi.org/10.1197/jamia.M1301.

21. Were MC, Emenyonu N, Achieng M, et al. Evaluating a scalable model for implementing electronic health records in resource-limited settings. *Journal American Medical Informatics Association*. 2010;17(3):237-44. doi: 10.1136/jamia.2009.002303.

22. Thompson A, Castle E, Lubeck P, Makarfi PS. Experience implementing OpenMRS to support maternal and reproductive health in Northern Nigeria [abstract]. *MEDINFO 2010, Studies in Health Technology and Informatics*. 2010; 160(Pt 1):332-6. doi: 10.3233/978-1-60750-588-4-332.

23. Alamo ST, Wagner GJ, Sunday P, et al. Electronic medical records and same day patient tracing improves clinic efficiency and adherence to appointments in a community based HIV/AIDS care program, in Uganda. *AIDS and Behavior*. 2012;16(2):368-74. doi: 10.1007/s10461-011-9996-9.

24. Talisuna S. Electronic medical records and same-day patient tracing improves clinic efficiency and adherence to appointments in a community-based HIV/AIDS care program in Uganda [abstract]. *7th International Conference on HIV Treatment and Prevention Adherence*, 2012. Accessed January 7, 2015.

25. Fraser HS, Blaya J. Implementing medical information systems in developing countries, what works and what doesn't. *American Medical Informatics Association - Symposium Proceedings*. 2010:232-36. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3041413/pdf/amia-2010_sympproc_0232.pdf. Accessed March 29, 2014.

26. Allen C, Jazayeri D, Miranda J, et al. Experience in implementing the OpenMRS medical record system to support HIV treatment in Rwanda. *MEDINFO 2007*, Studies in Health Technology and Informatics. 2007; 129(Pt 1):382-6. http://www.ncbi.nlm.nih.gov/pubmed/17911744. Accessed January 14, 2015.

27. Nucita A, Bernava GM, Bartolo M, et al. A global approach to the management of EMR (electronic medical records) of patients with HIV/AIDS in Sub-Saharan Africa: the experience of DREAM software. *BMC Medical Informatics and Decision Making*. 2009;9(42):1-13. doi:10.1186/1472-6947-9-42.

28. OpenMRS Inc. Home Page. *OpenMRS*. http://openmrs.org/. Published 2004-2015. Accessed April 25, 2015.

29. Akanbi MO, Ocheke AN, Agaba PA, et al. Use of electronic health Records in Sub-Saharan Africa: progress and challenges. *Journal Med Trop*. 2012;14(1):1-6. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4167769/pdf/nihms380682.pdf. Accessed January 6, 2015.

30. Sheikh M. Digital Health information system in Africa's resource poor countries: current challenges and opportunities. *Journal of Health Informatics in Developing Countries*. 2014;8(1):78-87. http://www.jhidc.org/index.php/jhidc/article/view/118/162. Accessed January 6, 2015.

31. Moster-Phipps N, Pottas D, Korpela M. Improving continuity of care through the use of electronic records: a South African perspective. *South African Family Practice*. 2012;54(4):326-31. doi:10.1080/20786204.2012.10874244.

32. Were MC, Meslin EM. Ethics of implementing electronic health records in developing countries: points to consider. *AMIA Annual Symposium Proceedings*, *2011*. 2011. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243215/pdf/1499_amia_2011_proc.pdf. Accessed January 6, 2015.

33. Amoroso CL, Akimana B, Wise B, Fraser HS. Using electronic medical records for HIV care in rural Rwanda. *MEDINFO 2010, Studies in Health Technology and Informatics.* 2010; 160(Pt 1):337-41. doi:10.3233/978-1-60750-588-4-337.

34. Moster-Phipps N, Pottas D, Korpela M. A Socio-technical approach to continuity of care and electronic records in the South African context. *MEDINFO 2010: Proceedings of the 13th World Congress on Medical Informatics, 2010.* 2010;160(Pt 1):406-10. doi:10.3233/978-1-60750-588-4-406.

35. Manders EJ, José E, Solis M, Burlison J, Nhampossa JL, Moon T. Implementing OpenMRS for patient monitoring in an HIV/AIDS care and treatment program in rural Mozambique. *MEDINFO 2010: Proceedings of the 13th World Congress on Medical Informatics, Studies in Health Technology and Informatics.* 2010;160(Pt 1):411-5. doi:10.3233/978-1-60750-588-4-411.

36. Blaya JA, Fraser HSF, Holt B. E-Health technologies show promise in developing countries. *Health Affairs*. 2010;29(2):244-51. doi: 10.1377/hlthaff.2009.0894.

37. Kalogriopoulos NA, Baran J, Nimunkar AJ, Webster JG. Electronic medical record systems for developing countries: review. *31st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS)*. 2009:1730-3. doi: 10.1109/IEMBS.2009.5333561.

38. Fritz F, Tilahun B, Dugas M. Success criteria for electronic medical record implementations in low-resource settings: a systematic review. *Journal American Medical Informatics Association*. 2015;22(2):479-88. doi: 10.1093/jamia/ocu038.

39. Tierney WM, Sidle JE, Diero LO, et al. Assessing the impact of a primary care electronic medical record system in three Kenyan rural health centers. *Journal American Medical Informatics Association.* 2015:1-18. doi: 10.1093/jamia/ocv074.

APPENDIX 2.1 Literature Review Properties

Search Checklist

- Include papers that focus on implementation of EMRs and EHRs (some bibliographic databases and countries refer to these two terms interchangeably)
- Include papers that focus on implementation challenges/barriers/disadvantages/failures of EMRs/EHRs/HIS
- Include papers that focus on implementation benefits/advantages/successes of EMRs
- Include papers that focus on implementation of EMRs in low resource settings
- Include papers that focus on implementation of EMRs in slum settings
- Include papers that focus on Sub-Saharan Africa and Kenya

Inclusion Criteria

- Include papers that focused on EMRs or EHRs
- Include papers that referred to eHealth systems or health information systems (that focused on EMRs or EHRs)
- Include papers that include low resource settings or limited resource settings
- Include papers that focused on Sub-Saharan Africa, African countries
- Include papers that focused on Kenya and developing countries (that focus on Sub-Saharan African countries)
- Include papers that focused on implementation of EMRs/EHRs or HIS systems that also referred to challenges/barriers/disadvantages and benefits/advantages of implementation
- Include papers which document the implementation or deployment of EMRs/EHRs/HIS system where authors discuss lessons learned, risks, outcomes or recommendations
- Include papers that include both positive, and negative views/results of implementations
- Include papers that discussed human resources, workflow, patient outcomes, buy-in of stakeholders, staff input or involvement in the implementation process, information technology infrastructure, privacy, confidentiality, safety, user perceptions, user satisfaction/dissatisfaction, successes, failures, adoption, or any other factors that are included in the pre, during, and post, implementation of such systems
- Include both quantitative and qualitative studies
- Include papers that refer to or focus on implementation in slum settings
- Include systematic reviews or literature reviews that align with the inclusion criteria/research question
- Include all papers that meet inclusion criteria regardless of date

Exclusion Criteria

- Exclude papers that did not include resource-limited environments
- Exclude papers that refer to databases or systems that manage health data such as District Health Information System, National Health Information Systems, National EMR/EHR/HIS implementations
- Exclude papers that refer to EHRs/EMRs/HIS implemented in hospital based settings

- Exclude papers that refer to hospital information systems, hospital management information systems, health management information systems, or health information systems implemented in a hospital setting
- Exclude papers that included or solely focused on financial analysis, cost, return on investment of EMRs
- Exclude papers that just focused on computerized physician order entry (CPOE) systems
- Exclude papers that focused on clinical decision support systems or clinical summaries systems
- Exclude papers that exclusively focused on electronic personal health records, electronic patient medical records, electronic patient registries, or patient centered health records
- Exclude papers that focused solely on personal digital assistant (PDA)
- Exclude papers that focused on mobile health technologies/systems, handheld technologies/systems/computers and/or mhealth strategies/policies
- Exclude papers on telemedicine
- Exclude papers that only focused on pharmacy stock systems or pharmacy medical systems
- Exclude papers on ambulance systems or ambulatory care systems
- Exclude papers on diabetes management systems or chronic disease management systems
- Exclude paper on laboratory information systems or laboratory management information systems
- Exclude papers on mental health systems or mental health information/tracking systems
- Exclude papers on medication management systems or medication therapy management systems
- Exclude paper that focus on immunization based systems
- Exclude papers that focus on dental information systems or dental health systems
- Exclude papers that focus on obstetrics health information systems
- Exclude papers that focus on occupational health information systems
- Exclude papers that focus on animal management information systems, animal health information systems and animal tracking/surveillance systems
- Exclude papers on data management systems, nutrition information systems, reporting systems, surveillance systems or emergency based data health systems that did not refer to EMRs or EHRs
- Exclude papers that focus on EMR/EHR/HIS implementations in developed countries or countries not in Sub-Saharan Africa

APPENDIX 2.2 Search Strategy

MEDLINE

(Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present)

Search Terms:

1. computerized medical record system.mp. or exp Medical Records Systems, Computerized/
2. (electronic medical record* or electronic health record* or emr or ehr).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
3. exp Health Information Systems/
4. 1 or 2 or 3
5. Developing Countries/
6. exp Poverty Areas/ or exp Poverty/
7. exp "Africa South of the Sahara"/
8. (low resource* or limited resource* or low income or resource poor or poverty or developing countr* or developing world).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
9. 5 or 6 or 7 or 8
10. 4 and 9
11. (adopt* or implement* or uptake or challeng* or benefit* or barrier*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
12. 10 and 11
13. (Nairobi or Kenya).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
14. 4 and 13
15. 12 or 14

EMBASE

(1974 to 2014 December 19)

Search Terms:

1. electronic medical record/
2. electronic medical record*.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]

3. electronic health record*.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
4. exp medical information system/
5. 1 or 2 or 3 or 4
6. low resource*.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
7. resource poor.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
8. limited resources.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
9. marginalized population*.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
10. low income.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
11. exp developing country/
12. poverty/
13. (developing countr* or developing world).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
14. exp "Africa south of the Sahara"/
15. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14
16. (adopt* or implement* or uptake).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
17. (challeng* or barrier* or benefit*).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
18. 5 and 15 and (16 or 17)
19. Nairobi.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
20. Kenya.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
21. 19 or 20
22. 5 and 21
23. 18 or 22

GLOBAL HEALTH

(1910-2014 Week 50)

Search Terms:

1. Medical Records Systems.mp.
2. electronic medical record*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]

3. electronic health record*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
4. health information system*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
5. 1 or 2 or 3 or 4
6. low resource*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
7. resource poor.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
8. limited resources.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
9. marginalized population*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
10. low income.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
11. Developing Countries/
12. exp Poverty/
13. exp "Africa South of Sahara"/
14. (developing countr* or developing world).mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
15. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14
16. (adopt* or implement* or uptake).mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
17. (challeng* or barrier* or benefit*).mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
18. 16 or 17
19. nairobi.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
20. kenya.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]
21. 5 and 15 and 18
22. 19 or 20
23. 5 and 22
24. 21 or 23

COCHRANE

(All EMB Reviews)

EBM Reviews - Cochrane Database of Systematic Reviews 2005 to November 2014, EBM Reviews - ACP Journal Club 1991 to December 2014, EBM Reviews - Database of Abstracts of Reviews of Effects 4th Quarter 2014, EBM Reviews - Cochrane Central Register of Controlled Trials November 2014, EBM Reviews - Cochrane Methodology Register 3rd Quarter 2012, EBM Reviews - Health Technology Assessment 4th Quarter 2014, EBM Reviews - NHS Economic Evaluation Database 4th Quarter 2014

Search Terms

1. computerized medical record system.mp. or exp Medical Records Systems, Computerized/
2. (electronic medical record* or electronic health record* or emr or ehr).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
3. exp Health Information Systems/
4. 1 or 2 or 3
5. Developing Countries/
6. exp Poverty Areas/ or exp Poverty/
7. exp "Africa South of the Sahara"/
8. (low resource* or limited resource* or low income or resource poor or poverty or developing countr* or developing world).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
9. 5 or 6 or 7 or 8
10. 4 and 9
11. (adopt* or implement* or uptake or challeng* or benefit* or barrier*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
12. 10 and 11 (total papers 206)
13. (Nairobi or Kenya).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
14. 4 and 13
15. 12 or 14

GOOGLE Search

Search Strings

1. "electronic medical record system" Kenya
2. ("electronic medical record system" or "electronic health record system" or "health information system") + ("Kenya" or "Nairobi" or "Africa South")
3. ("electronic medical record system") + ("challenge" or "benefit" or "advantages" or "disadvantages" or "implement" or "deploy" or "adopt") + ("Nairobi" or "Kenya")
4. ("electronic medical record system" or "electronic health record system" or "health information system") + ("challenges" or "benefits" or "advantages" or "disadvantages" or "implement" or "deploy" or "adopt") + ("limited resource settings" or "limited settings" or "slums" or "poverty areas")
5. ("electronic medical record system" or "electronic health record system" or "health information system") + ("challenges" or "benefits" or "advantages" or "disadvantages" or "implement" or "deploy" or "adopt") + ("Kenya" or "Nairobi" or "Africa South") + ("limited resource settings" or "limited settings" or "slums" or "poverty areas")

GOOGLE SCHOLAR Search

Search Strings:

1. ("electronic medical record system" or "electronic health record system" or "health information system") + ("Kenya" or "Africa South")
2. ("electronic medical record system" or "electronic health record system" or "health information system") + ("Kenya")
3. ("electronic medical record system" or "electronic health record system" or "health information system") + ("developing countries")
4. ("electronic medical record system" or "electronic health record system" or "health information system") + ("developing countries") + ("challenges" or "benefits" or "advantages" or "disadvantages" or "implement" or "deploy" or "adopt")
5. ("electronic medical record system" or "electronic health record system" or "health information technology") + ("developing countries")
6. ("electronic medical record system" or "health information technology") + ("developing countries")
7. ("electronic medical record system") + ("developing countries") + ("challenges" or "benefits" or "implement" or "deploy" or "adopt")
8. ("electronic medical record system") + ("developing countries") + ("World Health Organization")
9. ("electronic medical record system") + ("developing countries") + ("United Nations")

CHAPTER 3: Barriers and Facilitators to Electronic Medical Record Use in Urban Slums - Kibera Field Study[1]

[1] *A version of this chapter has been submitted for publication.*

ABSTRACT

Objective: This study seeks to discover practical insights about facilitators and barriers to EMR implementation in urban slum environments, what might improve success rates, and how impacts on slum community health care might be recognized.

Methods: This field study used a descriptive qualitative method to explore the perceptions of primary care clinic staff about an open-source EMR introduced into two different clinical settings in Kibera, Nairobi.

Data Collection: Clinic staff were interviewed, using open-ended, semi-structured questions followed by specific probe questions. Content analysis was used when exploring transcribed data.

Results: Three major themes – infrastructure, software, social and organizational – emerged from the content analysis, with one overarching consideration, sustainability, which was identified as an important concern for participants. Although participants reported many infrastructure (e.g., reliable power, Internet, networks, workstations, and interoperability) and software (e.g., health data, confidentiality, deployment) challenges, social and organizational factors (e.g., identity management, operations and incentives) appeared to be most potent and required more attention to enhance EMR impacts.

Discussion: These findings are consistent with what others have reported, especially the importance of practical (infrastructure and software) barriers to EMR use in limited resource settings and in developed countries. Other findings appear to be unique to or uniquely impactful in slum settings, including the importance of identity management, meaningful incentives and sustainability in Kibera clinics.

Conclusions: This study reveals front-line observations about opportunities and shortcomings of EMR implementations in two health clinics in one of East Africa's largest slums. Participants

understood the benefits gained from the EMR, noted issues specific to slum settings, and cautioned that sustainability remains the greatest challenge to effective EMR use.

INTRODUCTION

Since 2008, for the first time in human history, more people have lived in cities than in rural areas.[1] This rapid urbanization has led to a wide range of health problems facing these populations.[2,3] With increasing migration to urban centres and development of urbanicity,[4] the number and size of urban slums increases. One billion of the world's people already live in slums, mostly as marginalized populations.[5,6] They face real struggles with unemployment, poverty, geographic instability, and social discrimination.[7] Increased health care needs coexist with decreased capacity to deliver health care. Among the greatest impediments to comprehensive health care access are financial barriers,[6,8-10] poor communication systems between health facilities, fragmented health services[9,11] and almost no continuity of care.[12]

Given the promise of information technologies to improve communication, sharing and tracking of health care; policy-makers have promoted the introduction of Health Information Systems (HIS). In particular, Electronic Medical Record (EMR) Systems[2a] are extolled for their ability to overcome practical problems associated with use of paper-based records where there is little infrastructure for record storage, transport, exchange and upkeep.[13-15] The World Health Organization (WHO) encourages developing countries to invest in health information systems;[16] emphasizing reporting of health information (such as death, birth and disease rates) and better management of public health interventions.[17] Information requirements attached to WHO and other development grants further motivate developing countries to build or enhance HIS infrastructure by making it a priority item. Kenya, an emerging economy in East Africa has

2a An electronic medical record (EMR) is a digitized patient health record in one healthcare provider's office or health clinic. An electronic medical record system is a type of health information system that captures basic patient information such as demographics, lab results, medical history, allergies, drug history and patient billing information.[53] For the purpose of this study, an EMR is referred to in the general sense capturing standard patient health and clinical information as described by Ludwick and Doucettee (2009) all other terms will be referred to as digital health records.

heeded the call for health information investments. The country has developed a health information strategy and has crafted policies focused on the implementation and integration of HIS in major urban settings.[18] Evidence is cited to support the claim that digitized health records improve patient management, clinic efficiency and health outcomes in Sub-Saharan Africa.[19-24] As discussed in Chapter 2, limited resource settings experience systems, people, process and product issues that can fundamentally change pre-requisites for successful HIS deployments. Even resource-rich settings can experience failed HIS implementations when inadequate attention is given to similar considerations.[25]

In Nairobi, the capital city of Kenya, 60% of the population resides in slums.[26] Kibera is the largest slum in Nairobi and one of the largest in East Africa.[3a] It experiences all of the impediments to health care access for needy populations in disadvantaged settings. It also requires a focused effort to introduce health information systems to improve health care services.

