COST ANALYSIS OF AN ELECTRONIC MEDICAL RECORD SYSTEM AT AN URBAN CLINIC IN KAMPALA, UGANDA - AN ORGANIZATIONAL PERSPECTIVE

BONNY ENOCK BALUGABA

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE AWARD OF A MASTER OF SCIENCE IN HEALTH INFORMATICS DEGREE OF MOI UNIVERSITY.

2019

Declaration

This thesis is my original work and has not been presented for a degree in any other university. No part of this thesis may be reproduced without prior written permission of the author and or Moi University.

Signature:  Date: 18th June 2019

Bonny Enock Balugaba

SM/PGHI/12/15

Declaration by the supervisors

This thesis has been submitted with our approval as university supervisors.

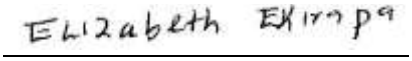
Signature: _____ Date----------

Dr Simon K. Ruttoh, Ph. D

Department of Health Policy and Management

School of Public Health

Moi University

Signature:  Date: 18th June 2019

Dr. Elizabeth Ekirapa- Kiracho Ph. D

Department of Health Policy Planning and management

School of Public Health

Makerere University

Dedication

This work is dedicated to my classmates in the MHI journey as well as the staff at the Institute of Biomedical informatics, Moi University.

Acknowledgement

I would first like to thank my supervisors Dr. Simon Ruttoh of Moi University and Dr. Elizabeth Ekirapa of Makerere University School of public Health for the tireless efforts rendered in guiding me throughout this journey.

I would also like to thank the study participants and the IDI management for the willingness to allow me access their system and records and the support that was rendered throughout this project. Without their passionate participation and input, the validation survey could not have been successfully conducted.

I would also like to acknowledge Prof. Martin Were and the entire HITRAIN fraternity for the moral support and guidance rendered from conception of the idea until the very end.

I also acknowledge the funding rendered by NORHED programme through the HITRAIN project (QZA-0484)

Cost analysis of an Electronic Medical Record system at an urban clinic in Kampala, Uganda - An organizational perspective

Abstract

Background: Electronic medical record systems (EMRS) are increasingly being adopted worldwide. While their benefits are well known, the costs of implementing and maintaining such EMRs in resource constrained settings are not well documented. Establishing such costs is crucial to enable policy and fiscal planners make sound decisions in allocation of scarce resources across multiple areas of need.

Objective: To conduct a comprehensive cost analysis for developing, implementing and maintaining an EMRS specifically looking at the direct costs for the development and implementation, the cost implications with use of an EMR as compared to paper based medical record system as well as a trend analysis of the cost of an EMR in resource limited settings.

Methods: This study was conducted at the Infectious Diseases Institute (IDI), a public HIV/AIDS care clinic situated in Kampala, Uganda an implementer of a custom-made EMRS. A comprehensive direct cost analysis was conducted using an organizational perspective. Elements for cost at pre-implementation, implementation and maintenance phases were identified based on industry-accepted cost metrics. Cost units were determined based on data from primary sources. A cost inventory was developed and used to extract data from the market survey findings, original receipts and invoices for associated products. Costs with a lifetime of greater than one year were annuitized and a standard-recommended Uganda government depreciation rate of 40% was applied. The costs were converted to their equivalent dollar value using the government of Uganda dollar rates and the total costs are reported. Sensitivity analysis was conducted to account for uncertainty.

Results: The total calculated cost of the IDI EMRS, since its inception in January 2009 until December 2016, was USD 1,066,965 while an opensource instance would cost just over USD 800,000. The annuitized total cost was USD 1,084,498. Maintaining a paper based medical record system over the same time would have cost almost half the cost of the EMR (USD 544,159). Salaries and wages contributed 70% (USD 757,332) and 81% (USD 438,842) of costs in the EMRS and paper-based system, respectively. Other cost drivers included software and licensing (20%, USD 258,341) in the EMRS and stationery (17%, USD 90,854) in the paper system. The sensitivity analysis model with open source architecture resulted in a 20% reduction in the total cost of the EMRS. Inclusion of public service rates to the model led to a further 25% reduction in the total cost of the EMRS. The costs expended showed a gradual decrease with time.

Conclusion: EMRS have higher costs as compared to paper-based medical record systems. However, expenditure on the system reduces with time. Salaries and wages are the largest contributors to the cost burden. Opensource systems have a potential to lower costs.

Recommendations: There is need to utilize open opensource systems to minimize costs as well as devise means of lowering personnel costs.

Table of Contents

List of tables

List of figures

Definition of terms

Annuitization: refers to spreading payments over multiple periods

Cost: refers to the money incurred in obtaining an assist or paid for tasks accomplished.

Custom made software: Is software that is specially developed for some specific organization or other user.

Electronic Health Record: An electronic record of health-related information on an individual that conforms to nationally recognized interoperability standards and that can be created, managed, and consulted by authorized clinicians and staff across more than one healthcare organization.

Electronic Medical Record: An electronic record of health-related information on individual that can be created, gathered, managed and consulted by authorized clinicians and staff in one healthcare organization.

Human Resource: the personnel of a business or organization, regarded as a significant asset in terms of skills and abilities.

Open source software: Software whose source code is available for modification or enhancement by anyone.

Software: a generic term used to describe computer programs are sets of instructions or programs instructing a computer to do specific tasks.

Utilities: The amount a household or office is expected to pay for electricity, water and/or gas each month.