A Canadian organization, Innovative Canadians for Change[27] has been working to support EMR efforts in Kibera clinics since 2011, using Internet-based open-source digital record software optimized for primary care[28] using the OpenMRS[29] EMR platform as the foundational infrastructure for the digital health record. The researcher's community access, relationships and collaborations associated with this work offer a unique opportunity to learn about factors affecting EMR initiatives in a highly challenged, resource-poor, slum settings in Sub-Saharan Africa. This study takes advantage of this access to discover whether, in the opinion of local stakeholders, digitization of health records has benefited the community. The study also seeks practical insight about how EMRs should be deployed in slum settings to maximize benefits and minimize harms, through the development of an implementation checklist. Qualitative method

3a. Kibera is one of the largest slums in East Africa located in Nairobi, Kenya.[33] It encompasses a very densely populated environment, lacking basic necessities.[33]

was used to explore the experiences of front-line participants, to further understand critical success factors, suggest a framework for understanding how EMR deployments affect slum clinics, and make recommendations for future EMR deployments in similar settings.

METHODS

Design

This study used descriptive qualitative method to explore the perceptions of primary care clinic staff about an open-source EMR introduced into two different settings in Kibera, Nairobi. The intent was to capture the true essence of participant's opinions, experiences and perceptions and to understand the how, what, where and why of the participants' EMR experience.[30,31] Purposeful sampling was used to find "information- rich" participants[31] for invitation to in-depth one-on-one interviews.

This study design was approved by the University of Alberta Research Ethics Board (Pro00051485) and by AMREF Ethics and Scientific Review Committee (ESRC) in Kenya (AMREF-ESRC P162/2015). All participants provided written informed consent.

Setting

Kibera is one of the largest slums in East Africa. While figures vary, some estimate the population to be close to one million persons[32-36] and are crowded in 13 sub-communities in a 2.38 square kilometer area.[32] Nestled in the heart of Nairobi (Appendix 3.1), Kibera's reputation is mixed.[33] Life-long residents describe it as a safe place, whereas outsiders regard it as unhygienic, disease-ridden and high-risk. Officially, Kibera and its land are government-owned. The slum's residents are "illegal settlers"[37] without entitlement to publicly funded health care or human services.[38] The government has tried to evict residents and redevelop the land,[39] creating

distrust of government intentions and programs. In this context, an informal service industry appears to have flourished. Examined on its own merits, Kibera has a competitive small business economy, with countless private shops throughout the slum.[40]

An entrepreneurial attitude extends to health care. Kibera's clinics are small and mostly independent, operating on a fee for service structure. Typically owned and operated by faith-based, non-government or private enterprises, they vary widely in infrastructure and staffing. There are over 100 clinics in Kibera[41] operating in isolation from one another and often competitively. Therefore, patients have difficulty knowing what types of services are available at which clinic. Many residents, when desperate, seek care at government facilities, which proves difficult due to their illegal settler status. For the most part, Kibera's clinical infrastructure is fragmented and inefficient, with poor health outcomes and lack of continuity of care.[42]

While some Kibera health clinics have adopted EMRs, most health clinics still use paper records. Given strong interest in bridging Kibera clinics through information management, the experience of EMR early-adopters is of particular importance. The clinics need to adapt to the patient needs and the environment. With most patients being "mobile" and accessing care at multiple different clinics within Kibera, developing the interoperability of EMR systems and securely sharing patient clinical data between registered health clinics could significantly improve patient outcomes. The two clinics selected for this study adapted the same open-source EMR, but to a different extent, with different outcomes. The clinics were distinguished by prior collaboration with a Canadian philanthropic organization, reducing barriers to access for the researcher. Both clinics are located well within the Kibera slum, see over 25 patients per day, offer primary care services and are devoted to marginalized populations living in slum environments.

Clinic 1 (C1): Clinic 1 is a medium-sized clinic serving 30-50 patients per day on one floor, (Appendix 3.2). It is owned, operated and funded by a community-based organization. It has a close referral relationship with Clinic 2. Previously a completely paper-based environment, Clinic 1 partially adopted the EMR, using it in reception and cashier areas, physician offices, nursing offices, pharmacy, laboratory, and the Comprehensive Care Clinic (CCC). The clinic has approximately ten full time staff (including, physicians, nurses, pharmacist, lab technician, two receptionists).

Clinic 2 (C2): Clinic 2 is a larger-sized clinic serving 150-200 patients per day on two floors (Appendix 3.3). It is operated and funded by a large non-government organizations (NGO). Clinic 2 has a mix of electronic and paper processes, using the EMR in reception, triage, physician offices, nursing offices, pharmacy, and the pediatrics department. The clinic employs approximately 30 full-time staff (including physicians, clinical officers, nurses, pharmacists, lab technicians, cashiers, triage support, receptionists, data entry clerks, and administration support staff). The clinic also employs part-time and temporary personnel.

Clinic 1 and 2 are open from 8am to 5pm daily with their maternity wings open 24 hours a day, seven days a week. However, depending on patient volume, hours of operation can sometimes change.

Computer and Networking Infrastructure

The clinics are using thin client computers that do not store any data for security and safety reasons; data is stored on a central server located off-site in a secure data-centre location. The cloud-based EMR operates on a secure network using a Secure Sockets Layer (SSL) certificate. Investment in Internet infrastructure (increase band-with and speed) has been upgraded at the clinics in order to accommodate the EMR. Ethernet cables plug into the thin

client computers for Internet access. The EMR operates as a point of care system, therefore there is a thin client computer with access to the EMR at every encounter point within the clinic. Users require a secure username and password to access the EMR (access is based on position and privilege). Backup of data is completed daily.

Sample

Participants were selected to participate in the study. Participants were consenting adults working fulltime for a minimum of one month at the clinic prior to the commencement of the study. Participant recruitment occurred onsite: the management team identified staff who might be "knowledge rich" with insights about the EMR in their clinic. Purposeful sampling[30,31] included nurses and support staff; these worker populations have been largely neglected by other studies of EMRs in primary care.[43,44] Data saturation[45] was reached with the sample size.

Participants

A total of 10 participants completed full interviews: four worked at Clinic 1 (three women, one man) and six at Clinic 2 (two women, four men; refer to Table 3.1). All participants were full time staff, all working at their clinic for over a year with seven having worked for over three years. Most participants (8/10) were between the ages of 29-39 years. All reported using a computer on a daily basis and most (8/10) rated their computer skills as "intermediate" with keyboarding skills using three or more fingers. All but one were present during the original EMR implementation in clinics.

Table 3.1: Participant Characteristics

	Physician/ Management	Clinical Officer	Nurse	Lab Technician	Pharmacist	Administrative/ Registration	**Total**
Clinic 1	1				1	2	**4**
Clinic 2	1	1	1	1	1	1	**6**
Total	**2**	**1**	**1**	**1**	**2**	**3**	**10**

Data collection

An interview guide was developed to ensure that all interviews maximized opportunity to discover unanticipated phenomena by using open-ended and semi-structured questions. The interview guide was the primary tool for data collection, formatted to encourage participants to speak freely without restricting their thought process.

The interview guide and questions were pre-tested with physician and pharmacist staff at two primary care clinics in Edmonton, Canada. One participant worked closely with marginalized populations and another worked with vulnerable patients who had complex health issues. The pre-test interviews were used to hone prompt questions, practice characterizing participant observations, and improve the researcher's ability to elicit information in a friendly and unthreatening manner. The interviews with the consenting participants were recorded. Transcripts of the interviews were analyzed and coded to further hone tagging, categorization and concept-mapping strategies. All pre-testing and practicing was done under the guidance of an expert in descriptive qualitative methods with the aim of optimizing the interviewer's skills well before going into the field. Mock data management also ensured that all needed equipment, software and processes were in place before travel to Nairobi, Kenya and implementation in Kibera.

Onsite data collection occurred in two stages. An introductory encounter was arranged with trusted community members (e.g., clinic managers) to explain the study, affirm

independence of the researcher from clinic management, attain informed consent, carefully detail how anonymity would be protected and establish rapport and trust with potential participants. Clinic managers approached participants directly to participate in the study. Emphasis was placed on creating a safe environment and context for information exchange. The second stage was an explicitly arranged session for the data collection interview at a location of the participant's choosing. The researcher conducted all the interviews.

After the preliminaries of a data collection interview were initiated, including confirmation of consent and availability for the anticipated interview duration, participants were asked to share any observations that might come to mind about the use of the EMR as part of their daily work at the clinic. Body language and verbal reinforcements were used to acknowledge the participants' responses and adaptively encourage further detail. If the question did not stimulate conversation, selective probing questions were used to express genuine curiosity about the participants' experiences (examples provided below):

- How would you describe the Kibera community?
- What do you use the EMR for when working with patients in Kibera?
- What do you like about the EMR?
- What do you dislike about the EMR?
- Tell me about your training experience, using and learning the EMR system?
- What are the unique challenge(s) when implementing an EMR in Kibera?
- What are the unique benefit(s) of implementing an EMR system in Kibera?
- Describe the advantages of using an EMR in the next three months, six months, one year and five years from now.
- Describe the disadvantages of using an EMR in the next three months, six months, one year and five years from now.
- What else comes to mind when you think about using an EMR in the next three months, six months, one year and five years from now?
- What motivates you to use the EMR system?
- In what ways has the EMR system influenced the operations of the clinic?
- How has management responded to the implementation of the EMR system?
- Is the clinic culture conducive to using an EMR system? Please explain.
- What impact has the EMR had on how you interact with patients in Kibera? Has it been a positive or negative impact? Please explain.

Data Analysis

After the interviews were completed, the entire sessions were transcribed verbatim. The audio-recording was re-played to verify accuracy and authenticity.[46] All individual identifiers or possibly personally-identifying phrases were stripped from the data, in keeping with the anonymity commitment to participants. Participants were assigned a meaningless digital identifier and transcripts were line-numbered. Finalized, anonymized and validated transcripts constituted data for analysis.

Content analysis method[31,46] was used when exploring the data. Content analysis requires the researcher to stay very close to the data, without undue interpretation.[30] After transcription validation and anonymization was completed, the transcript was printed and re-read to fully absorb the content prior to coding. Parts of reviewed transcripts were highlighted to flag unique observations about the EMR implementation. Clarification of local idiom was added as margin notes, where appropriate. For example, participants most often refer to patients as "clients," and so this convention was applied throughout transcript interpretation and in the findings. Key codes were identified and categorized. Through an inductive process, common themes that linked codes to categories emerged. Finally, illustrative quotations were abstracted to ground categories, subcategories and themes.

Rigor

Rigor concerns the logic and reasoning supporting decisions made during a research process: the how and why behind qualitative findings.[45] This study adopted criteria of Lincoln and Guba (1985) to maximize rigor in the domains of credibility, transferability, dependability and confirmability.[47] Credibility refers to ensuring the research findings make sense and are accurate based on the method chosen.[45] Participant and peer debriefing was used throughout the

study to validate key findings and interpretations. Transferability refers to the detail and recognisability of setting, participants, and process descriptions.[45] The researcher endeavoured to fully capture operationally important attributes of the Kibera clinic settings. Dependability relates to the researcher's ability to maintain an audit trail so that readers can understand how decisions are made throughout the study.[45] This report is supplemented by an audit journal, documenting and dating all actions and decisions made during the study. Confirmability enhances the rigor of bias control.[45,47] The researcher used a personal journal to reflect on all encounters, continually acknowledging possible sources of bias and staying as close as possible to the surface of the data.

RESULTS

Themes

Eight categories and four themes emerged during content analysis. The themes grouped categories into matters of 1) Infrastructure, 2) Software and 3) Social and Organizational. A fourth overarching theme, sustainability, pertained to all categories (Figure 3.1).

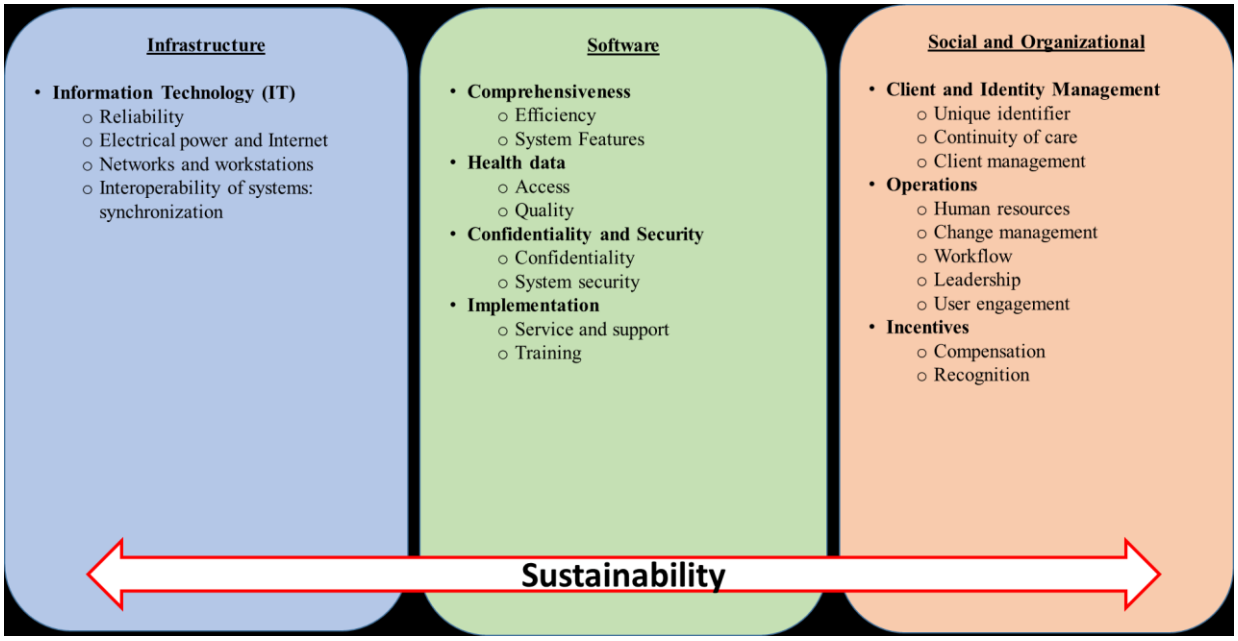


FIGURE 3.1: CONTENT ANALYSIS - THEMES, CATEGORIES AND SUBCATEGORIES

Infrastructure

Infrastructure is understood as all things and services needed for an EMR to be present and working in Kibera clinics. Accordingly, the theme includes structural considerations of reliability, availability and stability of power and Internet, adequate networks and workstations, and interoperability between systems (Table 3.2).

Reliability

Infrastructure challenges were emphasized by participants, with many illustrations of how infrastructure deficiencies are both common and impactful in slum settings. Poor infrastructure seemed to trump all other problems: when needed system supports went down, the EMR either could not function or would not function as intended. Network and Internet glitches often resulted in operational slow-downs, with major impacts on user confidence, EMR adoption and the need to continue paper-based records.

Electrical Power and Internet

Lack of reliable electrical power was emphasized among participants as a major barrier to a transition to digital health records. Kibera's power could go down at any time and could be out for as much as 12 hours. Even if the power remained on, Internet services could go down unpredictably for varying lengths of time. Even if the Internet remained operational, data transfer speeds were unpredictable and could slow the EMR so much that individual screens could take one to three minutes to load. Infrastructure-related slow-downs or interruptions forced continuation of a backup paper medical records. One participant suggested modifying the EMR so that it could work offline, updating a central data repository only when Internet speeds were adequate. Clinic 2 invested in a generator to bridge power interruptions. Both clinics developed workflows for retrospectively transcribing key EMR data from paper backups after power or Internet down-times.

Networks and Workstations

The installation of sufficient computer hardware and networking to serve all clinic functions proved problematic. Clinic 2, with its more complex floor plan, did not manage to equip all areas equally, or even adequately. One participant mentioned that it was difficult to access health information because her colleague's room did not have computer access. Although network reach was inadequate for some, when working well, it was cited as a major advantage over the prior disconnected workstations.

Interoperability of Systems: Synchronization

Lack of interoperability between the different health systems already in use at the clinics was cited by participants as another impediment to full EMR adoption. Participants expected health information systems to be able to connect clinics and services, or at least ease the

exchange of information with the use of one central system. Many felt that this promise went unfulfilled. Even though Clinics 1 and 2 implemented the same EMR, their informational infrastructure differed in ways that impeded interoperability. Differences related to administrative, financial and disease-specific systems. For example, Clinic 1 used an electronic database required by government to track medications subsidized for persons infected with human immunodeficiency virus (HIV). Given their focus on HIV care, they also had to interface with a system for tracking HIV primary care. The EMR did not integrate these functions enough to allow retirement of the HIV-focused information systems. And information entered to the HIV systems was not captured by the EMR. Clinic 2 relied heavily on an enterprise resource planning (ERP) system for ordering prescription drugs from pharmaceutical vendors but could not interface this with order-entry features of the EMR. Despite strong requests by participants for better integration, both clinics remained subject to incompatible data contingencies for funding opportunities, government requirements or NGO research projects. These external health information requirements did not interface with or recognize the EMR, leading to many examples of redundant data entry and inefficiencies when switching between multiple systems during episodes of care.

Table 3.2: Infrastructure – Illustrative Participant Responses

Concept	**Quotations**
Reliability - Erratic, often slow, system performance.	*"And when you want to save the bill there is a problem, it is not saving it is not saving." (P4 C1)* *"[…]It's slow at some point, it's slow. I think when it's used for some time it can be very very slow. […]. It is quite discouraging at some point." (P1 C1)*
Electrical power and Internet - Internet connectivity and power interruptions affecting EMR access.	*"Power fluctuations so we don't have you know reliable power, electricity." (P5 C2)* *"The challenge of the internet because you find that the system needs internet connectivity […] They made the lives of the people using the system boring, because <laughter> you try to post something and its slow, you're held up, you know delaying and clearing a patient is being*

Table 3.2: Infrastructure – Illustrative Participant Responses

Concept	Quotations
	reviewed, you end up making the queues much longer and you end up making the clinicians feel like maybe the manual system is the best." (P7 C2) "*We do not have constant and reliable internet band-width so this makes it a challenge because the EMR is cloud-based system and so the fluctuation of the internet makes entry sometimes very slow or impossible." (P3 C1)*
Networks and Workstations - Insufficient density of devices and connections.	*"The major challenges of [EMR system] like where I work you find that we have only one computer that has the [EMR system] that we can use, I know it [EMR system] can be accessed [by] any computer as long as there is internet. […]. Of course [EMR system] require patients to be registered and then also for both doctors to have computers and internet but now it is only [in] one room which has this […]. So that is the challenge, I am the only one who can access that [EMR system]. So you find that there is no way I can be the only one doing it [EMR system], my colleague is not doing it, the registration they are not registering using [EMR system]." (P9 C2)*
Interoperability of Systems: Synchronization - Fragmentation and duplication of data in multiple systems that do not communicate with each other, coordinate or exchange information.	"*I am not sure [if] [EMR] would be able to be synchronize with the HIV data, the [HIV Database] but if it were possible to, it would be okay to have one system that can help us since we have an integrated site, we have one system to see all the patient .. it would be good." (P10 C2)* *"The main challenge was first of all we had so many other systems that we were using. […].. Looking at the nature of the work in Kibera […] we usually see approximately 150 to 200 patients a day so the workload is quite high. [...] We had indicated that we needed it [EMR system] […] to be […] synergized […]. If they could have been synergized or made it to one system that would be much easier for us […] in terms of reporting, ordering drugs and that kind of inventory management." (P8 C2)*

Software

The "software" theme encompassed concepts about EMR functions, features and suitability for shared health information management. Considerations included comprehensiveness of the EMR, health data, confidentiality and security, and implementation (Table 3.3). In addition, user-interface issues were grouped within this domain.

Comprehensiveness

Participants acknowledged benefits associated with EMR use, emphasizing how the EMR could improve information efficiency in a busy clinic. Once fully implemented, the EMR

reduced time taken to find, retrieve and file client records in support of client management. The alternative involved working through piles of papers in different locations. EMR use decreased the time taken to arrange referrals between Clinics 1 and 2 because of common client identification, problem summary and treatment synopsis formats. One participant credited the referral system with improving timely management of complex chronic diseases. Repeat visits were more efficient because the client's past history could be retrieved and updated in a consistent way. Clinic reports, mandatory by the government, required less manual data collection and took less time to prepare and submit. There were also fewer delays pulling prior reports. An EMR report dashboard facilitated faster access to clinic-level information.

Another participant perceived efficiency advantage to the EMR related to the prospect of abandoning paper. Most participants suggested that the EMR would facilitate the reduction or elimination of paper which, in turn, would significantly reduce clinic supply costs. Later efficiencies could be realized through repurposing of storage and sorting areas. The paper system coped with client information losses by creating new records; something else that the EMR was expected to avoid.

Participants emphasized that significant functionality was either missing or incompletely realized by the EMR. Examples included detailed reporting (e.g., reports to satisfy research funding conditions or mandated government accountabilities), laboratory interfaces, test result tracking, and medical supply management. The absence of perceived key features discouraged users from fully embracing the EMR; and prevented the clinic from retiring its paper record system. Maintaining a 'hybrid' paper-electronic system proved time consuming when trying to juggle high client loads. Some participants declared that EMR functionality is an absolute pre-requisite before an EMR can supplant paper as the preferred medium for health care management.

Health Data

The most frequently cited specific EMR-attributable improvements related to information access, persistence and sharing. Participants felt that electronic client records were more useful than diverse paper records because the EMR information, however incomplete, appeared the same way, persisting from one visit to the next. For example, pregnant and young mothers are given a Maternity and Child Health (MCH) booklet during medical consultations. Before the EMR, key information would be lost if the booklet was lost; antenatal clinic paper-based records did not duplicate booklet content. After EMR implementation, MCH information was updated and maintained within the electronic record, the booklet and paper-based records. Participants cited that with the EMR it would be easier to track and share pre-natal clinical data if systems (paper and EMR) captured consistent health data. The importance of data persistence was prominent among participants. Clinic clients and sometime the staff would frequently misplace appointment cards. The EMR made it easier to quickly determine who was to be seen and when. Misplacement or loss of a paper file put the client at risk. In sum, many participants appeared to connote EMR-attributable "improvement" with the ability to reduce harmful exposures and misinformed decisions due to loss of paper records.

Clinic staff reported greater trust in the information committed to the EMR. The quality of information about clinic clients was enhanced because the EMR enforced entry of a minimum data set in a standardized format. The same information could be accessed from multiple locations within the clinic and all staff worked with the same core data for the same client. Quality and accuracy of data was very important to participants because they needed to generate accurate and complete reports based on this data. One participant commented that generating reports manually is likely to contain errors. Another participant suggested that quality health data could support public health interventions by looking at data trends from the month reporting and

assessing potential disease outbreaks (e.g., Cholera), allowing health practitioners to better understand the health landscape in Kibera. Another participant commented that users who had access to the EMR were accountable for the data entered into the system and that information correctly captured at the point of care by clinicians was especially important. Quality accountability also applied for retrospective data entry completed by clerks.

Confidentiality and Security

A frequently cited positive attribute of the EMR related to its ability to improve confidentiality of health data. Without prompting or hesitation, participants observed that busy Kibera clinics are overwhelmed with paper records, making it difficult to maintain the confidentiality of the information and leading to it being seen by unintended parties. The EMR impressed users with its ability to cut down on stray client-identifiable information and to better protect confidentiality of data stored offsite. It was obvious to participants that the system was secured with usernames and passwords and that it granted different rights to different levels of clinic staff. One participant commented that the EMR would protect against disasters like fires. Finally, some participants' trust of the EMR appeared to relate to its having encrypted and protected data stored and backed up off-site.

A reciprocal disadvantage of an encrypted, centralized, data repository was that it was vulnerable if not reliably backed up. Participants were aware of the importance of database backups and data loss risk management. One participant cited an example of a server crash during the EMR implementation. While there was complete disclosure of the incident, the data was not recovered and clinic operations suffered a major setback as the EMR was re-implemented.

Implementation

Study participants recalled EMR implementation challenges at both clinics, but with some important differences in clinic experiences. Apparently, the initial EMR implementation was well supported, but post-implementation operational support was either missing or inadequate. Staff and management engagement was inconsistent, but generally perceived to be inadequate from the start. Enthusiasts would embrace the system and use their workstations. But others, who were hesitant, did not get over the implementation challenges, as a result many workstations remained unused.

Post-implementation EMR user support challenges and deficiencies compounded problems with user acceptance. Requests for fixes, customizations or enhancements did not appear to be responded to in a consistent or timely manner. The EMR needs of Clinic 2 changed post-implementation but there did not appear to be support for changing the EMR footprint or customizations. An expansion resulted in workspaces that were not networked or equipped with workstations, re-enforcing dependence on hybrid records and retrospective data-entry.

User training was problematic both pre- and post-implementation. Some participants cited lack of standardization and a failure to match training approaches to user learning styles. In general, the training experience seemed shorter than needed. Participants described a single day of supervised training while others reported a half-day of on-the-job training while client care continued. Apparently, all Clinic 2 training occurred during the day and a number of night staff, part time staff, and community health volunteers were neglected. Additionally, participants felt that the clinics could not keep up with the change in staffing. One participant commented that government and temporary employees should be trained on the EMR to ensure consistency in use. Three participants also commented that the training provided did not make the case for EMR use and benefits. Other participants stated that they had adequate training.

Many suggestions were offered for improving EMR training, enhancing user-engagement and consolidating staff skills post-implementation. Some suggested that pre-go-live (prior to the EMR going live and fully implemented in the clinic) training should be off-site, outside normal duties and spread over a two-day period. The staff would have a shared team-building experience, could be better oriented to the EMR "bigger picture" and would gain a long-term vision to sustain them through the painful transition from paper to computer. They might also feel more ownership for the process, more power to tackle future problems self-reliantly, and more accountable for outcomes. Participants from both clinics suggested that post-implementation on-the-job training should be continuous, as staff would not fully appreciate features until they are used regularly and would not work with newer features unless given some orientation. Additional suggestions included breaking into groups for role-specific training (e.g., all doctors trained together), shift-aware ongoing training schedules and including clinic clients in some training. Most importantly, it was strongly suggested that clinic leadership be more involved in the training planning and participation.

There was no shortage of participant EMR complaints and frustrations. These related to missing functions, reliability, flawed implementation processes, post-implementation support, inadequate within-EMR help and training.

Table 3.3: Software – Illustrative Participant Responses

Concept	**Quotations**
Comprehensiveness: Efficiency and system features - Electronic referral functionality improves care coordination. - Challenges of using paper records. - Software features were missing which were necessary for clinic staff to use the EMR in their daily practice.	*"The fact that we can make solid […] real-time referral system, makes consultations for more complex cases easier. I mean in real-time I can consult with a colleague who is at Clinic 2 without necessarily having to send the patient there too. That reduces the time we would need to manage the referral and also gives us timely feedback and that is that an #addition to quality# in my opinion." […]* "*Yes, please work on the reporting modules that would be very important for acceptance. It will reduce the friction that we have met with." (P3 C1)* *"The challenge I've had for a long time is the use of the manual records which have many challenges in use, they are bulky." (P7 C2)*

	"*For us here if the system is installed the benefits will be many it will be such a great system because if you are able to go paperless, one it will reduce the patient waiting time because it's very fast for us. […] You'll find the appointment card that we give to the clients some of them lose it so we are not able to access their past records. So if you give an appointment then you [referring to staff] lose you can't remember the day you were here last since you are using the manual registers so it's very difficult to go back three months start searching for a patient, it will take a lot of time. […]. Though those patients who lose their appointment card we will be able to search [in the EMR system], using their name and be able to retrieve the patients records."(P10 C2)* *"The other challenges of course, I am unable to use it to prescribe or to order lab test so I feel that it does not really help me. If I use [EMR system] I will still have to go back to paper." (P9 C2)*
Health Data: Access - EMR has been efficient in searching and accessing information compared to paper. - Generating reports, reducing clinical error and ensuring accurate data, have been benefits of the EMR.	*"What I like about the system, it is easier. Like long time when we have these cards, sometime you can misplace them, but when you come to this system you can find the patient very easily. […] I am very grateful, it had made our work to be very easy." (P4 C1)* *"In terms of it [EMR system] really links up from the triage area, registration of the patient down to the clinician whether the patient will see the doctor, the doctor will either order lab test to be done […]or other services. […] So once you click and open the file in the system you are able to see […], all what the patient has gone through and the doctor that has prescribed. In itself, it's a good system." (P8 C2)* *"It wouldn't matter where a patient went. Like I know we have it at Clinic 1 and its internet based, so if they are to go to Clinic 1 or any other facility in Kibera one would be able to access their history. There would be that consistency and it would improve their health. We would be able to see their progress and even the treatment they've had before, how they were being managed. Now we keep going back and forth back and forth in terms of diagnosis and treatment." (P9 C2)* *"[Paper records] can have so many clinical errors when doing documentation, when you are trying to summarize and connect the reports at the end of the month, you find you know it is tedious and time consuming. […] But with an electronic medical record system it makes work very easy, it's more efficient because the data is entered at the point of use then of course with this EMR systems you will be able to have tools that can summarize the reports depending on your needs and it makes work much more easier. And you are likely to have a more accurate report within the shortest time possible. […] So I believe the EMR will be the best system, we have challenges but I think it's a good system in terms of efficiency and constant #correctness#?"(P7 C2)*
Health Data: Quality - EMR automatically generated reports that significantly reduced time to manage data. - Accurate minimum data required by the EMR was critical for research and reporting purposes.	*"There is a data we run each and every month. We really have to have one or two clerks about three days before the reporting time, they have to take all those different books, tabulate them manually and we don't know if there are still some errors while compiling the data. So it takes them even three days to take the different diseases, the different occurrences per day, monthly. So its takes a lot of their time." (P6 C2)*

	"It is easy to analyze data from the HIV clinic cause the data is in the [HIV Database] but data of the morbidity data in outpatient it's a bit difficult to do that data analysis. For that data give us some information for decision making, I think I would be motivated by the fact that we would be able to generate more accurate and complete data." (P10 C2)
Confidentiality and System security - Access to identifiable patient information restricted by role. - EMR data protection against slum disasters (e.g., fires). - Data security and backup systems essential.	*"The manual records that we have <laughter> they are not confidential at all. Anyone can walk in and take the file and read the file you know and look at everything. I think when we are talking about electronic medical records there is a way that controls can be put, […] so that not everyone can access certain files or you can only access a file up [to] a certain level which is really important and good for confidentiality. That is where I mean electric trumps manual [...] All the way through for confidentiality." (P8 C2)* *"But in terms of us here, it would be more secure in the [EMR system] rather than paper. […] In fact, in an event of a fire here, all the manual records would be lost. […] We would lose all that data apart from the reports we have generated we'd lose so much. […]. It's more secure in the system"(P10 C2)* *"I would also ask that you ensure the security of the client data is […] given at most priority cause and that the system cannot crash again and lose the data that is very important. I don't think people would agree to using it if it crashed again." (P3 C1)*
Implementation: Service and support - Post-implementation challenges with power, Internet and other issues not addressed with timely support. - Clinic changes not accommodated post-implementation.	*"It was rolled out well, but then after that nothing was done about it." (P8 C2)* *"It's been very slow […], use was very consistent and then it went down again mainly due to the crash of the server and the loss of data and this time we also hit by internet shortage crisis and so the motivation that may have been achieved by that time sort of died. […]First give it time, with I mean staff support, show them that eventually at the end of the month these are the benefits you get for using the system versus I mean compare that to not using the system and the amount of work they actually have to do. It feels like a lot of work initially but once you get used to it, it gets better." (P3 C1)* *"We have walked the journey putting in relevant modules or relevant applications that address the needs of the health centre. […] Of course the challenge has been its taken a bit long, which is understandable because there are a lot of things we are trying to put 11 modules among other things. […] I want to say so far so good." (P7 C2)* *"This current system has not really been installed completely because like in the outpatient department we are not using it [EMR system] […] because the process of installation is not complete. […] The problem is that the process of installation has taken quite some time. […] So I appreciate the system but I have not used it so much apart from the training and a few areas like registration where they have installed it."(P10 C2)*
Implementation: Training - Training experience varied, some had adequate training and others were not trained at all.	*"The people who trained us were good, they were thorough. And the training like personally it wasn't once, in fact I was trained twice. First they came and trained us and gave feedback. The trainer came back again to see how far we were, the training was on job […]. The only things is that I am not sure whether everyone got the opportunity to*

- Ongoing training challenges. - Staff turnover and transfers challenge the training process.	*train since they were doing during the normal working hours. […] So some people could have missed on training. But personally I was trained and it was good." (P10 C2)* *"We were trained and then we were told ok guys now … Go do you thing you know. <Laughter> […] We are three personnel now there. I think one was trained which I think that was me. So the rest, they don't have a really good idea about it [EMR system]. […]. If they are not also involved in the training early enough, they don't own the process." (P8 C2)* *"I say that the people who are transferred, the people who resign, and when you resign or you leave employment some other people are employed. Like the government employees they keep on being transferred so when we get new people and the system is operational we need to train those people. We need to train these people so that they can be on the same page with others." (P5 C2)*

Social and Organizational

Client and identity management (e.g., unique identifier, continuity of care and client management), operations (e.g., human resources, change management, workflow, user engagement and leadership) and incentives (e.g., compensation and recognition) were frequently cited by participants as determinants of EMR benefits and harms (Table 3.4; Figure 3.1). Identity management were common to both clinics, while organizational and operational factors differed between clinics.

Client and Identity Management

An example of unanticipated social-EMR interactions relates to identity management. Digital health records depend upon the existence of unique identifier; for clients, providers, and facilities. Health information – notes, laboratory results, medication records, etc. – must be flawlessly allocated to the correct client. By contrast, lack of unique identification can have social value in settings like Kibera. Residents tend to use different identities for different purposes, even for health care. They may offer one identity when seeking care for HIV, but use a different identity (possibly at the same facility) for primary care or maternal health needs. This behaviour

may relate to the stigma associated with particular disease states; clients may not even disclose key health status information to a spouse. Maintenance of multiple identities is enabled by lack of societal attention to unique personal identifiers and foundational flaws to the health care system. There is no national health care number and little incentive to have one. One participant noted that typical clients have at least five distinct identities. This kind of phenomenon was not anticipated by the EMR, which proved frustrating to the clinics. One clinic implemented home-visits by community health workers to more consistently identify persons by connecting them to a consistent place and improve continuity of care across multiple disease states. However, this was sometimes met with resistance from clients because they found it difficult to trust "outsiders" (e.g., community health workers) who were not directly linked to their care. Additionally, the EMR could not support this work. It offered no ability to link distinct medical records, to record multiple identities for one person, or to retrospectively merge health data.

Participants cited client management as a benefit post-EMR implementation. Staff were equipped with valuable information to make informed decisions on client care. Information about allergies, drug reactions and prior drug exposures was very important in the Kibera context, but frequently a frustration pre-EMR. Additionally, one participant mentioned that the EMR can be utilized to improve client management and to monitor epidemics or disease outbreaks, equipping the clinics with valuable information that was not present pre-EMR.

Operations

Operational challenges were closely tied to human resource considerations. Kibera clinics can experience high staff turnover, incentivizing EMR use can be difficult and leadership aspirations may not be fully aligned with staff goals. One participant noted that with the use of the EMR fewer staff would be required to maintain records and ultimately reduce clinic costs.

Staff turnover was greater at Clinic 2, affecting both front line staff and the leadership team. The new leaders did not necessarily inherit the EMR commitment of their predecessors and there was a perceived lack of active follow-up with staff about how the EMR was working and what kind of support they required. High staff turnover and other operational challenges appeared to have also increased confusion about EMR responsibilities and accountabilities. The effects of human resource challenges were not consistent at each clinic. While Clinic 2 staff reported more turn-over related challenges, Clinic 1 did not face such challenges. New staff introduced to the EMR were excited and brought enthusiasm, development of new skills and support of peer to peer learning.