List of abbreviations

AIDS	Acquired Immuno deficiency syndrome
AMPATH	Academic Model for Providing Access to Healthcare
CDSS	Clinical Decision Support System
CPOE	Computerized Provider Order Entry.
EHRS	Electronic Health Record System
EMRS	Electronic Medical Record System
HIV	Human Immuno deficiency virus
ICEA	Integrated Clinic Enterprise Application
IDI	Infectious Diseases Institute
IT	Information Technology
NGO	Non-Governmental Organization
PLHIV	People Living with HIV
USD	United States Dollar

Chapter one

This section contains an introduction and background to the subject matter, the problem statement and justification, research questions and study objectives.

1.1 Introduction and background

The healthcare delivery system of a nation hinges, amongst other things, on how well its hospitals can deliver qualitative and affordable healthcare to its citizens(A. I. Ojo & S. O. Popoola, 2015). Therefore, the healthcare delivery system has a big role to play(Adebowale I Ojo & Sunday O Popoola, 2015). Good record keeping is essential in health care for good quality services relevant for adequate planning, development and maintenance of the health care system. The amount and quality of information available to healthcare professionals in patient care impact the outcome and continuity of patient care. The healthcare industry generates tremendous amounts of data which have a potential to inform decisions once collected, stored and managed properly. However, the developing world is lagging as regards health data collection, collation and analysis which often results in many inappropriate outcomes. Furthermore, medical information needed for clinical decision making continues to increase, especially in developing countries.

The Electronic Health Record (EHR) is a key component of medical informatics that is increasingly being utilized in industrialized nations to improve healthcare(Akanbi et al., 2012; Blumenthal, 2009). A number of developed countries have had their physicians use electronic medical records (EMR) a component of EHR for more than a decade (Schoen et

al., 2006). These systems have been implemented in a number of developing countries(Fraser et al., 2005) although their adoption is limited by multiple factors that include limited human resource, cost of equipment, software and personnel (Williams & Boren, 2008). These limitations imply that resource limited countries face a dilemma in having to decide whether to continue using traditional paper based medical record systems or adopt EMR that requires a relatively high initial investment (Taylor, Manzo, & Sinnett, 2002).

EMRs have been taken up by many sub-Saharan African countries including Uganda, Kenya, Ghana, Rwanda, and Nigeria among others (Akanbi et al., 2012; Odekunle, Odekunle, & Shankar, 2017). These systems have been deployed mainly in care for specific diseases with HIV/ AIDS being the main beneficiary for the deployment of EMR systems(Akanbi et al., 2012). Most of these implementations mainly donor funded in many of the sub-Saharan Africa countries(Akanbi et al., 2012). Non-governmental organisations (NGOs) have been the leading champions of EMR adoption and the Infectious Diseases Institute (IDI) Uganda is among such organizations. In September 2009, the IDI implemented a custom-made EMR system called Integrated Clinic Enterprise Application (ICEA) (Castelnuovo et al., 2012). Provider-based entry was an important planned feature to reduce the rate of errors, provide real time validation of data, and automate tasks such as drug prescription writing. The following principles were considered when developing ICEA: efficiency of clinical workflow, continuity of care, quality of care and information, confidentiality, information security and storage, as well as flexibility for additional applications such as new subspecialty clinic data.

System Architecture

ICEA is a Microsoft (MS) Windows forms application that is based on Microsoft.NET technologies and developed in C# with a MS SQL Server backend. ICEA is a proprietary medical record system that was developed in-house at the institute. Steps of the development of the application (including the source code) were well documented from envisioning, conceptual design, logical design and physical design to enable anyone who understands these standards (including Windows coding language) and has access to the documentation to maintain and extend the application. The server computer is a HPDL380 G7 series and the client computers are as well HP PCs.

To enable provider-based entry, ICEA had to be visually compelling and user-friendly, workflow management was in-built to enable tracking of patients from the time their visit was registered to visit triage, counseling session, medical examination, drug prescription and collection. To eliminate omission of important steps, such as scheduling the patient next visit, automated queries were created that were mandatory. Many fields are mandatory and must be filled-in before the record can be considered valid and saved. Moreover, there are internal consistency checks which ensure that the data entered is accurate and falls within required ranges while maintaining the integrity of the information.

Each user in the system must explicitly login on a computer and into ICEA which is joined to the IDI domain using their username and password. Each user falls within a user group and each group is enabled to specific tasks only (e.g. medical officers are not able to access the inventory of pharmacy stock). Information collected in ICEA database server is backed

up daily onto a secondary server and weekly backed up onto tapes which are stored outside the IDI building.

Features

The system has a modular design, which enables plug-ins to be developed and installed without affecting the existing system. This feature has enabled the phased development of additional modules to meet additional clinical needs (for example a module to house the integrated tuberculosis clinic database was one such addition).

1.2 Statement of the problem.

Medical record management is currently poor in the developing world(Hassibian, 2013; Tierney et al., 2007). This can be attributed to the somewhat old fashioned style of keeping such records that is to say, paper based medical record management systems are the predominant means by which medical records are kept(Hassibian, 2013) and such systems are known to have a number of flaws(Stausberg, Koch, Ingenerf, & Betzler, 2003). Besides these systems being tedious to deal with when one tries to access patient medical history like is the case for many of the 'chronic diseases' including HIV/AIDS, the space requirements in form of records stores and time taken to access a record are all resources that could be used for other health operations(Girosi, Meili, & Scoville, 2005; Hillestad et al., 2005; Jang, Lortie, & Sanche, 2014; Levingston, 2012; Tierney et al., 2010). Other issues like data loss in case of a fire in the store cannot be overlooked since such systems barely have backup mechanisms and predicament when it comes to sharing and transfer of patient medical records as is required for some medical operations and referrals.