Operational challenges to EMR implementation were emphasized by a number of participants. Two participants commented that it is expected for challenges to arise when implementing a new system. Participants noted a number of ways in which change management could be improved. In particular, participants also emphasized effective communication about the purpose and process of the EMR implementation was felt to be important, but suboptimal. Communication, or lack thereof, from the leadership team seemed especially impactful during the EMR initial roll out. Ineffective communication was often cited as an impediment to effective change management. One participant noted that deployment delays and glitches were less upsetting when there was warning that this might happen. Another participant noted that the EMR may be unfairly cited for clinic problems by staff resistant to change who preferred to stick with the prior paper-based systems. Participants seemed to agree that different reactions to change could be better managed through perceived commitment of leadership to the EMR, sharing of a clinical improvement vision, emphasizing the team value of EMR use, and continuing communication about the ins and outs of the EMR deployment.

Participants expressed that the workflow at the clinic had improved - a standardized process was developed post-EMR, this was more evident at Clinic 1 (Appendix 3.4). With the improved workflow, clinic staff and clients understood how to manoeuver through the clinic based on their needs. For example, clients were aware they must check in at the reception desk before seeing a physician, a pharmacist or a laboratory technician.

Lack of local leadership engagement and EMR use role-modeling compounded the implementation challenge, particularly at Clinic 2 where managers commented that missing features, erratic performance and retrospective charting inefficiencies made it hard for them to advocate for the system. Repeated emphasis by participants suggested the leadership must actively participate in the entire EMR process; from setting the vision to being involved in training. It was evident that leadership support pre, during and post EMR implementation was a critical success factor in order to garner buy-in from staff and users.

Participant experiences varied regarding EMR involvement, some participants felt engaged during the process but most did not. As a result, lack of buy-in from users decreased their motivation to invest in system utilization, there was disconnect and lack of understanding on the overall benefits of the EMR.

Incentives

The diverse complement of participants had mixed attitudes towards financial incentives and non-monetary recognition. Some felt that the considerable time and effort of implementation should be rewarded, either financially or through some kind of portable certification or recognition. One participant suggested that this approach would send the wrong message to staff, that clinical improvement projects were somehow outside of clinic expectations or core business. It was emphasized by certain participants that there is a lack of sustainability towards providing

financial incentives. One participant suggested that successful EMR implementation should create its own incentives, by seeking gratitude and improving the quality of work. Other participants suggested that the EMR can help to attract and retain staff by offering a more modern, progressive, efficient and effective clinic; reflecting the entrepreneurial spirit of Kibera. Overall, opinions about financial rewards were split amongst the participants.

Others seemed to want more evidence that the work of EMR adoption was valued by the organization. One participant suggested that staff be provided with a formal certificate upon achieving EMR milestones; something that would showcase their commitment to the EMR initiative. Another recommendation would adapt an "Employee of the Month" initiative to champion EMR accomplishments and peer leadership.

Table 3.4: Social and Organizational – Illustrative Participant Responses

Concept	**Quotations**
Client and Identity Management: Unique identifier and continuity of care - Clients use different names to protect their multiple health identities. - Identifier needed to facilitate continuing and cross-clinic care.	*"If [patients] are given a good reason and the information is sorting in the right way, they are open to providing information. […] A unique identifier is a very fundamental component of the EMR because that way it can minimize the chances multiple registrations. […] Making it easier to track history and to avoid repetition. In my opinion a unique identifier is the one basic thing that would make the EMR very successful because without a very solid unique identifier it is possible that someone can double register in different facilities. If we had a way to create a unique identifier across all platforms then that way we would make sure that .. follow-up is easier and retrieval from the past medical history is also easier, management becomes easier and someone cannot register as a different person for the same condition." (P3 C1)* *"I would say is the continuity of […] the sustainability of the data. […]In terms that continuity of data […] Their health seeking behaviour is quite different from the economically advantaged people. […] So it becomes really difficult to get their previous history. So for the unique identification, it helps to identify this patient that has come in previously with certain conditions. You can know how they take their medication, do they complete their dosage well, is it habit that they are used to come in to the hospital could be an indication of maybe another illness. It basically allows us to better take care of these patients, better follow up on the patients so for us the ID would be very very important." (P8 C2)*
Client and Identity Management: Client management - EMR supported informed decisions. - Health risk and disease surveillance.	"*I mean we are using that data to inform our decisions on how to manage the patient. I believe overall it has an impact on the health of the client who we serve because if you are able to make good decisions based on the information you have then you are likely to come up with an intervention that addresses the needs of the people you are serving. […] Ultimately the patients start to gain a lot because you have decisions being made based on the available information and they address issues that are coming up out of the information and the reports that we have.." (P7 C2)* *"[EMR system] would be a big benefit for the facility and to the client as well cause they would be able to get quality health care. [….] I'll give an example if [the client] had an allergy to maybe penicillin or sulphur that would not be indicated cause you wouldn't know. And then you prescribe that medication containing sulphur. […] This was not captured because they came in as a new person. […] The system would […]improve the health care in terms of quality of the health care." (P8 C2)* *"It is something that will change the entire Kibera #community#" […] I mean at the end of the day we can know today we have two cases of cholera, what is happening. Is it that we have a outbreak in the community. We need to*

	communicate, even we can have those reports whereby we can make interventions as soon as possible." (P6 C2)
Operations: Human resources - Require less staff with the EMR. - EMR impact on attracting and retaining staff. - Transition process from paper to EMR. - Gaining of new skills.	"W*e'd like to use less staff by the way. Even the data clerks they are likely to be less because the manual entry would have been abolished here." (P7 C2)* *"She got many other responsibility especially when we didn't have a manager she had to act. […] But now currently, we need to agree on a way forward in terms of that now what you are calling the local leadership. […] We need another meeting with the [EMR] team and us as the staff here in the facility where people are again given the process, what is happening, what is expected of us, what we expect to see. An opportunity also for the other staff to be able to voice their feelings about the whole system, the challenges they have had […] I think that is missing, how we transition from the paper to the paperless. It would be good for us to […] have some timelines […] the [EMR] team to tell us we hope to have installed [EMR system] by this time and then you people need to use [EMR system] from this time together with the paper probably as a backup and then at a point we transition now from paper to the system completely."(P10 C2)* *"It was my first time to use a computer. […] When I came here I was just excited <happiness and laughter> Very excited! […] Me I am very grateful, very happy." (P4 C1)*
Operations: Change management - Change management and communications affected implementation.	*"And generally change is expected to make some friction, eventually they will accept, but it is inevitable." (P3 C1)* *"Management should communicate and make it clear that we are not trying to force something down their throats but rather the current thinking and the current direction is such that people need to move towards EMR. […] I think the reactions to the use of the system have been two fold. Some staff are excited about the system and there are those who are not excited. The ones who are excited […] want to embrace technology cause they probably understand the advantages […]. On the other hand, we have had those who hesitant, who are resisting this change because they feel they are so used to the manual [paper] system, they feel they are so use to doing things the same way they have been doing them for years. Embracing an electronic medical record system it's like you are adding another task to them so they are resisting. […]We just need communication, cause management need to give direction and the staff have a responsibility of following directly. […] Its explaining why we should move in this particular direction and the advantages we likely to get at the end of the day." (P7 C2)*
Operations: Workflow - Improved clinical workflow.	*"I can say the workflow is much better because there is a system now to follow that eventually becomes the norm it's not fully absorbed by the staff and the patients especially the new patients but I see improvements." (P3 C1)*
Operations: Leadership	*"So I don't know who is leading it, I have no idea. I think that is a problem because different faces come and go and we have no idea who is spearheading this." (P9 C2)*

- Participant adoption was influenced by perceived leadership team endorsement and engagement.	*"You have to involve the management […], this is where we are heading, this is the output we want at the end of the day and this is part of our job description. […] They are involved from the word GO. The management still have a stake to play […] Leadership will have to strike hard. So that it will have all of us going toward the same direction" (P6 C2).*
Operations: User engagement - User engagement is necessary to garner buy-in for the EMR.	*"I think the best things is that everyone to be involved, all the health personnel to be involved, even the community health care workers, cause they are part of the way the health system in this clinic works. […]. They will be able to own the process once they are also trained on it, they are also told this is what happens, they also have an interest now to use it." (P8 C2)*
Incentives: Compensation and recognition - Monetary rewards. - Excitement towards being part of a modern facility. - Improving quality of work.	*"I've been paid by whoever who is paying. So when I know very well when I am not being paid and there I am being paid I weigh these options." (P1 C1)* *"It's like they were expecting some stipend. […] Yeah like money." (P6 C2)* *"The future of this system, I think we'll not use these cards anymore, we will be feeding direct.* […] "*These era we are going digital. […] Yeah! The world [is] going, we have to go digital." (P4 C1)* *"And the fact that we know now a days that we are going more digital and I think that would also motivate us and that we are part of the health, a modern health facility especially a health centre that is paperless I think that would also motivate. [...] For me it's not a temporary thing, if we begin it that way with incentives is it sustainable? […] I don't think it's sustainable. That means people will only use [the EMR system] when the incentives are there. If they are not there people will not use it. So for me I don't think of incentives, probably just that motivation of people understanding it [EMR system] very well." (P10 C2)* *"No we don't incentive. It's like you are told you are employed somewhere and your employer tells you this is what I want you to work and I've given you the facilities to work the way I want. Surely I don't have to give you additional money because you are doing the same work, only that, this time around you are not doing paper cards or the paper files you […] enter the data directly into the system. […] So we don't need to give incentives in terms of money cause that may not be sustainable in the first place."(P7 C2)* *"If we are here to serve the patients and to serve them well, then the best motivation should be getting a good result out of it and understanding what we are doing; cause with lots of paper its kind of hard to evaluate our quality of work. […] Initially the double entry is difficult and someone would mostly want monetary motivation in the long-term. I think we should endeavour to seek gratitude, I mean motivation from the quality of work that we give. […] I think it's good to speak to our staff generally to find motivation and the quality of work that we do rather than how much we take home. […]*

	Without proper capability to analyze what we are doing, it is difficult to understand how to improve." (P3 C1)

Sustainability

Sustainability of the EMR was an overwhelming concern emphasized by participants. The HIV and EMR systems are funded by different organizations that have different mandates and priorities, it was no surprise that participants were anxious about the funding strategies for both systems. They were unsure what would occur when the funding commitments would run out; how their roles may be potentially impacted and whether or if funding would be renewed. Another reasonable concern by participants was the sustainability of providing financial incentives to staff in order to increase motivation and use of the EMR. Participants were worried that staff would only use the EMR when incentives were provided and would abandon use when incentives were withdrawn. As a result, it would send the wrong message to staff and would ultimately create significant pressure for the clinics to sustain incentives, which is not feasible in resource-constrained settings like Kibera where qualified man power and funding are both scarce. Additionally, the EMR is seen by some participants as a "pilot" project, therefore they have not yet recognized the EMR as a sustainable program. This may have explained some of the resistance by participants; they feel in part that the EMR will not be used in the long-term, therefore their attitude towards the EMR has been, overall, complacent.

Participants recommended that staff empowerment, user engagement and leadership alignment was necessary to improve sustainability of the EMR initiative. Interestingly, the importance of building organizational capacity was emphasized more than the needs for reliable power, networks, good Internet connectivity and EMR software. Some participants suggested that values-based incentives (e.g., doing the right thing, quality of work, etc.) needed to be

supplemented with monetary (e.g., financial incentives) and social (e.g., employee certification and recognition) rewards. The most pragmatic, and Kibera-spirited, comments related to the business case to be made for EMR adoption and how the clinics could be made more sustainable through use of digital health records.

One participant noted that observation and study of EMR implementations might enable sustainability. Anticipating mandatory use of health information systems in Kenya, it was suggested that lessons learned about implementation challenges be widely shared, including leveraging those from this study.

In a place like Kibera where people live day to day, the thought of long-term sustainability may not be a first priority for most people. However, at the clinics, the ability to survive in conditions of constant change is not only a priority but necessary. Whether the EMR proves an aid or a hindrance to adaptive change may ultimately prove the greatest determinant of sustainability.

DISCUSSION

The results of this study revealed a multitude of challenges associated with deployment of the same open-source EMR at two different Kibera clinics. Some barriers to EMR uptake are outside the influence of clinic stakeholders and are likely to affect all clinics in similar environments. The reliability of electrical power, good Internet service, networks and personal computing devices is unlikely to change without community-wide infrastructure investments. Until reliability can be assured, EMR deployment initiatives should anticipate infrastructure problems and have software features that allow rapid switching to alternate power sources and instant support for off-line modes that allow clinic operations to continue during Internet or network outages. Even if such fail-safes are available, this study highlights the importance of on-

site technical support and rapid iterative EMR adaptation to change. Mitigation and risk management is fundamentally important in settings where unforeseen circumstances are commonplace.

Other barriers to consider relate to factors that may be within the means of individual clinics to influence, given sufficient preparation and support. Participants in this study highlighted the importance of technical support, training, leadership and change management before EMR implementation as well as long after any go-live date. These needs are not extraordinary, but they may be more acute in resource-poor settings. It is possible that a relatively greater investment is needed to customize an EMR product (that responds to the needs of users) and to adapt a standard EMR implementation strategy for an urban slum environment in order to achieve a successful outcome. The clinics observed in this study were well aware of the need to invest time and energy before seeing a return on investment. It is possible that they were not fully aware of the extent or type of investment required to get over the implementation hump and find their way to new, more efficient, post-implementation processes. The particular importance of building organizational capacity for EMR use did not appear to be apparent to clinic stakeholders before the new health information systems were introduced. Although it was recognized that EMR efficiency benefits would take time to emerge,[48] insufficient training, resistance to change, lack of communication and inadequate change management strategies led many study participants to worry about the sustainability of what advantages they associated with the EMR adoption they did achieve.

The results also suggest that experienced EMR users at two clinics were very aware of the need for an EMR and the potential benefits to be gained from consistent management of quality health data. There were oft-repeated perceptions that an EMR-enabled clinic would be safer, be better able to protect patient privacy, be more able to comply with drug and disease surveillance

strategies, support continuity of care for complex chronic disease and be more attractive to a relatively scarce health care workforce. Staff would be more productive if cumbersome paper-based processes could be retired. However, the participant reports also make it clear that the promised advantages of EMR use were yet to be fully realized and may not be achievable without a different approach to human resource and change management.

Similar potential benefits from EMR use, and barriers to benefit realization, have been observed with other implementations in low resource settings.[13,14,21,22,24,49-52] The principle facilitators and barriers to meaningful EMR implementation and use resonate with observations based on EMR initiatives in seven developed countries.[53] Factors observed in Kibera but not in more advantaged settings principally related to infrastructure. However, the potential disabling effects of insufficient up-front investment, user-support, leadership commitment and adaptation to local needs appear to span all deployment contexts.

We also observed some social and cultural challenges that may be unique to urban slums, including a fascinating mismatch between EMRs and community approaches to identity management and strong emphasis on the importance of rewards, financial or reputational, for new users. Although the national government has started work on the development of a national unique personal identifier, this is unlikely to impact slum settings until slum residents attain more of the rights and legal status afforded the rest of the population. There is growing interest in the use of biometric identifiers, and Kenyans are starting to use biomarkers for voting. Even so, EMR products will need to be more tolerant of multi-identity contexts until biometric technology is widespread, affordable, trusted and accepted.

Responsibility for effective use of the EMR ultimately rests with users, not implementers. Although it is tempting to focus on the challenges of implementation processes, our results suggest that post-implementation operational barriers and facilitators most affected the

sustainability of EMR initiatives in resource-challenged settings. This is especially true for primary care EMR systems that may not attract niche funding for disease specific medical record systems, such as those promoted in Kibera for HIV and TB care management.

Qualitative inquiry is most valued for its ability to generate insights that can be further explored and tested with other study designs. We aspire to follow-up studies that will single out EMR adoption barriers and facilitators specific to disadvantaged settings and evaluate possible remedial interventions. For example, little is known about how financial incentives (or other alternative options) could be used to advantage in resource-limited settings. Tierney et al. (2007) suggests a financial stipend should be provided for capacity building.[54] A follow-up intervention study could compare the experience of clinics adopting different types of staff incentives. Participatory action research could be used to find pathways to optimal EMR use in slum clinics that have got through implementation to at least 80% digital health record use.

Based on the State-of-the-Art review (Chapter 2), we found a significant gap in the literature regarding implementation checklists, with little information published on this topic. We have responded to this need by using the findings of this study along with the observations of the literature and experiences of the researcher to develop key considerations for a pre- and post-implementation checklist (Appendix 3.5) that similar clinics might use to better anticipate challenges associated with EMR use in urban slums. We hope that the checklists will help guide future EMR implementations, and so improve the overall sustainability of EMR projects in resource-challenged settings. We hope to validate the pre-implementation checklist to assess its applicability in a wider range of clinic environments.

Limitations

Although, we may have been "too close" to the data due to previous philanthropic work in Kibera, it can be argued that this was a benefit to the research study. As a result, detection of intricate details and overall understanding of what was shared by participants was uncovered. We were able to empathize with participants, building relationships and trust which was crucial when working in Kibera. Participants were surprisingly open with their feedback, willing to share their thoughts, which was a bit unexpected considering the cultural context of Kibera. Generally in more business or formal relationships Kenyans tend to be uncomfortable with providing blunt feedback.[55] Additionally, this study also helped to re-engage the staff in reflection on the EMR implementation process, possibly giving them an opportunity to impact organizational adaptations. Although a qualitative study with a small sample size cannot represent the experience of all clinic staff contemplating EMRs in Kibera, it does uncover important experiences that others may wish to emulate or avoid.

CONCLUSION

The purported advantages of EMR implementation in urban slums are widely promoted. Increasingly capable health information systems could facilitate communication, help coordinate care, and improve the continuity of care in disadvantaged communities like Kibera. However, available systems may not have the ability to simplify care or improve efficiency where funding and human resources are scarce, infrastructure is unreliable and health data demands are opportunistic, not strategic.

This study exposed and described opinions of local stakeholders. Their participation and voice was appropriate, given an objective to discover practical insights about how EMRs should be deployed in slum settings to maximize benefits and minimize harms while understanding how digitization of health records affect the slum community. A descriptive qualitative method

included in-depth interviews that offered a unique opportunity for safe disclosure of both hopes and frustrations. Participants did not shy away from illustrating how leadership, operational support, incentives, software and post-implementation customization challenges could hamper EMR user acceptance. Participants also freely highlighted the potential benefits gained from EMR deployment, including consistent capture of quality health data, reduction if not the elimination of paper, and better continuity of care for complex chronic disease. It was evident that users are critical stakeholders; they seemed to worry most about sustainability of their EMR initiatives.

This qualitative inquiry suggests that more experience sharing, strategic collaboration, program evaluation and knowledge translation to develop practical instruments like checklists could improve success rates of EMR deployments in limited resource and slum settings. Leveraging the findings of this study to improve deployment processes in urban slums like Kibera could assist other implementations and researchers exploring this topic. However, it is clearly apparent that long-term sustainability strategies and customized implementation plans must be a first priority if EMR deployments are to be protected from crippling infrastructure, software, social and organizational challenges.

REFERENCES

1. United National Population Fund. State of World Population 2007: Unleashing the potential of urban growth. *UNFPA.* 2007. http://www.unfpa.org/sites/default/files/pub-pdf/695_filename_sowp2007_eng.pdf. Accessed March 26, 2014

2. The World Bank. Developing countries need to harness urbanization to achieve the MDGs: IMF-World Bank report. *The World Bank*. Published April 17, 2013. http://www.worldbank.org/en/news/press-release/2013/04/17/developing-countries-need-to-harness-urbanization-to-achieve-mdgs-imf-world-bank-report. Accessed August 31, 2015.

3. Runde D. Urbanization will change the (developing) world. *Forbes.* Published February 25, 2015. http://www.forbes.com/sites/danielrunde/2015/02/24/urbanization-development-opportunity/. Accessed August 31, 2015.

4. Vlahov D, Galea S. Urbanization, urbanicity, and health. *Journal of Urban Health: Bulletin of the New York Academy of Medicine.* 2002;79(4 Suppl 1):S1-S12. doi: 10.1093/jurban/79.suppl_1.S1.

5. World Health Organization. Social determinants of health. Facts: urban settings as a social determinant of health. *World Health Organization.* 2014. http://www.who.int/social_determinants/publications/urbanization/factfile/en/. Accessed March 2014.

6. WHO Centre for Health Development, Kobe Centre. A billion voices: listening and responding to the health needs of slum dwellers and informal settlers in new urban settings. *World Health Organization Kobe Centre.* 2005. http://www.who.int/social_determinants/resources/urban_settings.pdf. Accessed April 5, 2014.

7. Jenson J. Backgrounder: Thinking about marginalization: what, who and why? *Ottawa: Canadian Policy Research Networks Inc. (CPRN)*; 2000. http://www.cprn.org/documents/28944_en.pdf. Accessed September 6, 2014.

8. Amnesty International. Kenya the unseen majority: Nairobi's two million slum-dwellers. *Amnesty International Publications.* 2009. http://www.refworld.org/pdfid/4a3660e82.pdf. Accessed October 14, 2015.

9. Bhojani U, Mishra A, Amruthavalli S, et al. Constraints faced by urban poor in managing diabetes care: patients' perspectives from South India. *Global Health Action*. 2013;6(10):3402/gha.v6i0.22258. doi: 10.3402/gha.v6i0.22258.

10. Taffa N, Chepngeno G. Determinants of health care seeking for childhood illnesses in Naiorbi slums. *Tropical Medicine and International Health*. 2005;10(3):240-5. doi: 10.1111/j.1365-3156.2004.01381.x.

11. Democracywatch. Health problems of women living in slums: a situation analysis of three selected slums in Dhaka City. Dhaka: *Democracywatch.* 2014. http://www.dwatch-bd.org/ggtp/Research%20Reports/health%20problem.pdf. Accessed October 14, 2015.

12. Afsana K, Wahid SS. Health care for poor people in the urban slums of Bangladesh. *The Lancet*. 2013;382(9910):2049–2051. doi: 10.1016/S0140-6736(13)62295-3.

13. Fraser HS, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P. Implementing electronic medical record systems in developing counties. *Informatics in Primary Care.* 2005;13(2):83-95. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000002/art00002. Accessed March 13, 2014.

14. Kalogriopoulos NA, Baran J, Nimunkar AJ, Webster JG. Electronic medical record systems for developing countries: review. *31st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS)*. 2009:1730-3. doi: 10.1109/IEMBS.2009.5333561.

15. Tomasi E, Facchini LA, Maia MS. Health technology in primary health care in developing countries: a literature review. *Bulleting of the World Health Orgnization*. 2004;82(11):867-74. http://www.who.int/bulletin/volumes/82/11/en/867.pdf. Accessed March 20, 2014.

16. World Health Organization. Electronic health records: manual for developing countries. *World Health Organization.* Geneva 2006. http://www.wpro.who.int/publications/docs/EHRmanual.pdf. Accessed January 8, 2015.

17. World Health Organization. Country health information systems: a review of the current situation and trends. *World Health Organization.* Switzerland 2011. http://www.who.int/healthmetrics/news/chis_report.pdf. January 8, 2015.

18. Ministry of Health. Health information system policy 2010-2030. Nairobi 2010. https://www.healthresearchweb.org/files/HISPolicyReportfinaldocument05.08.pdf. Accessed August 31, 2015.

19. Alamo ST, Wagner GJ, Sunday P, et al. Electronic medical records and same day patient tracing improves clinic efficiency and adherence to appointments in a community based HIV/AIDS care program, in Uganda. *AIDS and Behavior*. 2012;16(2):368-74. doi: 10.1007/s10461-011-9996-9.

20. Blaya JA, Fraser HSF, Holt B. E-Health technologies show promise in developing countries. *Health Affairs.* 2010; 29(2):244-51. doi: 10.1377/hlthaff.2009.0894.

21. Rotich JK, Hannan TJ, Smith FE, et al. Installing and implementing a computer-based patient record system in Sub-Saharan Africa: the mosoriot medical record system. *Journal of the American Medical Informatics Association*. 2003;10(4):295-303. doi: http://dx.doi.org/10.1197/jamia.M1301.

22. Sheikh M. Digital health information system in Africa's resource poor countries: current challenges and opportunities. *Journal of Health Informatics in Developing Countries*. 2014;8(1):78-87. http://www.jhidc.org/index.php/jhidc/article/view/118/162. Accessed January 6, 2015.

23. Were MC, Emenyonu N, Achieng M, et al. Evaluating a scalable model for implementing electronic health records in resource-limited settings. *Journal American Medical Informatics Association*. 2010;17(3):237-44. doi: 10.1136/jamia.2009.002303.

24. Williams F, Boren SA. The role of the electronic medical record (EMR) in care delivery development in developing counties: a systematic review. *Informatics in Primary Care.* 2008;16(2):139-145. http://www.ingentaconnect.com/content/bcs/ipc/2008/00000016/00000002/art00008?crawler=true. Accessed March 13, 2014.

25. Keshavjee K, Bosomworth J, Copen J, et al. Best practices in EMR implementation: a systematic review. *Proceedings of the 11th International Symposium on Health Information Management Research – iSHIMR*. 2006:1-15. http://www.infoclin.ca/assets/7e474_best%20practices%20in%20emr%20implementation%20-%20july,%202006.pdf. Accessed September 13, 2014.

26. Syrjänen, Raakel; UN-Habitat KENSUP Team. UN-HABITAT and the Kenya slum upgrading programme: strategy document. Nairobi 2008. http://unhabitat.org/books/un-habitat-and-the-kenya-slum-upgrading-programme-strategy-document/. Accessed February 19, 2014.

27. Innovative Canadians for Change. Home Page. ICChange. Published 2015. www.icchange.ca. Accessed September 14, 2015.

28. Jawhari B, Berenger B, Saleh A. Kibera Medical Record Initiative: barriers of implementing an electronic medical record system [abstract]. *26th Medical Informatics in Europe Conference (MIE2015).* 2015; 210:1031-32. doi:10.3233/978-1-61499-512-8-1031.

29. OpenMRS. About us. OpenMRS. Published 2004-2013. http://openmrs.org/about/. Accessed September 2014.

30. Neegaard MA, Olesen F, Andersen RS, Sondergaard J. Qualitative description - the poor cousin of health research? *BMC Medical Research Methodology*. 2009;9(52):1-5.

31. Sandelowski M. Focus on research methods: whatever happened to qualitative description? *Research in Nursing and Health.* 2000;23(4):334-340. doi: 10.1002/1098-240X(200008)23:4<334::AID-NUR9>3.0.CO;2-G.

32. Desgroppes A, Taupin S. Kibera: the biggest slum in Africa?. *Les Cahiers de l'Afrique de l'Es*t, 2011, 44, pp.23-34. doi: halshs-00751833.

33. Ekdale B. Slum Discourse, media representations and Maisha Mtaani in Kibera, Kenya. *Ecquid Novi: African Journalism Studies*. 2014;35(1):92-108. doi: 10.1080/02560054.2014.886277.

34. Fihlani P. Kenya's Kibera slum gets a revamp. *BBC News: Africa.* Published February 23, 2015. http://www.bbc.com/news/world-africa-31540911. Accessed August 27, 2015.

35. Tovrov D. 5 Biggest slums in the world. *International Business Times*. Published December 9, 2011. http://www.ibtimes.com/5-biggest-slums-world-381338. Accessed August 31, 2015.

36. Kibera UK. Kibera facts & information. *kibera.org.uk.* Published 2010-2015. http://www.kibera.org.uk/facts-info/. Accessed August 31, 2015.

37. Parsons T. "Kibra Is Our Blood": the Sudanese military legacy in Nairobi's Kibera location, 1902-1968. *The International Journal of African Historical Studies*. 1997;30(1):87-122. doi: 10.2307/221547.

38. Mutisya E, Yarime M. Understanding the grassroots dynamics of slums in Nairobi: the dilemma of Kibera informal settlements. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*. 2011:197-213. http://tuengr.com/V02/197-213.pdf. Accessed January 12, 2015.

39. Karanja IW, Makau J. An inventory of the slums in Nairobi.1-221. http://www.irinnews.org/pdf/nairobi_inventory.pdf. Accessed March 28, 2015.

40. The Economist. Upwardly mobile Africa: boomtown Slum. *The Economist*. Published December 22, 2012. http://www.economist.com/news/christmas/21568592-day-economic-life-africas-biggest-shanty-town-boomtown-slum. Accessed January 3, 2013.

41. MapKibera. Download. MapKibera. Published n.d.. http://mapkibera.org/download/. Accessed March 12, 2014.

42. Patel H, Jonash R, Anderson K, Bautista J. Social enterprise challenge: improving chronic disease care in slums by 2019. *Hult International Business School Publishing*. 2014.

43. Laerum H, Faxvaag A. Task-oriented evaluation of electronic medical records system: development and validation of a questionnaire for physicians. *BMC Medical Informatics and Decision Making*. 2004;4(1):1-16. doi:10.1186/1472-6947-4-1.

44. Paterson GI, Shaw N, Grant AM, et al. Cross-Canada EMR case studies: analysis of physicians' perspectives on benefits and barriers. *electronic Journal of Health Informatics*. 2011;6(4):e34. http://www.ejhi.net/ojs/index.php/ejhi/article/viewFile/186/120. Accessed September 29, 2015.

45. Mayan MJ. *Essentials of Qualitative Inquiry*. Walnut Creek: Left Coast Press, Inc.; 2009.

46. Milne J, Oberle K. Enhancing rigor in qualitative description: a case study. *Journal of Wound, Ostomy and Continence Nursing*. 2005;32:413–420.

47. Lincoln YS, Guba EG. *Naturalistic Inquiry.* Beverly Hills: SAGE Publications Inc.; 1985.

48. Canada Health Infoway and Pricewaterhouse Coopers. The emerging benefits of electronic medical record use in community-based care. *Canada Health Infoway*. 2013:1-98. https://www.pwc.com/ca/en/healthcare/publications/pwc-electronic-medical-record-use-community-based-care-report-2013-06-en.pdf. Accessed September 7, 2014.

49. Akanbi MO, Ocheke AN, Agaba PA, et al. Use of electronic health records in Sub-Saharan Africa: progress and challenges. *Journal Med Trop*. 2012;14(1):1-6. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4167769/pdf/nihms380682.pdf. Accessed January 6, 2015.

50. Castelnuovo B, Kiragga A, Afayo V, et al. Implementation of provider-based electronic medical records and improvement of the quality of data in a large HIV program in Sub-Saharan Africa. *Plos ONE*. 2012;7(12):e51631. doi: 10.1371/journal.pone.0051631.

51. Fraser HS, Blaya J. Implementing medical information systems in developing countries, what works and what doesn't. *American Medical Informatics Association - Symposium Proceedings*. 2010:232-36. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3041413/pdf/amia-2010_sympproc_0232.pdf. Accessed March 29, 2014.

52. Kamadjeu RM, Tapang EM, Moluh RN. Designing and implementing an electronic health record system in primary care practice in Sub-Saharan Africa: a case study from Cameroon. *Informatics in Primary Care*. 2005;13(3):179-86. doi: http://dx.doi.org/10.14236/jhi.v13i3.595.

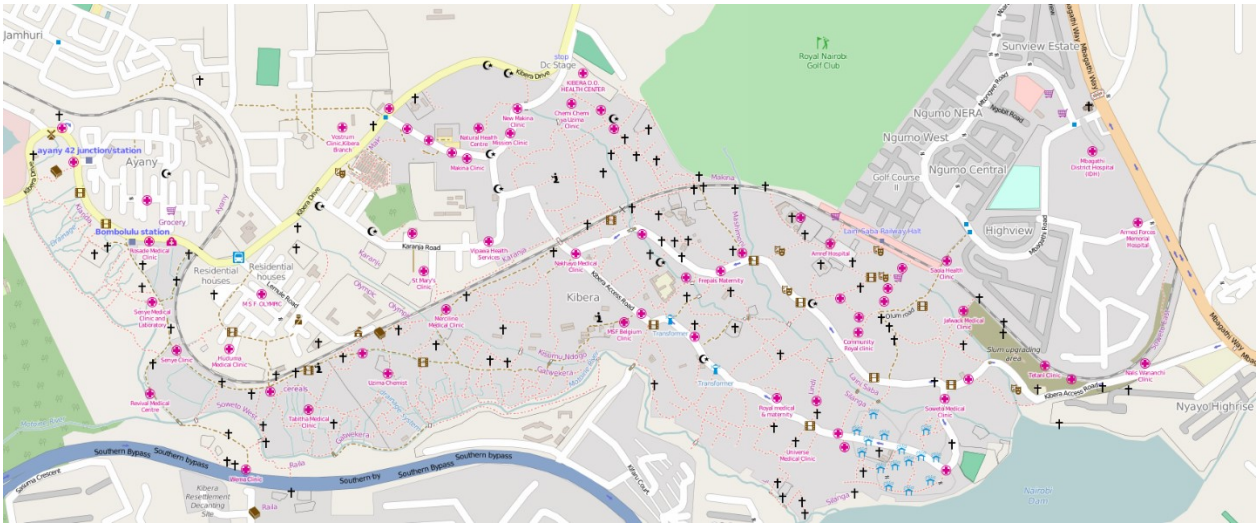
53. Ludwick D, Doucette J. Adopting electronic medical records in primary care: Lessons learned from health information systems implementation experience in seven countries. *International Journal of Medical Informatics*. January 2009;78(1):22-31. doi: 10.1016/j.ijmedinf.2008.06.005.

54. Tierney WM, Rotich JK, Hannan TJ, et al. The AMPATH medical record system: Creating, implementing, and sustaining an electronic medical record system to support HIV/AIDS care in Western Kenya. *MEDINFO 2007: Proceedings of the 12th World Congress on Health (Medical) Informatics; Studies in Health Technology and Informatics*. 2007;129(Pt 1):372-6. Accessed January 6, 2015.

55. Kwintessential. Kenya: language, culture, customs and etiquette. Published 2014. http://www.kwintessential.co.uk/resources/global-etiquette/kenya.html. Accessed October 13, 2015.

56. OpenstreetMap. Map of Kibera. OpenStreetMap. Published n.d.. http://www.openstreetmap.org/#map=16/-1.3119/36.7901. Accessed August 31, 2014.