To overcome such challenges, developed countries have greatly embraced the uptake of Electronic Medical Record systems (EMRS)(Blumenthal, 2009) and these have been shown to have a number of advantages in addition overcoming the above listed challenges. One of the key features is computerized clinical decision support (CDSS), and computerized provider order entry (CPOE)(Pirnejad, Niazkhani, van der Sijs, Berg, & Bal, 2008) among others that can easily be incorporated into the EMR hence improving patient care(Ranji, Rennke, & Wachter, 2013; Wolfstadt et al., 2008). EMRs have also been piloted in the

developing world with more affordable open source EMR systems like OpenMRS(Seebregts et al., 2009; M. C. Were et al., 2010) at the forefront of such implementations(Seebregts et al., 2009). The challenge is many of these implementations don't survive beyond such pilots. EMRs have also been more broadly adopted by the private sector and NGOs that deal with health care provision and the main area of focus has been in the provision of HIV/AIDS services. One of the approaches to ensure increased uptake, support and expansion of these systems is documentation of the costs both direct and indirect of setting up functional EMR. Currently such documented evidence is limited (Hillestad et al., 2005) especially in the developing world and Uganda in particular. Therefore, this study set out to conduct a comprehensive cost analysis of an electronic medical record system used at an urban clinic in Kampala, Uganda.

1.3 Justification

Several cost evaluation studies of EMR have been conducted in the developed world but there is limited documentation about the costs of such systems in the developing world.

A comprehensive evaluation of costs for the EMRs was thus highly informative not only for the Ugandan ministry of Health but also other partners directly or indirectly involved in adoption and implementation of EMR systems. An analysis of costs of such systems would help guide policy makers and managers of health institutions to make appropriate choices in the bid to improve health care and meet the strategic development goals. Clear documentation of the costs needed to set up EMRs is necessary to guide any future adoptions and implementation of such systems both by the public and private sectors.

1.4 Research questions.

1. What are the direct costs of developing and implementing an electronic medical record system?
2. What are the cost implications with use of provider based EMR as compared to paper based medical record system?
3. What trend do costs take during development, implementation and maintenance of EMRS?

1.5 Study objectives

Broad objective: To conduct a comprehensive cost analysis of an electronic medical record system used at an urban clinic in Kampala, Uganda.

Specific objectives.

i. To determine the direct costs for the development and implementation of an EMR system.
ii. To determine the cost implications with use of an EMR as compared to paper based medical record system.
iii. To conduct a trend analysis of the cost of an electronic medical record system.

Chapter two

Chapter two contains a review of literature on use of medical record systems, the benefits and challenges associated with their use. economic evaluations of the existing systems and the methods and tools used to carry out such evaluations and the status of EMR implementation in developing countries.

2.1 Literature review.

Several studies have been conducted regarding Electronic Health Records with special focus on EMR. The studies have ranged from benefit analyses of the systems, challenges and barriers to their adoption among other areas. In this chapter, a review literature on the available works in the EMR domain is presented.

2..1.1 Status of EMR implementation in developing countries

Different forms of EMR systems have been implemented in more than 25 developing countries including Peru, Haiti, Kenya and Uganda(Seebregts et al., 2009; M. C. Were et al., 2010) especially in the areas of HIV/AIDS, T.B and malaria care(Akanbi et al., 2012; Fraser et al., 2005). These implementations have undergone several changes from basic systems to somewhat more sophisticated systems (Seebregts et al., 2009; Tierney et al., 2007; M. C. Were et al., 2010). Given the resource constraints experienced by many low-income countries, use of open source has been on the rise and the most common among these is OpenMRS. The idea of OpenMRS was hatched in Kenya by the Academic Model of Providing Access to Healthcare (AMPATH) through collaboration between Moi teaching and referral hospital, Moi University and Indiana University in the United States of

America(Tierney et al., 2010). The initial idea was to create an electronic medical record system that could be used to manage data on HIV/AIDS patients(Thompson, Castle, Lubeck, & Makarfi, 2010; Tierney et al., 2010). Partners in Health having also been largely involved in tuberculosis and HIV care and in need of a better records system joined this collaboration and OpenMRS was borne. Since inception, OpenMRS has been deployed in several developing countries that include, Kenya, Uganda, Rwanda, Nigeria among others(Thompson et al., 2010; Were et al., 2008; M. C. Were et al., 2010). These implementations have not come without challenges and several barriers to implementation have been highlighted by the different implementers (Akanbi et al., 2012; M. C. Were et al., 2010).

Uganda has had a number of electronic medical record systems implemented both in the public and private health facilities(Castelnuovo et al., 2012; Liang, Wiens, Lubega, Spillman, & Mugisha, 2018; Tierney et al., 2010; Were et al., 2008; Martin C Were et al., 2010). The systems implemented vary from setting to setting with some being opensource while others are proprietary. However, since 2010, the government of Uganda with partners embarked on development and implementation of a national medical record systems which came to be known as UgandaEMR(Mwotasubi Isaac, Ocaya Stephen, Charity Kyomugasho, Evelyn Akello, & Bazeyo., 2016). UgandaEMR is a customization of the widely used opensource electronic medical record system known as OpenMRS(Mamlin et al., 2006; Seebregts et al., 2009; UgandaEMR, 2019). This is currently mainly being deployed in public health facilities(Ndira, Rosenberger, & Wetter, 2008; M. C. Were et al., 2010).

2.1.2 About OpenMRS

OpenMRS is a software platform and a reference application which enables design of a customized medical records system with no programming knowledge (although medical and systems analysis knowledge is required)(Mamlin et al., 2006; Seebregts et al., 2009; Thompson et al., 2010). It is a common platform upon which medical informatics efforts in developing countries can be built. The system is based on a conceptual database structure which is not dependent on the actual types of medical information required to be collected or on particular data collection forms and so can be customized for different uses.

OpenMRS is based on the principle that information should be stored in a way which makes it easy to summarize and analyze, i.e., minimal use of free text and maximum use of coded information(Mamlin et al., 2006; Seebregts et al., 2009; Thompson et al., 2010). At its core is a concept dictionary which stores all diagnosis, tests, procedures, drugs and other general questions and potential answers. OpenMRS is a client-server application, which means it is designed to work in an environment where many client computers access the same information on a server.

2.1.3 Barriers to adoption of EMR/EHR.

In those countries where EMR has been highly adopted, the reasons given by those providers that haven't yet adopted include; financial constraints given the high startup capital, lack of adequate and reliable information on investment returns among other factors(DesRoches et al., 2008; Gans, Kralewski, Hammons, & Dowd, 2005; Miller & Sim, 2004). In a survey conducted among 34,000 private medical groups in the US, productivity loss during implementation and insufficient return on investment were ranked among the top 5 barriers to EMR adoption(Gans et al., 2005). The same barriers have been highlighted by a qualitative study conducted in Boston and Denver(Poon et al., 2006). Another study still conducted in the Massachusetts cited inadequate funding, absence of physician support, lack of technical knowledge and support and inability to find systems that suit providers' needs(Simon et al., 2008). Other studies have cited technical limitations of computers and productivity loss as the main barriers to adoption (Ajami & Arab-Chadegani, 2013; Akanbi et al., 2012; Sequist et al., 2007).

These challenges are even more pronounced in developing countries given their low resource power (Akanbi et al., 2012; Fraser et al., 2005; Williams & Boren, 2008). The major documented challenge to the establishment of EHR is the high cost of set-up and maintenance(Akanbi et al., 2012). This is due to poor existing infrastructure, frequent power outages and network failure. In facilities with EHRs, use is sub-optimal because of the need for parallel entry of data to paper and computer which increases the work-load of over-stretched staff(Akanbi et al., 2012). Despite these challenges, some facilities have

documented benefits of the use of EHR in sub-Saharan Africa; these include greater data accuracy, improved timeliness, and availability of routine reports and reduced data duplication(Thompson et al., 2010; Tierney et al., 2007; Waters et al., 2010).

2.1.4 Benefits of EMR

Digital technology has tremendously transformed the world, with tablets, smart phones and web enabled devices changing the way we communicate. Medicine being an information rich enterprise, a greater and more seamless flow of information within a digital health care infrastructure, created by electronic health records (EHRs), involves and controls digital progress and can transform the way care is delivered and compensated. EHRs make information available whenever and wherever needed (Akanbi et al., 2012; Castelnuovo et al., 2012; Levingston, 2012) which is not the case with paper based medical record systems.

Electronic medical record systems have many benefits. These include medical practice efficiencies and cost savings, improved care coordination and better decisions, improved patient care, improved diagnostic and patient outcomes (Menachemi & Collum, 2011).

Proper functioning EMR systems have personal health records embedded in them and these also have several benefits. They help improve access of patients to health information, data and knowledge. This has been shown to be useful especially for chronic disease care and given the high HIV/AIDS scourge these could be leveraged upon in the developing world. Collaborative disease tracking has the potential to lower communication barriers between patients and caregivers(Tang, Ash, Bates, Overhage, & Sands, 2006). Improved communication makes it easier for patients and care givers to make any queries to the

providers, book and review appointments, request for refills and referrals and report problems. EMR systems have the potential to provide ongoing connection between patient and physicians which has been shown to substantially lower the time needed to address any emergencies as a result of an ongoing treatment(Tang et al., 2006).

2.1.4.1 Medical Practice Efficiencies & Cost Savings

Several health care providers have reported that electronic medical records (EHRs) help improve medical practice management and through better practice efficiencies and cost savings. A nationwide survey conducted in the United States of America among medical practitioners provides useful evidence on this matter(Levingston, 2012). Regarding functionality of their systems, 79% of the providers reported that their practices functioned more efficiently, regarding time saving, 82% reported that sending prescriptions electronically (e-prescribing) saved time(Levingston, 2012). EHRS also minimized the time lag between requesting and receiving of laboratory results. EHRs were also viewed as an asset when it came to recruitment of physicians with more physicians willing to take up work in units that implemented EHRs. Such time savings would be highly needed in resource limited settings that have limited staff with large patient numbers from a time motion study conducted in Uganda(Were et al., 2008). Savings are primarily attributed to automating several time-consuming paper-driven and labor-intensive tasks(Kumar & Bauer, 2011), reduced transcription costs, reduced chart pull, storage, and re-filing costs, improved and more accurate reimbursement coding with improved documentation for highly compensated codes. There are also reduced medical errors(Castelnuovo et al., 2012) through better access

to patient data and error prevention alerts. Studies have tried to estimate the cost savings of EMRs and among these is Bill et al, who estimated a range from $37M to $59M over a five-year period in addition to incentive payments based on the scope of the implementation and size of the health system(Bell & Thornton, 2011) Worth noting is the fact that most of this literature is from the developed world. Such figures might not be representative of what the actual situation is in the developing world.

2.1.4.2 Patient Participation.

Providers and patients who share access to electronic health information can collaborate in informed decision making. Patient participation is especially important in managing and treating chronic conditions such as asthma, diabetes, and obesity and HIV/AIDS which is highly prevalent in sub Saharan Africa. Electronic health records (EHRs) can help providers ensure high-quality care. With EHRs, providers can give patients full and accurate information about all their medical evaluations(Hsu et al., 2005). Providers can also offer follow-up information after an office visit or a hospital stay, such as self-care instructions, reminders for other follow-up care, and links to web resources(Hsu et al., 2005). EHRs also create an avenue for communication with their patients. With EHRs, providers can manage appointment schedules electronically and exchange e-mail with their patients(Bates & Bitton, 2010), Quick and easy communication between patients and providers may help providers identify symptoms earlier and it can position providers to be more proactive by reaching out to patients (Eysenbach & Jadad, 2001). The developing has great potential of attaining some of these benefits given the penetration of mobile internet and advanced mobile technologies,

however, this can only be achieved after comprehensive and sustainable EMR systems are implemented.