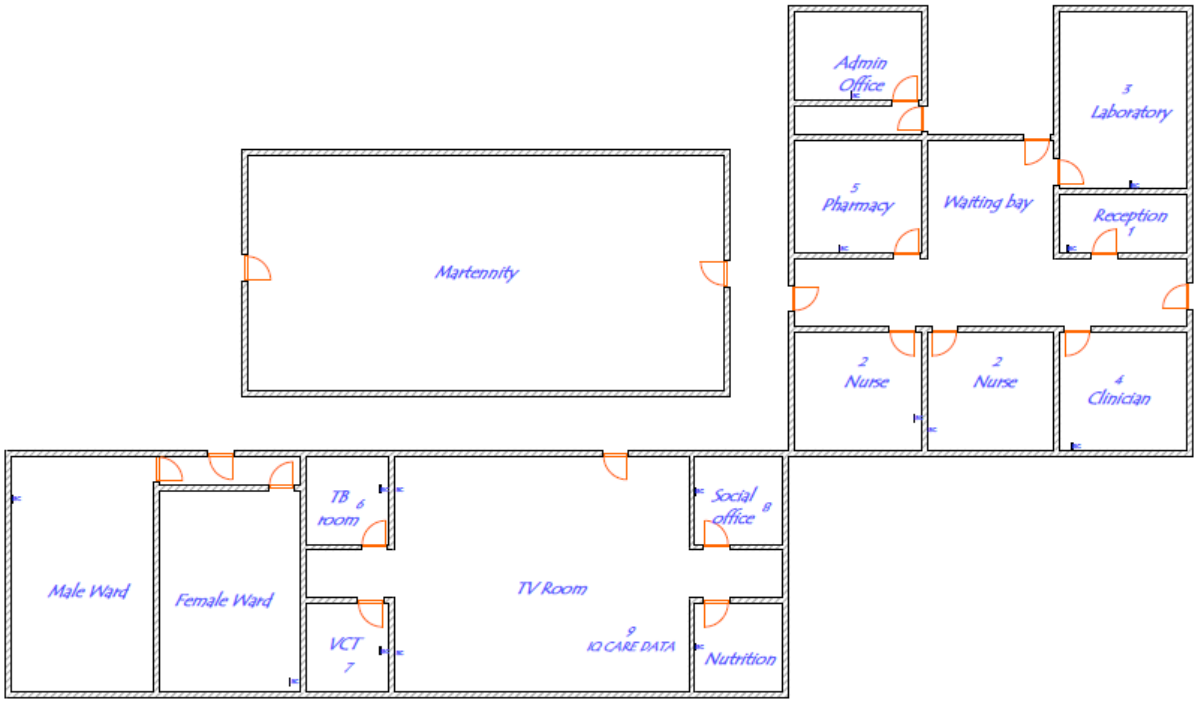
APPENDIX 3.1 Map of Kibera



Map of Kibera[56]

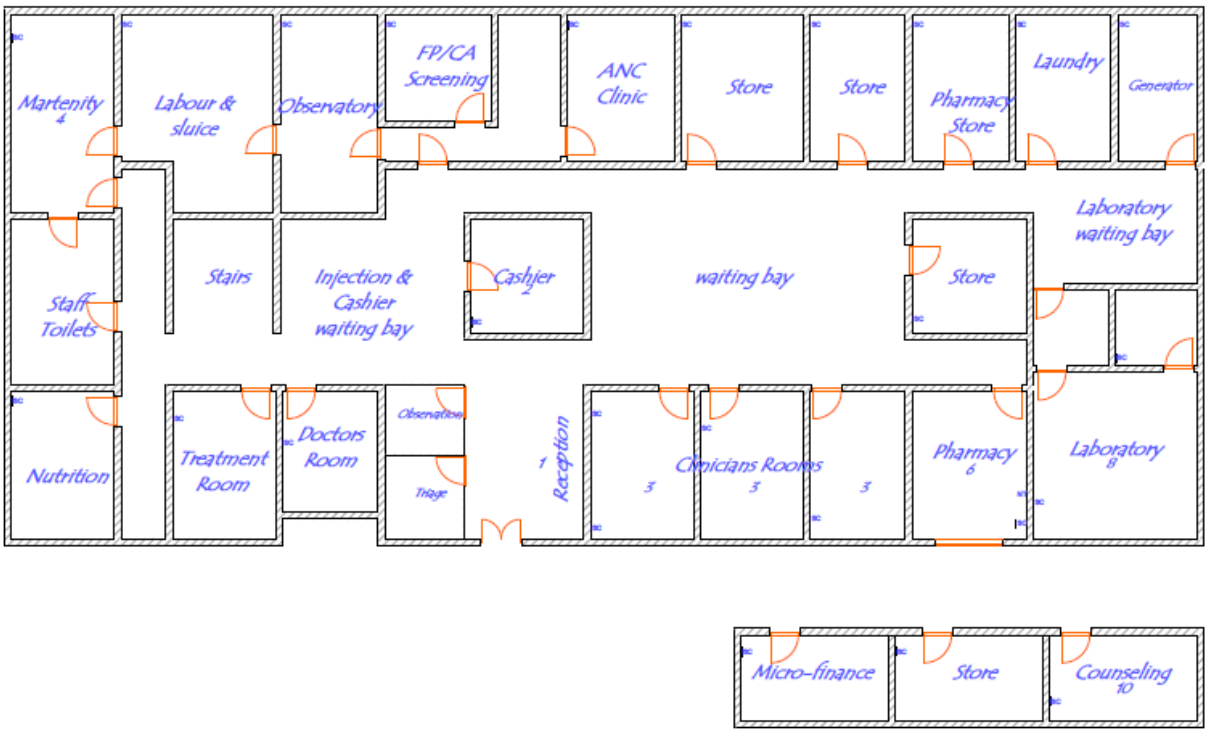
APPENDIX 3.2 Clinic 1 Architecture Layout

Clinic 1 Main Floor Plan



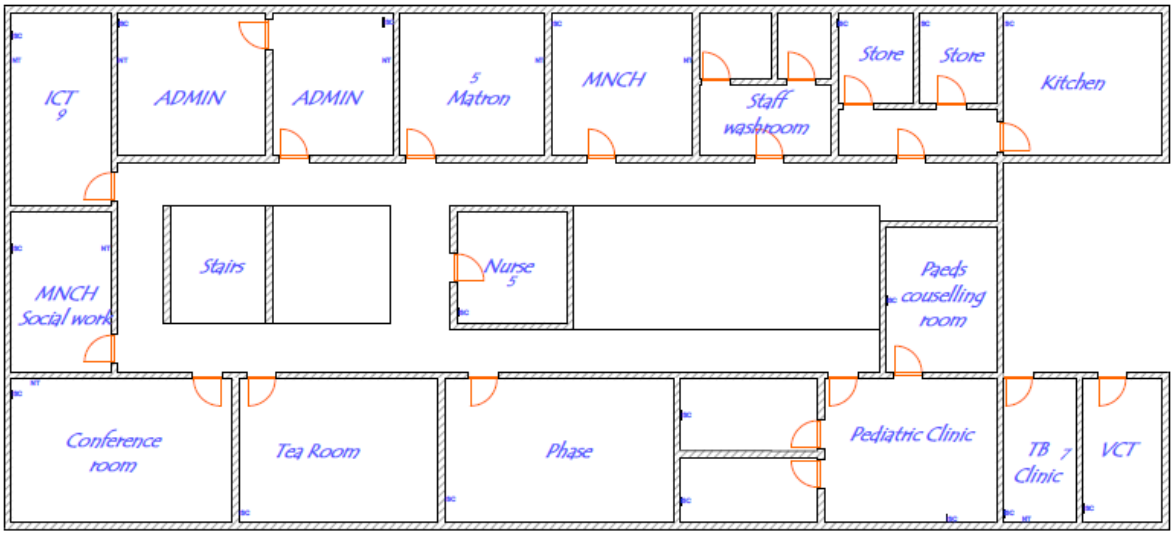
APPENDIX 3.3 Clinic 2 Architecture Layout

Clinic 2 Main Floor

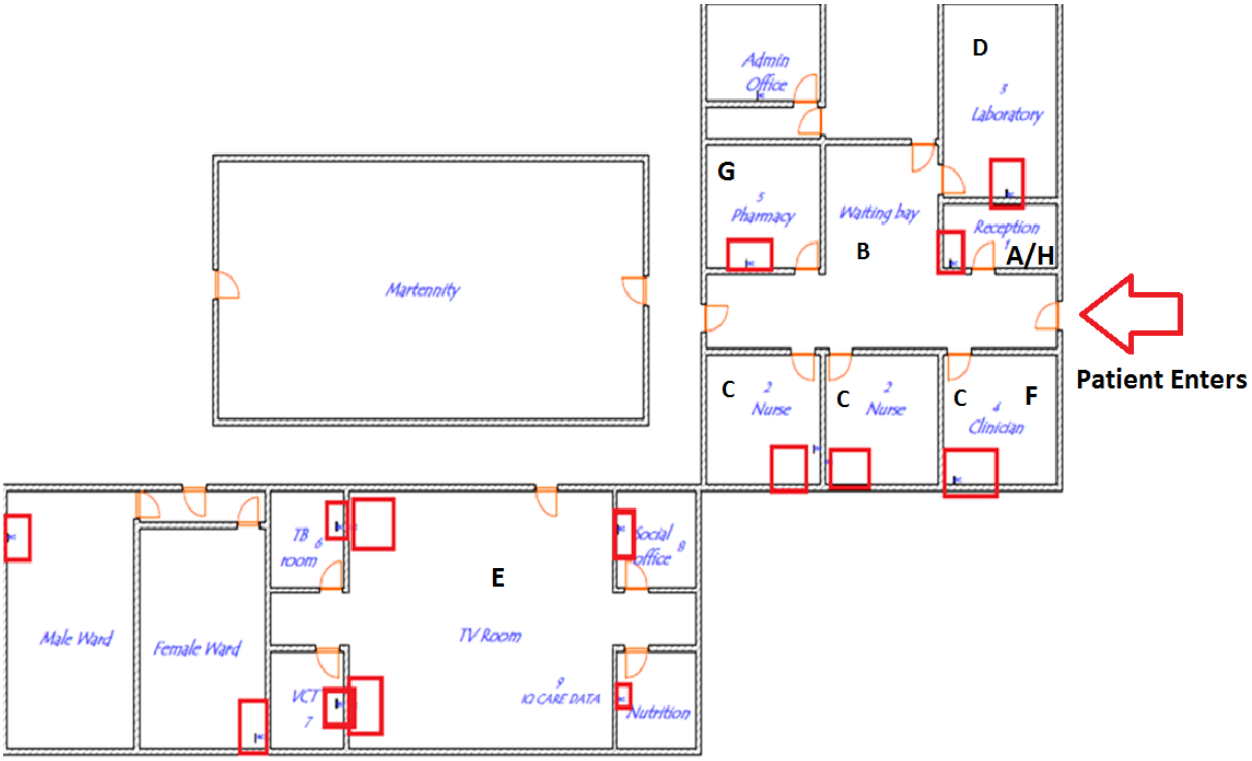


APPENDIX 3.3 Clinic 2 Architecture Layout (Continued)

Clinic 2 Second Floor



APPENDIX 3.4 Workflow and Infrastructure



Infrastructure placement and workflow changes in Clinic 1. Red boxes indicate area in which infrastructure investment was made (power and Ethernet connection) and where computers were placed. Now a standard workflow process indicated from “A through H.”

APPENDIX 3.5 Checklist of Considerations when Implementing an EMR in Slum Settings

PRE-Implementation

- ☐ Conduct a baseline assessment of the culture, community and setting forming the context for EMR implementation.
    - What patient and staff motivators most affect clinic operations?
    - What health, policy or financial trends may change the clinic context?
    - What is the current funding model for the clinic and how might it be affected by the introduction of an EMR?
    - Which patient health needs are prioritized by the clinic and require particular accommodation by an EMR?
    - How many patients are seen per day?
    - What is the current patient demographic?
    - Would patients be accepting of an EMR?
    - How many users will be using the EMR at any given time?
    - How many staff are there at the health clinic?
- ☐ Relationship building: Cultivate and build relationships with the clinic ownership, management team and staff.
    - Converse with clinic management.
    - Learn about the challenges they face on a daily basis with the current system they are using (e.g., paper records or a health information system in use).
    - Take time to build trust.
- ☐ Site visits
    - Conduct multiple visits to understand the community, the clinic and common workflows.
    - Explore specific EMR features essential to the clinic's daily practice.
- ☐ Develop a sustainability plan to ensure that EMR customization, maintenance and optimization can continue long past any implementation. **
    - How will the EMR be funded? Is funding sustainable?
    - Is clinic management and staff actively supporting the EMR implementation?
    - Who is responsible for the EMR pre- and post- implementation?
    - Develop a comprehensive communication and change management strategy.
        - All staff should be aware of the implementation process prior to go-live.
        - The benefits and challenges of the system should be explained.
        - Long-terms strategies of the system and the clinic need to be clearly outlined to clinic staff.
        - Why and when the implementation is to occur.
        - Describing the timeline of the implementation process (e.g., dates of certain events that will occur and when staff are expected to transition from paper to EMR).
        - Staff should have the opportunity to share and voice their opinion by providing feedback on the EMR implementation.
        - Encouraging staff involvement will allow for a comfortable setting where staff concerns can be addressed.
        - This process will gain buy-in from staff.
- ☐ Software adaptation and development

- Work with clinic managers and staff to identify key system features
- Ensure system features respond to clinic and staff needs.
- Consider creating an online ticketing system embedded into the EMR where staff can directly submit immediate technical problems.
- EMR System Testing
  - When the EMR software is complete (beta version), pre-testing the software in a clinic setting by the users is a critical component prior to implementation. The pre-testing phase allows the technical team to benchmark the software to the user's standards. The technical team is able to detect and fix any bugs and system deficiencies prior to a go-live implementation.

☐ Infrastructure Strategy
- Is there an existing LAN or WLAN network set up?
- Is there wireless capability?
- Identify secure server infrastructure and location (both offsite and onsite at the clinic).
- Is their sufficient and consistent power supply (e.g., more than 12 hours a day)?
  - If not, how often is the power supply interrupted? How many times a day are their power outages or blackouts?
  - Does the clinic have an alternative power supply?
  - If not, consider a generator or alternative power supply to support the EMR implementation.
- Daily if not hourly backups should be conducted for the EMR once operational.
- EMR data should be securely encrypted.
- Necessary safeguards and data security should be in place prior to go-live implementation.
- What type of hardware is currently at the clinic?
- What type of hardware is necessary in order to support the EMR?
  - Cabling
  - Router(s)
  - Server(s)
  - Computer(s)
  - Printer(s)

☐ Implementation strategy**
- Identify the project team that will lead and support the EMR implementation.
- Decide whether the EMR implementation will occur in a *Big Bang* approach or whether it will be an *Incremental* approach.
- Create a timeline for the implementation process.
  - Identify key priorities (when tasks are to be completed).
  - Identify which key stakeholder is accountable for each priority.
  - Communicate this timeline with clinic staff to ensure they are aware of the process.
- Ensure post-implementation technical support is available for clinic staff.
- Ensure sufficient resources are available to support clinic staff.
- Clinic staff should know who to go to for support or if they require assistance on the EMR.

☐ Ensure EMR station placement is appropriate

- Assess and identity where EMR stations are to be positioned.
- EMR stations need to be placed at each encounter point within the clinic.
  - Furnishings (desk, seat, mouse, keyboard tray)
  - Computer
  - Electrical outlet
  - Internet connection
- Does station conform to ergonomic guidelines?

☐ Training
- Develop a detailed training schedule and plan.**
  - Identify how many staff are to be trained.
  - Ensure staff are comfortable with using computers.
  - Identify staff learning styles (e.g., class room based training, one on one training, etc.)
  - It is recommended that training be split up by department and position (e.g., all physicians trained together etc.).
- Training should be used as a way to educate staff about proper use of the EMR, confidentiality and privacy of patient data.
  - If this has not yet been administered at the clinic level, *Confidentiality Agreements* should be discussed with all staff members to ensure misuse of the system is prevented and safeguarded.
- Train a Super-User to support staff pre, during and post-implementation.
  - The Super-User chosen at the clinic should be part of the training process to ensure users recognize their role during and after the implementation process. Staff are to notify the Super-User of any technical issues at the clinic. The role of the Super-User is to support staff and address any technical concerns.
- Ensure a hard copy or electronic training manual is supplied to clinic staff.
- It is important that once the EMR is implemented and training is complete that staff are immediately using the system as part of their daily activities.

IMPLEMENTATION Phase

☐ Once the implementation plan is approved, infrastructure and networking has been completed, and the installation of computers are set up at each encounter point, the EMR roll-out should commence.

☐ Training should be conducted 5-7 days before go-live allowing users time to adjust to the EMR (time may need to be adjusted based on staff needs and computer literacy).
- Training should be conducted in a safe environment that encourages staff to learn how to use the EMR. Staff should be comfortable asking questions and making mistakes without judgement.

☐ Once the system is live, users should be using the EMR software as part of their daily activities.

☐ It is important that the transition process from paper to EMR is supported by the clinic management. A date should be determined to properly transition from paper to EMR, this deadline should be respected by all clinic staff (including management).

- ☐ Technical issues and other IT challenges will continue during the implementation process, this is expected. It is important that management/leadership team support staff during implementation process.
    - Management should also lead by example by using the system daily. This is critical to encourage others to use the system.
- ☐ During the first 2-6 weeks of system implementation having technical/IT experts at the clinic will assist in reducing user stress and to respond to immediate needs.

POST-Implementation Phase

- ☐ Management and the vendor who implemented the EMR system should constantly check in with staff and the Super-User to make sure issues and challenges are being addressed.
- ☐ Training (especially of new features) should be ongoing even after implementation.
- ☐ Communication strategy should be ongoing, management and the leadership team of the clinic should be keeping staff and users informed on the implementation process and encouraging continued use of the EMR.
- ☐ A full and complete transition from paper to EMR should occur post-implementation. The time it takes to transition from paper to EMR will depend on the clinic, staff and the implementation process.
- ☐ User adoption issues may continue to arise, staff will need to continue to adjust to the EMR even after implementation.
- ☐ IT and technical support should be ongoing.

** Work closely with local stakeholders (clinic staff and management team)

CHAPTER 4: Conclusion

Summary of Findings

Little is known about the benefits, barriers and the potential impact of primary care EMR implementations in urban slums within developing countries. To date, most published experience concerns niche health information systems, such as computerized methods for tracking treatment of disease associated with the human immunodeficiency virus and tuberculosis bacterium in resource-limited settings.[1-6] The economic, social and organizational challenges associated with the growth of urbanization and slum development, however, suggest that a comprehensive primary care EMR is urgently needed. Experience in developed countries suggests that it could facilitate improved multidisciplinary communication, help coordinate a continuum of care, and improve chronic disease management.

This study explored how primary care EMR learnings from developed settings may apply to resource-constrained settings, while directly collecting observational data about the benefits, challenges and impacts of primary care EMRs in two Kibera clinics with typical resource constraints. Although the Kibera EMR implementations encountered many challenges that could be anticipated from the experience of others,[7-16] there were also perceived positive effects. Many front-line staff noted improved efficiency and accuracy of health care documentation. These and other Kibera EMR hopes resonated with expectations for EMR opportunities in limited-resource settings.[14,17-19]

The Kibera field study also uncovered a number of EMR deployment considerations that appear unique to or uniquely impactful within slum settings. A number of social and organizational factors (e.g., financial incentives, human resource availability, and change management strategies) proved to be significant success criteria during the EMR deployment

process. Although broad success factors, like skills access and leadership, have been emphasized in a recent review,[20] the specific nuances of financial incentives in slum settings have not been described. The social and cultural phenomena uncovered by this study, including intricacies of user behaviours and complex attitudes about technology change, can inform the design of future studies. Some of the observed social challenges (such as slum residents' resistance to unique personal identifiers and frequent use of multiple identifiers) might suggest EMR software adaptations necessary for smoother implementations in slum settings.