2.1.4.3 Improved Diagnostics & Patient Outcomes

When health care providers have access to complete and accurate information, patients receive better medical care (Christensen & Grimsmo, 2008; Hillestad et al., 2005; Jamoom, Patel, Furukawa, & King, 2014; Jarvis et al., 2013) . Electronic health records (EHRs) can improve the ability to diagnose diseases and reduce even prevent medical errors, improving patient outcomes. A US national survey of doctors who were ready for meaningful use of EMR highlighted the following; 94% of providers reported that their EHRs made records readily available at point of care and 75% of providers reported that their EHRs allowed them to deliver better patient care and this was similar to finding from another study conducted in Norway (Bates & Bitton, 2010). A study was conducted after implementation of the ICEA at the infectious diseases institute and reported an over 60% (Castelnuovo et al., 2012) reduction in the total proportion of errors just two year after implementation of the system.

2.1.5 The downside of EMR implementation.

Despite the numerous benefits presented by health IT and EMR in particular, they also have some shortcomings (Christensen & Grimsmo, 2008; Himmelstein, Wright, & Woolhandler, 2010; Menachemi & Collum, 2011; Sood et al., 2008) especially in the developing world. Hospitals with very the most sophisticated IT systems have been reported to have higher costs than those with systems not as sophisticated, although mortality was lower for heart attack patients in the hospitals with complicated systems (Himmelstein et al., 2010). Some

Norwegian physicians noted a reduction in comprehensiveness of each patient record compared to the periods before implementation of EMR especially for chronically ill patients(Christensen & Grimsmo, 2008). An impairment in the nurse-physician medication collaboration after the implementation of Computerized Provider Order Entry (CPOE) in 6 internal medicine wards in Netherlands was also reported(Control & Prevention, 2008; Pirnejad et al., 2008). A study in New Jersey after the state implemented electronic reporting for suspected Lyme disease cases found that the number of reports increased, yet the percentage of positive cases after investigation decreased, which suggested that the e-reporting system facilitated over reporting. However, from the available evidence, the benefits of EMR outweigh the shortcomings and therefore, their adoption in the developing world is a step in the right direction (Choi, Lee, & Rhee, 2013; Wu, Laporte, & Ungar, 2007).

In the developed world, there is a conscious effort by governments to drive adoption of EMR systems and one good example is the united states of America where there is specific reimbursement for early adopters of these systems(Jones, Rudin, Perry, & Shekelle, 2014).

2.1.6 Costs of Implementing an EHR System.

A number of studies have quantitatively assessed the cost of implementing an EHR system (Kim et al., 2009; Menachemi & Collum, 2011; Schmitt & Wofford, 2002; Wang et al., 2003). . The costs have been broadly divided into two categories namely, costs of the system itself (hardware, software, license, maintenance and support) and implementation costs that include training, human resource, loss of productivity among others. These costs vary significantly by the scale of the health care organization and the functionality of the EHR

system. However, some of the basic requirements are universal in all these implementations and not varying so largely in costing (Adler-Milstein et al., 2007; Bartlett, Molinari, Ortega-Sanchez, & Urquhart, 2006; Bassi & Lau, 2013) in their review reported that the costs in implementation and maintenance of EMR included; costs for design and development, implementation, Information Technology (IT) support, and clinical support. Other categories being hardware and peripherals, network and peripherals, supplies, and equipment, and packaged and customized software. One thing worth noting is the fact these costs vary from setting to setting and the size of the implementation. For example, a study conducted in south Korea (Choi et al., 2013) and another conducted in the United states of America (Fleming, Culler, McCorkle, Becker, & Ballard, 2011) report varying costs for the EMR systems with US study reporting relatively lower rates as compared one in south Korea. This difference in cost could be attributable to several factors the primary one being the difference in size of facility.

Financing of EMR system implementation in the public health facility solely lies on the side of government(Government of Uganda, 2015; Ministry of Health Uganda, 2016) which in some cases also gets funding from development partners like USAID, CDC among others. For example, the current UgandaEMR implementation is funded in part by CDC(Mwotasubi Isaac et al., 2016). In private facilities, such implementations are funded by the proprietors. Given the stringent budget and competing health priorities, there is a competition for the limited resources.

This, therefore, is a clear indication of how one study in a particular setting may not be solely relied on and the figures applied in a copy and paste manner to another setting. A clear

understanding of the local setting and local factors and cost drivers needs to be established in order to achieve successful implementations of EMR systems.

2.1.7 Methodologies used to estimate costs

Several studies have used different methodologies to estimate the costs of health information systems. These methods have included use of publicly available databases for other the systems and their associated costs, simulation and extrapolation of costs (Hillestad et al., 2005), interviews with experts and reliance on peer reviewed literature (Choi et al., 2013; Kaushal et al., 2006; Wang et al., 2003). Other methods included bench marking and review of organizational budgets(Byrne et al., 2010; Poley et al., 2007) among others. The methods used solely depended on the stage of implementation of the EMR system, the availability of records and level of similarity of the system under study to the published EMR systems.

2.1.8 Cost evaluation perspectives

The perspective taken in any economic evaluation has a great implication on the costs and cost inputs. The main cost evaluation perspectives are the societal and organizational perspectives(Byford & Raftery, 1998). With the organizational perspective, cost inputs as well as outputs from the perspective of the implementers who can be governments and other stakeholders like project funders among others. On the contrary, societal perspectives looks at costs and outputs from all stakeholders from implementers as well as users and all other beneficiaries from the project. A programme that looks unattractive from one perspective may look significantly better when other perspectives are considered. Analytic perspectives may include any or all of the following: the individual patient, the specific institution, the

target group for specific services, the Ministry of Health budget, the government's overall budget position (Ministry of Health plus other ministries), and the wider economy or the aggregation of all perspectives(Drummond, Sculpher, Claxton, Stoddart, & Torrance, 2015).

The organizational perspective is the most widely studied and a number of studies have been conducted to this effect(Bartlett et al., 2006; Choi et al., 2013; Drummond et al., 2015; Fleming et al., 2011; Tseng, Kaplan, Richman, Shah, & Schulman, 2018; Wu et al., 2007).

Chapter three

Chapter three presents the methodology used in this study and it contains information about the study setting, the study design, data collection and management procedures, study tools, inclusion and exclusion criteria and ethical considerations among other items as documented in this section.

3.1 Methodology.

This chapter contains the methodological details that will be used for this state. The chapter is sectioned into study design, study area, study participants, cost inventory, data collection, costing methodology, study tools, data management, analysis and presentation, Ethical considerations and quality control.

3.1.1 Study area

The Infectious Diseases Institute (IDI), established within Makerere University, is a Ugandan not-for-profit organization which aims to strengthen health systems in Africa, with a strong emphasis on infectious diseases; through research and capacity development. In pursuit of its mission both in Uganda and Sub-Saharan Africa, IDI provides care to People Living with HIV (PLHIV) and other infectious diseases, builds capacity among healthcare workers through training and ongoing support, maintains a focus on prevention, and carries out relevant research. The institute (Figure 2) has its main clinic in Kampala, district the capital city of Uganda (Figure 1).

The city is divided into five boroughs that oversee local planning: Kampala Central Division, Kawempe Division, Makindye Division, Nakawa Division, and Rubaga Division. Surrounding Kampala is the rapidly growing Wakiso District, whose population more than doubled between 2002 and 2014 and now stands at over 2 million (Uganda Bureau of Statistics, 2014).

The IDI clinic is located in Kawempe division (Control & Prevention, 2008; Pirnejad et al., 2008) with more than 50,000 adult patients cumulatively registered by December 2017. The facility gradually converted into a referral facility and therefore patient numbers gradually reduced to about just over 8500 as of December 2016 in active care. Data collected in the clinic database is used for clinical care, internal audits, generation of reports for partners and stakeholders, as well as planning for drug procurement (Kumar & Bauer, 2011). Prior to 2009, the IDI used both paper-based free text and standardized forms completed by health care providers and subsequently entered in an electronic tool by data clerks to populate a patient database(Castelnuovo et al., 2012) . This approach led to high rates of missing and inaccurate data in both steps. That is the providers transcribing the notes correctly and the data entry clerks entering this information into the database(Kiragga, Castelnuovo, Schaefer, Muwonge, & Easterbrook, 2011) . In 2011 to present, the IDI introduced phased solutions leading to a provider-based EMR that was complemented with a structured process of data validation. This system was developed in-house. Both local and international consultants were recruited to build the capacity of the local staff. The consultants worked for a period of 2 years on a full-time basis after which the system was manned by the local staff.