Kibera clinic staff frequently expressed concerns about the sustainability of EMR implementations in their limited resource settings. EMR enthusiasts promise that a combination of systems and devices can bring order to the clinical and organizational complexities of slum settings. But seasoned health care providers working in urban slums recognize that whatever challenges are surmounted during an EMR implementation, gains are lost when post-implementation support, customization, training and data management are not maintained. This observation may even suggest a significant policy recommendation: EMR implementations should not be started if support cannot be committed for the years of post-implementation optimization that inevitably will be required. Trust, once lost, is very hard to rebuild in resource-constrained settings.

Limitations

The choice of State-of-the-Art overview method, a qualitative approach to research synthesis, proved a good fit to the types of articles and research designs found in the available literature. A lack of intervention studies that use controlled trial methods, comparison groups, or standardized outcome measures meant that there was insufficient data extractable for any kind of quantitative synthesis or meta-analysis. Similarly, great variability in reported settings, EMR

systems, units of exposure (e.g., patient, physician, clinic, and organization) and impact estimates make it difficult to discern which barriers or facilitators to EMR implementation might be more or less important in resource-constrained environments. Given a relatively "young" research literature applicable to EMR use in developing countries, a State-of-the-Art review has the advantage of identifying common observations and themes in what has been published while surveying how available key messages were derived. The review provided a solid foundation for the design of a field study. However, the review was not able to generate valid insights about the relative importance of external findings that might be compared to the internal findings emergent from the field study.

The choice of a descriptive qualitative method for the Kibera EMR implementation field study proved a good fit to the early stage and "chaos" of EMR experiences in that resource-constrained setting. Even if more time and resources were available, it would be exceptionally difficult to control the multiple co-variates associated with implementation of a complex informational intervention in an exceptionally complex socio-clinical context. Use of qualitative inquiry allowed a special clinic-access opportunity to be used to carefully gather observations about user perceptions of the effects of the EMR implementations.

The particular approach taken had at least three important limitations. First, the timing of the field study was such that both clinics were still in the process of implementation (in certain key areas of the clinics). This is known to be an especially difficult time and "growing pains" may have been overemphasized in the reports of participants. It is possible that interviews during later phases in the EMR journey would have exposed more advantages associated and greater stability. A follow-up field study, using similar qualitative methods, conducted at least two years post-implementation, could be more informative about lasting advantages of EMR implementation and keys to sustainability.

A second limitation of the reported use of descriptive qualitative methods relates to the relative increased availability and use of witnesses from one of the two available clinics. Given that the descriptive methods emphasized responsive exploration of any new factors mentioned by participants, that representative informants were chosen rather than representative samples, and that the frequency of new key messages significantly dropped as the number of participants increased, the smaller number of interviews at the smaller clinic is unlikely to have significantly distorted the reported observations. Learning was honed as a discovery instrument, care was taken to encourage conversational uncovering of new ideas, and ordering effects related to questions or persons did not appear to affect what was discovered.

Finally, the EMR experiences uncovered by the Kibera field study may have been distorted by the unique situation of the key researcher. The researcher had been involved in earlier work to promote use of open-source EMRs in the Kibera community. Familiarity with and trust of the researcher proved a strength in that the researcher had prior exposure, presence and reputation with the available clinics, and so was less an "outsider" and could more quickly gain access, guide spontaneous conversation, and reduce a general mistrust of officials in that setting. Association of the researcher with prior work could also have predisposed participants to politely spare the researcher from harsh criticism of the EMR or of the organizations promoting its use. To the extent that participants seemed very comfortable listing a wide range of EMR-related issues, the reputation of the researcher does not appear to have been a barrier to the disclosure of negative experiences.

Implication for Future Research

Both the literature review and the field study revealed possible gaps in understanding EMR experiences in slum settings. The State-of-the-Art overview exposed a wide range of non-

quantitative report types but no pragmatic guidance or checklists that clinics might employ to increase the probability of a successful EMR deployment. Tools to better characterize local systems, people, process and product factors are needed for appropriate EMR considerations, selection and successful implementation in resource-limited settings. We drafted an EMR considerations checklist, derived from the findings of this study, our direct observations and the reported experience of others. This checklist also summarizes a number of EMR success-factor considerations that could be validated using future EMR intervention studies. Other studies in other slum and non-slum resource-constrained environments could help validate the checklist transferability to other settings.

Although neither the State-of-the-Art literature review nor the descriptive qualitative field study were able to generate estimates of the relative importance of diverse EMR benefits, harms and impacts, there was frequent and strong emphasis on social, cultural and organizational factors. Software and infrastructure challenges certainly were important and it is obvious that a workable and versatile EMR is a necessary condition for any EMR implementation. Even diverse "non-technical" factors appeared capable of derailing deployment, despite ideal software or infrastructure. Further research is required to better understand how to approach change management, the people and process dynamics of EMR deployments, especially in resource-constrained environments.

Worries about EMR initiative sustainability were especially prominent in the discovered experience of slum clinics. Further research is required to better understand how to structure the initial and ongoing support of digital health record initiatives in slum settings. In particular, the roles of monetary and non-monetary incentives to meaningful use need further exploration.

The work reported in this Thesis focus on the experiences of direct users of EMRs in slum settings. However, it was apparent that clinic clients (patients) are increasingly comfortable with

mobile technologies. Rapid proliferation of wireless devices in slum settings can "leapfrog" EMR dependency on wired infrastructure, it may be possible to leapfrog some EMR implementation barriers by placing greater emphasis on consumer-oriented EMR functions. These might include digital health passports maintained on mobile phones, a wider range of self-management options for chronic disease treatments and other off-loading of documentation loads to clients. Very little is known about how slum residents feel about digital health records, or whether their unique identity and privacy concerns might prove an insurmountable barrier to use. Focusing on the patient in EMR implementation field-work might provide a new avenue for research and understanding and for cost-effective progress.

Finally, this research may have relevance in a Canadian context. Pre-field study interviews with clinics serving marginalized populations disclosed strong resonance between clinic staff perceptions and reports of work in resource-constrained environments, including the field study reported here. Further exploration of insights from Kibera using validation studies focusing on disadvantaged populations in Canada (including First Nations, migrants, refugees and the homeless) could inform strategies for improving complex disease management in developed countries. Moreover, studies like ours may help Canadian clinics that serve immigrants from resource-poor countries.

Communication of Findings

Lessons learned from the State-of-the-Art literature review and the Kibera field study will be shared locally and through scientific communications. A digest of this report will be provided to stakeholder Kibera clinics in the form of an annotated EMR implementation checklist. It is hoped that this form of pragmatic feedback will help them to organize conversations about how best to proceed with the EMRs now in place. We also intend to share the findings of this study

with the participants and community members through informal meetings, where attendees have the opportunity to ask questions and participate in the discussion. We anticipate this exercise will continue to build trust and develop sustainable outcomes for the clinics and the populations they serve.

Direct Impact

We believe this research has brought to light the significance and unique impacts that an EMR system can bring to urban slum primary care clinics. Clearly, there is potential for positive benefits. EMR interventions should not be discounted simply because slums may suffer geographic, financial or staffing challenges. Efficiencies are possible that can improve clinic functions and the medical support provided to vulnerable populations. Potential benefits are so important that the many possible barriers to intervention need to be properly described, measured, understood and innovatively overcome. We hope that the results of this Thesis work will help create new opportunities and encourage others to explore further.

REFERENCES

1. Allen C, Jazayeri D, Miranda J, et al. Experience in implementing the OpenMRS medical record system to support HIV treatment in Rwanda. *MEDINFO 2007,* Studies in Health Technology and Informatics. 2007; 129(Pt 1):382-6. http://www.ncbi.nlm.nih.gov/pubmed/17911744. Accessed January 14, 2015.

2. Braitstein P, Robert M. Einterz JES, Kimaiyo S, Tierney W. "Talkin' about a revolution": how electronic health records can facilitate the scale-up of HIV care and treatment and catalyze primary care in resource-constrained settings. *Journal of Acquired Immune Deficiency Syndromes.* 2009;52:S54-7. doi: 10.1097/QAI.0b013e3181bbcb67.

3. Castelnuovo B, Kiragga A, Afayo V, et al. Implementation of provider-based electronic medical records and improvement of the quality of data in a large HIV program in Sub-Saharan Africa*. Plos ONE*. 2012;7(12):e51631. doi: 10.1371/journal.pone.0051631.

4. Ekouevi DK, Karcher S, Coffie PA. Strengthening health systems through HIV monitoring and evaluation in Sub-Saharan Africa. *Current Opinion in HIV and Aids Journal.* 2011;6(4):245-50. doi: 10.1097/COH.0b013e3283479316.

5. Fraser HS, Thomas D, Tomaylla J, et al. Adaptation of a web-based, open source electronic medical record system platform to support a large study of tuberculosis epidemiology. *Medical Informatics and Decision Making*. 2012;12(125):1-10. doi:10.1186/1472-6947-12-125.

6. Tierney WM, Rotich JK, Hannan TJ, et al. The AMPATH medical record system: creating, implementing, and sustaining an electronic medical record system to support HIV/AIDS care in Western Kenya. *MEDINFO 2007: Proceedings of the 12th World Congress on Health (Medical) Informatics*; *Studies in Health Technology and Informatics.* 2007;129(Pt 1):372-6. Accessed January 6, 2015.

7. Fraser HS, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P. Implementing electronic medical record systems in developing counties. *Informatics in Primary Care.* 2005;13(2):83-95. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000002/art00002. Accessed March 13, 2014.

8. Kamadjeu RM, Tapang EM, Moluh RN. Designing and implementing an electronic health record system in primary care practice in Sub-Saharan Africa: a case study from Cameroon. *Informatics in Primary Care.* 2005;13(3):179-86. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000003/art00003?crawler=true. Accessed September 13, 2014.

9. Mamlin BW, Biondich PG, Wolfe BA, et al. Cooking up an open source EMR for developing countries: OpenMRS - a recipe for successful collaboration. *AMIA Annual Symposium Proceedings.* 2006:529-33.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1839638/pdf/AMIA2006_0529.pdf. Accessed June 12, 2014.

10. Manders EJ, José E, Solis M, Burlison J, Nhampossa JL, Moon T. Implementing OpenMRS for patient monitoring in an HIV/AIDS care and treatment program in rural Mozambique. *MEDINFO 2010: Proceedings of the 13th World Congress on Medical Informatics,* Studies in Health Technology and Informatics. 2010;160(Pt 1):411-5. doi:10.3233/978-1-60750-588-4-411.

11. Mohammed-Rajput NA, Smith DC, Mamlin B, Biondich P, Doebbeling BN, OpenMRS Collaborative Investigators. OpenMRS, a global medical records system collaborative: factors influencing successful implementation. *AMIA Annual Symposium Proceedings 2011*. 2011:960-68. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243141/pdf/0960_amia_2011_proc.pdf. Accessed January 6, 2015.

12. Nucita A, Bernava GM, Bartolo M, et al. A global approach to the management of EMR (electronic medical records) of patients with HIV/AIDS in Sub-Saharan Africa: the experience of DREAM software. *BMC Medical Informatics and Decision Making.* 2009;9(42):1-13. doi:10.1186/1472-6947-9-42.

13. O'Mahony D. Implementing an electronic medical record system in a rural general practice. *South Africa Family Practice*. 2009;51(4):346-7. doi: 10.1080/20786204.2009.10873878.

14. Sheikh M. Digital health information system in Africa's resource poor countries: current challenges and opportunities. *Journal of Health Informatics in Developing Countries*. 2014;8(1):78-87. http://www.jhidc.org/index.php/jhidc/article/view/118/162. Accessed January 6, 2015.

15. Simbini T. Computerised information management systems in HIV/AIDS care and outcomes research. *The Central African Journal of Medicine*. 2006;52(5/6):65-7. http://www.ncbi.nlm.nih.gov/pubmed/18254459. Accessed January 16, 2015.

16. Williams F, Boren SA. The role of the electronic medical record (EMR) in care delivery development in developing counties: a systematic review. *Informatics in Primary Care.* 2008;16(2):139-145. http://www.ingentaconnect.com/content/bcs/ipc/2008/00000016/00000002/art00008?crawler=true. Accessed March 13, 2014.

17. Blaya JA, Fraser HSF, Holt B. E-Health technologies show promise in developing countries. *Health Affairs.* 2010; 29(2):244-51. doi: 10.1377/hlthaff.2009.0894.

18. Rotich JK, Hannan TJ, Smith FE, et al. Installing and implementing a computer-based patient record system in Sub-Saharan Africa: the mosoriot medical record system. *Journal of the American Medical Informatics Association*. 2003;10(4):295-303. doi: http://dx.doi.org/10.1197/jamia.M1301.

19. Tierney WM, Sidle JE, Diero LO, et al. Assessing the impact of a primary care electronic medical record system in three Kenyan rural health centers. *Journal American Medical Informatics Association.* 2015:1-18. doi: 10.1093/jamia/ocv074.

20. Fritz F, Tilahun B, Dugas M. Success criteria for electronic medical record implementations in low-resource settings: a systematic review. *Journal American Medical Informatics Association.* 2015;22(2):479-88. doi: 10.1093/jamia/ocu038.

WORKS CITED

Accenture. Connected Health: The drive to integrated healthcare delivery 2012. http://www.himss.eu/sites/default/files/Accenture-Connected-Health-Global-Report-Final-Web.pdf. Accessed May 13, 2014.

Adler-Milstein J, Daniel G, Grossmann C, et al. Return on information: a standard model for assessing institutional return on electronic health records. *Institute of Medicine of the National Academies.* 2014:1-21. http://nam.edu/wp-content/uploads/2015/06/ReturnonInformation1.pdf. Accessed May 13, 2014.

Afsana K, Wahid SS. Health care for poor people in the urban slums of Bangladesh. *The Lancet*. 2013;382(9910):2049–51. doi: 10.1016/S0140-6736(13)62295-3.

Akanbi MO, Ocheke AN, Agaba PA, et al. Use of electronic health records in Sub-Saharan Africa: progress and challenges. *Journal Med Trop*. 2012;14(1):1-6. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4167769/pdf/nihms380682.pdf. Accessed January 6, 2015.

Alamo ST, Wagner GJ, Sunday P, et al. Electronic medical records and same day patient tracing improves clinic efficiency and adherence to appointments in a community based HIV/AIDS care Program, in Uganda. *AIDS and Behavior*. 2012;16(2):368-74. doi: 10.1007/s10461-011-9996-9.

Allen C, Jazayeri D, Miranda J, et al. Experience in implementing the OpenMRS medical record system to support HIV treatment in Rwanda. *MEDINFO 2007*, Studies in Health Technology and Informatics. 2007; 129(Pt 1):382-6. http://www.ncbi.nlm.nih.gov/pubmed/17911744. Accessed January 14, 2015.

Amoroso CL, Akimana B, Wise B, Fraser HS. Using electronic medical records for HIV care in rural Rwanda. *MEDINFO 2010, Studies in Health Technology and Informatics.* 2010; 160(Pt 1):337-41. doi:10.3233/978-1-60750-588-4-337.

Amnesty International. Kenya the unseen majority: Nairobi's two million slum-dwellers. *Amnesty International Publications.* 2009. http://www.refworld.org/pdfid/4a3660e82.pdf. Accessed October 14, 2015.

Azubuike MC, Ehiri JE. Health information systems in developing countries: benefits, problems, and prospects. *The Journal of Royal Society for the Promotion of Health*. 1999;119(3):180-4. http://rsh.sagepub.com/content/119/3/180.long. Accessed January 6, 2015.

Bhojani U, Mishra A, Amruthavalli S, et al. Constraints faced by urban poor in managing diabetes care: patients' perspectives from South India. *Global Health Action*. 2013;6(10):3402/gha.v6i0.22258. doi: 10.3402/gha.v6i0.22258.

Blaya JA, Fraser HSF, Holt B. E-Health technologies show promise in developing countries. *Health Affairs*. 2010; 29(2):244-51. doi: 10.1377/hlthaff.2009.0894.

Braitstein P, Robert M. Einterz JES, Kimaiyo S, Tierney W. "Talkin' about a revolution": how electronic health records can facilitate the scale-up of HIV care and treatment and catalyze primary care in resource-constrained settings. *Journal of Acquired Immune Deficiency Syndromes*. 2009;52:S54-7. doi: 10.1097/QAI.0b013e3181bbcb67.

Canada Health Infoway. Annual Report 2013-2014. *Canada Health Infoway*. 2014. https://www.infoway-inforoute.ca/en/component/edocman/1957-annual-report-2013-2014/view-document. Accessed September 21, 2014.

Canada Health Infoway. What we do. *Canada Health Infoway*. 2014. https://www.infoway-inforoute.ca/index.php/about-infoway/what-we-do. Accessed September 7, 2014.

Canada Health Infoway and Pricewaterhouse Coopers. The emerging benefits of electronic medical record use in community-based care. *Canada Health Infoway*. 2013:1-98. https://www.pwc.com/ca/en/healthcare/publications/pwc-electronic-medical-record-use-community-based-care-report-2013-06-en.pdf. Accessed September 7, 2014.

Castelnuovo B, Kiragga A, Afayo V, et al. Implementation of provider-based electronic medical records and improvement of the quality of data in a large HIV program in Sub-Saharan Africa. *Plos ONE*. 2012;7(12):e51631. doi: 10.1371/journal.pone.0051631.

Chuma J, Okungu V. Viewing the Kenya health system through an equity lens: implications for universal coverage. *International Journal for Equity in Health.* 2011;10(22). doi:10.1186/1475-9276-10-22.

Democracywatch. Health problems of women living in slums: a situation analysis of three selected slums in Dhaka City. Dhaka: *Democracywatch.* 2014. http://www.dwatch-bd.org/ggtp/Research%20Reports/health%20problem.pdf. Accessed October 14, 2015.

Desgroppes A, Taupin S. Kibera: the biggest slum in Africa?. *Les Cahiers de l'Afrique de l'Est*, 2011, 44, pp.23-34. doi: halshs-00751833.

Edworthy SM. Telemedicine in developing countries: may have more impact than in developed countries. *British Medical Journal.* 2008;323:524–525. doi: http://dx.doi.org/10.1136/bmj.323.7312.524.