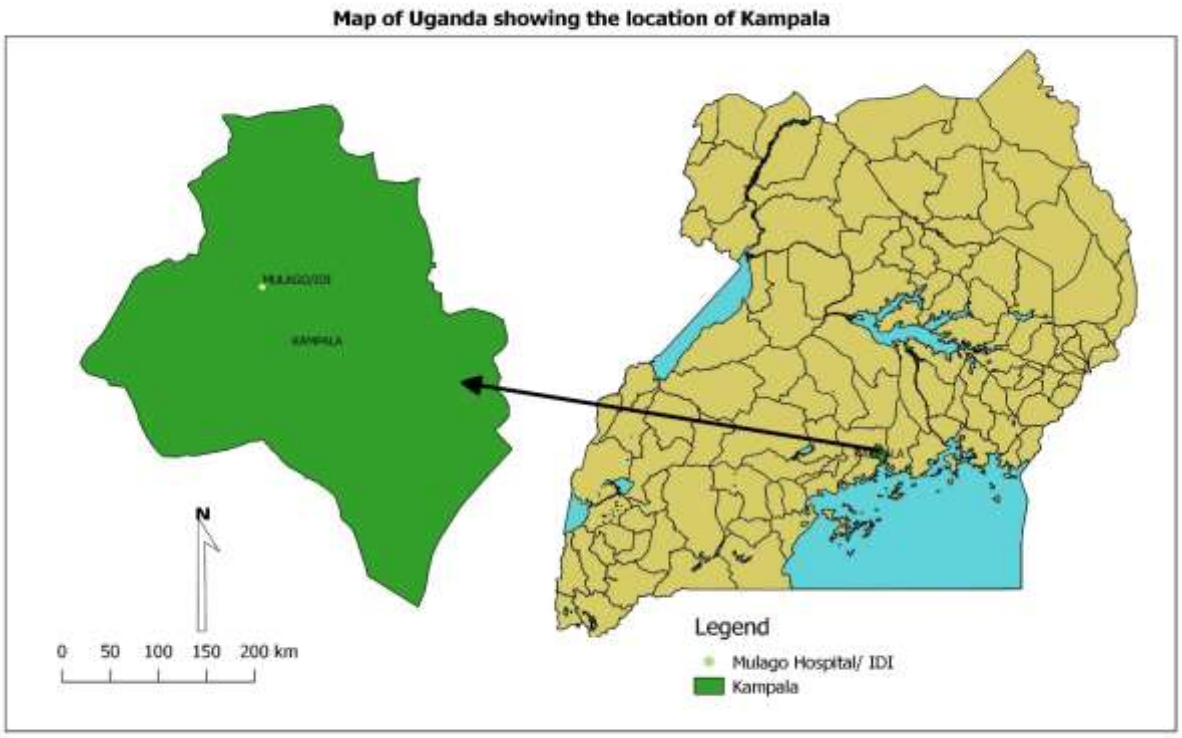


Figure 1: Location of Kampala in Uganda

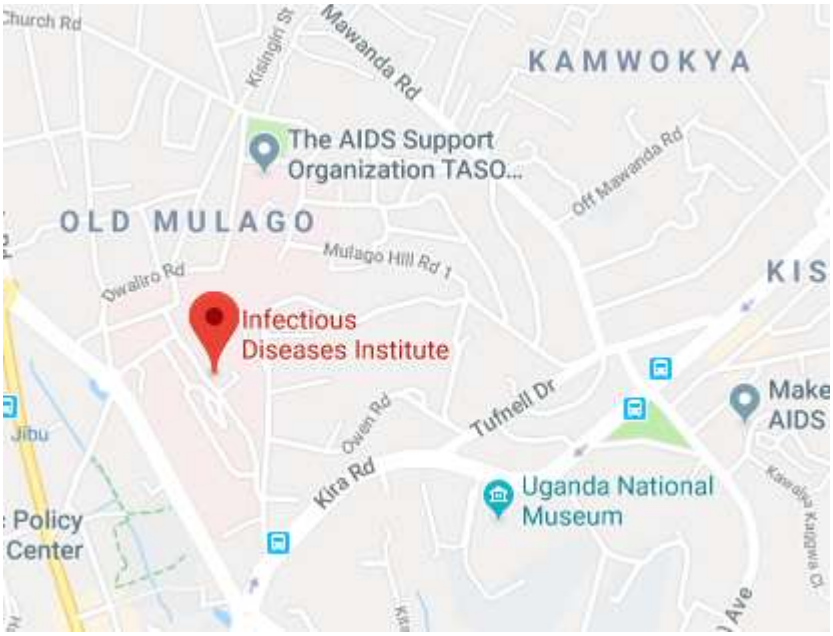


*Figure 2: Map showing the location of IDI within Kampala (*Source: Google Maps)

3.1.2 Study setting.

Prior to implementation of the EMR system, the institution used a paper based medical record system and these records were kept in a records store. In addition, the institution had a Microsoft Access based electronic aggregation system where summaries were entered by data entrants. These records are used for both patient care and also research purposes. The data entrants were tasked to abstract data for research purposes whenever needed in addition to their routine tasks of entering summaries.

3.1.3 Study participants.

Participants included the human resource manager, the head of the clinical department, Information Technology, data and research department personnel.

3.1.4 Study design

This was a retrospective quantitative study. Cost data was retrieved from financial records from the accounts department of the institution. Where original receipts or invoices were not available, prevailing market rates were used. Therefore, the cost collection was largely retrospective but where records were not available then market rates from both local and international vendors were used.

3.1.5 Sampling

The study utilized purposive sampling to identify key personnel that had the required information relevant to the study.

3.1.6 Costs for the paper based medical record system.

To ascertain the costs of running a paper based medical record system over the same time period, all items and consumables for such a system were estimated through interviewing key people at the institution. With one of the core mandates of the Institute being research, the number of publications that have been produced over that same time period were accessed and the research and data department personnel were interviewed to attach costs onto such publications if they were to be coming from data collected using a paper based medical record system.

3.1.7 Study tools

The tool used in this study were cost inventories that was as designed by the researcher prior to going visiting Infectious diseases institute. After visiting the institute, the tools were

refined with input from the stakeholders involved in the design, implementation of the system. These stakeholders included the human resource manager, the head of the clinical department, Information Technology, data and research department personnel.

3.1.8 Data collection.

3.1.8.1 Data collection procedure

Payroll data was collected. To estimate the time each employee spent working on the system. A modified Delphi technique involving key people present right from conceptualization to implementation of the EMR was used to come to a consensus on percentage of time staff spent towards the system in development, deployment and maintenance of the system. This included development of interfaces, work flow design and re-design, among others. Compensation for external consultants for the duration spent working on the EMR was also documented.

Provider time spent on the system was also quantified through the modified Delphi technique. Their percentage time contribution was estimated and then this time percentage was applied onto their monthly salaries to estimate the costs expended by these onto the system. The tasks these were engaged in included training of other providers that had not been fully engaged during the design and implementation of the system. All time estimates were based on interviews with people engaged in the implementation of the system.

Government documents from the ministry of Public Service of Uganda were also reviewed to provide salary and wage rates and employee benefits(Ministry of Public Service Uganda,

2014) as well as job descriptions(Ministry of Public Service Uganda, 2011), depreciation rates used were also obtained from the Uganda Investment Authority(Uganda Investment Authority, 2012).

3.1.8.2 For hardware and Software

The costs of hardware components were retrieved from the financial records at the institution for the amounts spent in acquiring such hardware and these records included receipts and ledger books. Where no such records exist either due to the fact that such hardware was donated or due to the failure to access receipts, the costs of such hardware were got through a market survey where local suppliers from within Kampala city were approached and the costs of such hardware determined. A minimum of 3 vendors was approached and the average cost estimated. If no such item existed on the local market, online vending sites like Amazon and eBay were considered to provide information on the cost of items.

For software, manufacturer sites were visited, and the costs of licenses were verified from the official sites. Where software was required on more than one computer, the volume licensing prices were utilized.

To factor opensource systems into the equation, a simulation model was adopted where, after calculating the costs, the costs of using OpenMRS instead of the inbuilt system were estimated. The human resource rates used were those used at IDI.

3.1.8.3 Human resource

Human resource personnel numbers and associated costs were retrieved from the records in the human resource department within IDI.