Ekdale B. Slum discourse, media representations and Maisha Mtaani in Kibera, Kenya. *Ecquid Novi: African Journalism Studies*. 2014;35(1):92-108. doi: 10.1080/02560054.2014.886277.

Ekouevi DK, Karcher S, Coffie PA. Strengthening health systems through HIV monitoring and evaluation in Sub-Saharan Africa. *Current Opinion in HIV and Aids Journal*. 2011;6(4):245-50. doi: 10.1097/COH.0b013e3283479316.

Fihlani P. Kenya's Kibera slum gets a revamp. *BBC News: Africa*. Published February 23, 2015. http://www.bbc.com/news/world-africa-31540911. Accessed August 27, 2015.

Fraser HS, Blaya J. Implementing medical information systems in developing countries, what works and what doesn't. *American Medical Informatics Association - Symposium Proceedings*. 2010:232-36. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3041413/pdf/amia-2010_sympproc_0232.pdf. Accessed March 29, 2014.

Fraser HS, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P. Implementing electronic medical record systems in developing counties. *Informatics in Primary Care*. 2005;13(2):83-95. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000002/art00002. Accessed March 13, 2014.

Fraser HS, Thomas D, Tomaylla J, et al. Adaptation of a web-based, open source electronic medical record system platform to support a large study of tuberculosis epidemiology. *Medical Informatics and Decision Making*. 2012;12(125):1-10. doi:10.1186/1472-6947-12-125.

Fritz F, Tilahun B, Dugas M. Success criteria for electronic medical record implementations in low-resource settings: a systematic review. *Journal American Medical Informatics Association*. 2015;22(2):479-88. doi: 10.1093/jamia/ocu038

Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*. 2009;26(2):91-108. doi: 10.1111/j.1471-1842.2009.00848.x.

Hannan TJ, Rotich JK, Odero WW, et al. The Mosoriot medical record system: design and initial implementation of an outpatient electronic record system in rural Kenya. *International Journal of Medical Informatics*. 2000;60(1):21-28. doi:10.1016/S1386-5056(00)00068-X

Hannan TJ, Tierney WM, Rotich JK, et al. The MOSORIOT medical record system (MMRS) phase I to phase II implementation: an outpatient computer-based medical record system in rural Kenya. *MEDINFO 2001, Studies in Health Technology and Informatics*. 2001;84(Pt1):619-22. doi: 10.3233/978-1-60750-928-8-619.

Innovative Canadians for Change. Home Page. ICChange. Published 2015. www.icchange.ca. Accessed September 14, 2015.

Jawhari B, Berenger B, Saleh A. Kibera Medical Record Initiative: barriers of implementing an electronic medical record system [abstract]. *26th Medical Informatics in Europe Conference (MIE2015).* 2015; 210:1031-32. doi:10.3233/978-1-61499-512-8-1031

Jenson J. Backgrounder: Thinking about marginalization: what, who and why? *Ottawa: Canadian Policy Research Networks Inc. (CPRN)*; 2000. http://www.cprn.org/documents/28944_en.pdf. Accessed September 6, 2014.

Kalogriopoulos NA, Baran J, Nimunkar AJ, Webster JG. Electronic medical record systems for developing countries: review. *31st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS)*. 2009:1730-3. doi: 10.1109/IEMBS.2009.5333561.

Kamadjeu RM, Tapang EM, Moluh RN. Designing and implementing an electronic health record system in primary care practice in Sub-Saharan Africa: a case study from Cameroon. *Informatics in Primary Care*. 2005;13(3):179-86. http://www.ingentaconnect.com/content/bcs/ipc/2005/00000013/00000003/art00003?crawler=true. Accessed September 13, 2014.

Karanja IW, Makau J. An inventory of the slums in Nairobi.1-221. http://www.irinnews.org/pdf/nairobi_inventory.pdf. Accessed March 28, 2015.

Keshavjee K, Bosomworth J, Copen J, et al. Best practices in EMR implementation: a Systematic review. *Proceedings of the 11th International Symposium on Health Information Management Research – iSHIMR*. 2006:1-15. http://www.infoclin.ca/assets/7e474_best%20practices%20in%20emr%20implementation%20-%20july,%202006.pdf. Accessed September 13, 2014.

Kibera UK. Kibera facts & information. kibera.org.uk. Published 2010-2015. http://www.kibera.org.uk/facts-info/. Accessed August 31, 2015.

Kwintessential. Kenya: language, culture, customs and etiquette. Published 2014. http://www.kwintessential.co.uk/resources/global-etiquette/kenya.html. Accessed October 13, 2015.

Kypbutungi C, Ziraba AK, Ezeh A, Yé Y. The burden of disease profile of residents of Nairobi's slum: results from a demographic surveillance system. *Population Health Metrics.* 2008;6(1). doi:10.1186/1478-7954-6-1.

Laerum H, Faxvaag A. Task-oriented evaluation of electronic medical records system: development and validation of a questionnaire for physicians. *BMC Medical Informatics and Decision Making*. 2004;4(1):1-16. doi:10.1186/1472-6947-4-1.

Lincoln YS, Guba EG. *Naturalistic Inquiry.* Beverly Hills: SAGE Publications Inc.; 1985.

Ludwick D, Doucette J. Adopting electronic medical records in primary care: lessons learned from health information systems implementation experience in seven countries. *International Journal of Medical Informatics*. January 2009;78(1):22-31. doi: 10.1016/j.ijmedinf.2008.06.005.

Mamlin BW, Biondich PG, Wolfe BA, et al. Cooking up an open source EMR for developing countries: OpenMRS - a recipe for successful collaboration. *AMIA Annual Symposium Proceedings*. 2006:529-33.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1839638/pdf/AMIA2006_0529.pdf. Accessed June 12, 2014.

Manders EJ, José E, Solis M, Burlison J, Nhampossa JL, Moon T. Implementing OpenMRS for patient monitoring in an HIV/AIDS care and treatment program in rural Mozambique. *MEDINFO 2010: Proceedings of the 13th World Congress on Medical Informatics, Studies in Health Technology and Informatics.* 2010;160(Pt 1):411-5. doi:10.3233/978-1-60750-588-4-411.

MapKibera. Download. MapKibera. Published n.d.. http://mapkibera.org/download/. Accessed March 12, 2014.

Matheson A, Baseman JG, Wagner SH, et al. Implementation and expansion of an electronic medical record for HIV care and treatment in Haiti: an assessment of system use and the impact of large-scale disruptions. *International Journal of Medical Informatics.* 2012;81(4):244-256. doi: 10.1016/j.ijmedinf.2012.01.011.

Mayan MJ. *Essentials of Qualitative Inquiry*. Walnut Creek: Left Coast Press, Inc.; 2009.

Millard PS, Bru J, Berger CA. Open-source point-of-care electronic medical records for use in resource-limited settings: systematic review and questionnaire surveys. *BMJ Open*. 2012;2:e000690. doi:10.1136/bmjopen-2011-000690.

Milne J, Oberle K. Enhancing rigor in qualitative description: a case study. *Journal of Wound, Ostomy and Continence Nursing*. 2005;32:413–420.

Ministry of Health. Health information system policy 2010-2030. Nairobi 2010. https://www.healthresearchweb.org/files/HISPolicyReportfinaldocument05.08.pdf. Accessed August 31, 2015.

Mohammed-Rajput NA, Smith DC, Mamlin B, Biondich P, Doebbeling BN, OpenMRS collaborative investigators. OpenMRS, a global medical records system collaborative: factors influencing successful implementation. *AMIA Annual Symposium Proceedings 2011*. 2011:960-68. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243141/pdf/0960_amia_2011_proc.pdf. Accessed January 6, 2015.

Moster-Phipps N, Pottas D, Korpela M. Improving continuity of care through the use of electronic records: a South African perspective. *South African Family Practice*. 2012;54(4):326-31. doi:10.1080/20786204.2012.10874244.

Moster-Phipps N, Pottas D, Korpela M. A socio-technical approach to continuity of care and electronic records in the South African context. *MEDINFO 2010: Proceedings of the 13th World Congress on Medical Informatics, 2010.* 2010;160(Pt 1):406-10. doi:10.3233/978-1-60750-588-4-406.

Mutisya E, Yarime M. Understanding the grassroots dynamics of slums in Nairobi: the dilemma of Kibera informal settlements. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*. 2011:197-213. http://tuengr.com/V02/197-213.pdf. Accessed January 12, 2015.

Neegaard MA, Olesen F, Andersen RS, Sondergaard J. Qualitative description - the poor cousin of health research? *BMC Medical Research Methodology*. 2009;9(52):1-5.

Nucita A, Bernava GM, Bartolo M, et al. A global approach to the management of EMR (electronic medical records) of patients with HIV/AIDS in Sub-Saharan Africa: the experience of DREAM software. *BMC Medical Informatics and Decision Making*. 2009;9(42):1-13. doi:10.1186/1472-6947-9-42.

O'Mahony D. Implementing an electronic medical record system in a rural general practice. *South Africa Family Practice*. 2009;51(4):346-7. doi:10.1080/20786204.2009.10873878.

OpenMRS. About us. OpenMRS. Published 2004-2013. http://openmrs.org/about/. Accessed September 2014.

OpenMRS Inc. Home page. *OpenMRS*. http://openmrs.org/. Published 2004-2015. Accessed April 25, 2015.

OpenstreetMap. Map of Kibera. OpenStreetMap. Published n.d.. http://www.openstreetmap.org/#map=16/-1.3119/36.7901. Accessed August 31, 2014.

Parsons T. "Kibra Is Our Blood": the Sudanese military legacy in Nairobi's Kibera location, 1902-1968. *The International Journal of African Historical Studies*. 1997;30(1):87-122. doi: 10.2307/221547.

Patel H, Jonash R, Anderson K, Bautista J. Social enterprise challenge: improving chronic disease care in Slums by 2019. *Hult International Business School Publishing*. 2014.

Paterson GI, Shaw N, Grant AM, et al. Cross-Canada EMR case studies: analysis of physicians' perspectives on benefits and barriers. *electronic Journal of Health Informatics*. 2011;6(4):e34. http://www.ejhi.net/ojs/index.php/ejhi/article/viewFile/186/120. Accessed September 29, 2015.

RefWorks. *RefWorks*. https://www.refworks.com/. Published 2009. Accessed December 2014.

Riley LW, Ko AI, Unger A, Reis MG. Slum health: Diseases of neglected populations. *BMC International Health and Human Rights*. 2007;7(2). doi:10.1186/1472-698X-7-2.

Rotich JK, Hannan TJ, Smith FE, et al. Installing and implementing a computer-based patient record system in Sub-Saharan Africa: the mosoriot medical record system. *Journal of the American Medical Informatics Association*. 2003;10(4):295-303. doi: http://dx.doi.org/10.1197/jamia.M1301.

Runde D. Urbanization will change the (developing) world. *Forbes*. Published February 25, 2015. Available at: http://www.forbes.com/sites/danielrunde/2015/02/24/urbanization-development-opportunity/. Accessed August 31, 2015.

Sandelowski M. Focus on research methods: whatever happened to qualitative description? *Research in Nursing and Health*. 2000;23(4):334-340. doi: 10.1002/1098-240X(200008)23:4<334::AID-NUR9>3.0.CO;2-G.

Shcherbatykh I, Holbrook A, Thabane L. Methodologic issues in health informatics trials: the complexities of complex interventions. *Journal of the American Medical Informatics Association.* 2008;15:575-580.

Sheikh M. Digital health information system in Africa's resource poor countries: current challenges and opportunities. *Journal of Health Informatics in Developing Countries*. 2014;8(1):78-87. http://www.jhidc.org/index.php/jhidc/article/view/118/162. Accessed January 6, 2015.

Simbini T. Computerised information management systems in HIV/AIDS care and outcomes research. *The Central African Journal of Medicine*. 2006;52(5/6):65-7. http://www.ncbi.nlm.nih.gov/pubmed/18254459. Accessed January 16, 2015.

Syrjänen, Raakel; UN-Habitat KENSUP Team. UN-HABITAT and the Kenya slum upgrading programme: strategy document. Nairobi 2008. http://unhabitat.org/books/un-habitat-and-the-kenya-slum-upgrading-programme-strategy-document/. Accessed February 19, 2014.

Taffa N, Chepngeno G. Determinants of health care seeking for childhood illnesses in Nairobi slums. *Tropical Medicine and International Health*. 2005;10(3):240-5. doi: 10.1111/j.1365-3156.2004.01381.x.

Talisuna S. Electronic medical records and same-day patient tracing improves clinic efficiency and adherence to appointments in a community-based HIV/AIDS care program in Uganda [abstract]. *7th International Conference on HIV Treatment and Prevention Adherence*, 2012. Accessed January 7, 2015.

The Economist. Upwardly mobile Africa: boomtown Slum. *The Economist*. Published December 22, 2012. http://www.economist.com/news/christmas/21568592-day-economic-life-africas-biggest-shanty-town-boomtown-slum. Accessed January 3, 2013.

The World Bank. Developing countries need to harness urbanization to achieve the MDGs: IMF-World Bank report. *The World Bank*. Published April 17, 2013. http://www.worldbank.org/en/news/press-release/2013/04/17/developing-countries-need-to-harness-urbanization-to-achieve-mdgs-imf-world-bank-report. Accessed August 31, 2015.

Thompson A, Castle E, Lubeck P, Makarfi PS. Experience implementing OpenMRS to support maternal and reproductive health in Northern Nigeria [abstract]. *MEDINFO 2010, Studies*

in Health Technology and Informatics. 2010; 160(Pt 1):332-6. doi: 10.3233/978-1-60750-588-4-332.

Tierney WM, Rotich JK, Hannan TJ, et al. The AMPATH medical record system: creating, implementing, and sustaining an electronic medical record system to support HIV/AIDS care in Western Kenya. *MEDINFO 2007: Proceedings of the 12th World Congress on Health (Medical) Informatics*; *Studies in Health Technology and Informatics.* 2007;129(Pt 1):372-6. Accessed January 6, 2015.

Tierney WM, Rotich JK, Smith FE, Bii J, Einterz RM, Hannan TJ. Crossing the "digital divide:" implementing an electronic medical record system in a rural Kenyan health center to support clinical care and research. *AMIA Annual Symposium Proceedings*. 2002:792-5. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2244335/. Accessed January 6, 2015.

Tierney WM, Sidle JE, Diero LO, et al. Assessing the impact of a primary care electronic medical record system in three Kenyan rural health centers. *Journal American Medical Informatics Association.* 2015:1-18. doi: 10.1093/jamia/ocv074.

Tomasi E, Facchini LA, Maia MS. Health technology in primary health care in developing countries: a literature review. *Bulleting of the World Health Orgnization*. 2004;82(11):867-74. http://www.who.int/bulletin/volumes/82/11/en/867.pdf. Accessed March 20, 2014.

Tovrov D. 5 biggest slums in the world. *International Business Times.* Published December 9, 2011. http://www.ibtimes.com/5-biggest-slums-world-381338. Accessed August 31, 2015.

UN-Habitat. What are slums and why do they exist? *United Nations.* http://www.unhabitat.org/downloads/docs/4625_51419_gc%2021%20what%20are%20slums.pdf. Accessed March 26, 2014.

United National Population Fund. State of world population 2007: unleashing the potential of urban growth. *UNFPA*. 2007. http://www.unfpa.org/sites/default/files/pub-pdf/695_filename_sowp2007_eng.pdf. Accessed March 26, 2014

Vlahov D, Galea S. Urbanization, urbanicity, and health. *Journal of Urban Health: Bulletin of the New York Academy of Medicine.* 2002;79(4 Suppl 1):S1-S12. doi: 10.1093/jurban/79.suppl_1.S1.

Were MC, Emenyonu N, Achieng M, et al. Evaluating a scalable model for implementing electronic health records in resource-limited settings. *Journal American Medical Informatics Association*. 2010;17(3):237-44. doi: 10.1136/jamia.2009.002303.

Were MC, Meslin EM. Ethics of implementing electronic health records in developing countries: points to consider. *AMIA Annual Symposium Proceedings*, *2011*. 2011. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243215/pdf/1499_amia_2011_proc.pdf. Accessed January 6, 2015.

Whitehead M, Dahlgren G, Evans T. Equity and health sector reforms: can low-income countries escape the medical poverty trap? *The Lancet.* 2001;358(9284):833-6. doi:10.1016/S0140-6736(01)05975-X.

WHO Centre for Health Development, Kobe Centre. A billion voices: listening and responding to the health needs of slum dwellers and informal settlers in new urban settings. *World Health Organization Kobe Centre.* 2005. http://www.who.int/social_determinants/resources/urban_settings.pdf. Accessed April 5, 2014.

Wikipedia. OpenEMR. *Wikipedia*. https://en.wikipedia.org/wiki/OpenEMR#cite_note-2. Published June 26, 2015. Accessed July 17, 2015.

Williams F, Boren SA. The role of the electronic medical record (EMR) in care delivery development in developing counties: a systematic review. *Informatics in Primary Care*. 2008;16(2):139-145. http://www.ingentaconnect.com/content/bcs/ipc/2008/00000016/00000002/art00008?crawler=true. Accessed March 13, 2014.

World Health Organization. Country health information systems: a review of the current situation and trends. *World Health Organization.* Switzerland 2011. http://www.who.int/healthmetrics/news/chis_report.pdf. January 8, 2015.

World Health Organization. Electronic health records: manual for developing countries. *World Health Organization.* Geneva 2006. http://www.wpro.who.int/publications/docs/EHRmanual.pdf. Accessed January 8, 2015.

World Health Organization. *Kenya Maternal and Child Health Data.* Countdown to 2015: maternal, newborn and child Survival. 2014. http://www.countdown2015mnch.org/documents/2014Report/Kenya_Country_Profile_2014.pdf. Accessed July 2014.

World Health Organization. Social determinants of health. Facts: urban settings as a social determinant of health. *World Health Organization.* 2014. http://www.who.int/social_determinants/publications/urbanization/factfile/en/. Accessed March 2014.

Zandieh SO, Yoon-Flannery K, Kuperman GJ, Langsam DJ, Hyman D, Kaushal R. Challenges to EHR implementation in electronic- versus paper-based office practices. *Journal of General Internal Medicine.* 2008;23(6):755-761. doi:10.1007/s11606-008-0573-5.