3.1.8.4 Cost inventory.

Costs were collected from the accounts and records departments of IDI. First, a thorough cost inventory and activity was developed with reference to already existing categories that have been utilized in other studies(Bassi & Lau, 2013). Costs were cross checked, adjusted to account for inflation and depreciation, and analyzed. A preliminary list of costs was developed and then reviewed with implementers and those that maintain the systems to ensure that the lists capture all the direct costs involved.

3.1.8.5 Costing Methodology.

The detailed items of costs were determined based on differential costing, which is mainly used for decision making in managerial accounting, after comparison of workflows between the paper-chart system and the EMR system.

Cost collection was retrospective and activity based. Activities for pre-implementation, implementation, and maintenance were documented and cost categories developed for each activity. Costs with a lifetime of greater than one year were annuitized.

3.1.8.6 Cost standardization

Majority of the costs were recorded in the Uganda shillings, yet a standard dollar value is required for costing studies for external validity of the findings and therefore, had to be

converted to the equivalent dollar value for the years in which such costs were expended as recommended by Drummond(Drummond et al., 2015). This conversion was conducted using the mid-year rate for each of the individual years using the government of Uganda rates given by the Bank of Uganda(Bank of Uganda, 2017b).

3.1.8.7 Annuitization

The Annuitization formula used is from the book on Methods of Economic Evaluation for Health care programmes (Drummond et al., 2015).

If the capital outlay is K, we need to find the annual sum E which over a period of n years (the life of the facility), at an interest rate of r, will be equivalent to K.

$$K = \frac{E}{(1+r)} + \frac{E}{(1+r)^2} + \cdots + \frac{E}{(1+r)^n}$$

$$K = E\frac{1-(1-r)^{-n}}{r}$$

$$K = E[Annuityfactor, nperiods, interestr]$$

For equipment and buildings that have a resale value at the end of the period a modification of the above formula is employed.[52]

$$S = theresalevalue$$

$$n = theusefullifeoftheequipment$$

$$r = discount(interestrate)$$

$$A(n,r) = theannuityfactor(nyearsatinterestrater)$$

$$K = purchaseprice \vee initialoutlay$$

$$E = equivalentannualcost$$

Then,

$$E = \frac{K - \frac{S}{(1+r)^n}}{A(n,r)}$$

A reducing balance depreciation rate of 40% was used as this is the recommendation by the Uganda government (Ministry of Finance Uganda, n.d). Government rates were used because the institution has no documented depreciation policy as was discovered during data collection. The annuity factor (0.823) and interest rate (4%) used was adopted from the annuity tables and recommendations by Drummond et al., 2015. To quantify nonfinancial costs, payroll data were collected, and time estimates for staff at the implementation site by interviewing the various personnel working within the facilities (including clinic managers). Focus was put on the time spent on activities such as training, implementation support and workflow redesign related to the EHRs implementation. Payroll data was used to assign an average hourly wage by job category for practice members (physicians, other clinical staff, and nonclinical staff) and to estimate the costs of the time spent in training and preparation. This approach is similar to the one used by another cost evaluation study (Fleming et al., 2011). The timeframe for cost analysis included costs related the pre-implementation and initial implementation phases regardless of when these occurred. Ongoing maintenance costs

were estimated for the maintenance period starting with the EHRs launch date and continuing through the first one year of operation.

However, given the unique nature of the institution, that is to say, assets are used until they breakdown without provision for depreciation, the costs are first presented without factoring in depreciation in Table 2 and then annuitized figures presented in Table 3. Where cost records were not available either because the systems were donated, or the records could not be traced, market prices were used. These prices were got from both local vendors and online vendors specifically Amazon. Online vendors were only quoted if the product were not available on the local market.

3.1.8.8 Inclusion criteria

All direct costs incurred in the design and implementation of the EMR were considered for inclusion into the analysis for this study.

3.1.8.9 Exclusion criteria

Those costs incurred but were shared across systems that is to say, costs that were incurred for both the EMR and paper based medical record systems were excluded from the analysis.

3.1.9 Data management, analysis and presentation.

The study looked at costs and savings from the implementer's perspective and only looked at the only direct financial effects without considering value placed on non-financial outcomes. Cost data was analyzed in excel and is presented in tables with totals and percentages. The data was also visualized and presented in graphs that were generated from

Ms. Excel 2013. The dollar rate used was obtained from the official Bank of Uganda website(Bank of Uganda, 2017a) and the midyear rate for each of the years understudy was utilized. Costs were assumed to have accrued at the end of the year.

3.1.10 Sensitivity analysis

To ensure external validity of the findings and applicability to other settings, two scenarios were simulated. These included using OpenMRS within IDI at the same IDI rates and the other involved using public service rates with ICEA within IDI. OpenMRS was used since it is one of the widely used open source medical record systems and many national EMR systems like the Uganda EMR and Kenya EMR are based on it. The public service rates for the financial year 2016/2017 were acquired from Ministry of Public service of Uganda.

3.2 Ethical considerations and quality control.

This study was approved by the Moi University College of medicine Institutional Review and ethics committee. Permission to conduct the study was also sought from the top management of the institution and a data sharing agreement was signed between the investigator and the head of the Research Unit. Within each department permission was sought from the head of department and then each respondent was consented prior to engaging in the study.

Chapter four: THE RESULTS

Chapter fours presents the findings from the study and these are presented under the different subheadings. The costs are broken down into development and maintenance costs. These results are presented in tables and graphs with brief narratives.

Results

The results for the EMR are broken down into hardware, software and human resource costs. All costs reported in this study are direct costs involved in the development, deployment and maintenance of the EMR system and this gave costs to a tune of USD 1,066,965. The largest portion of these between 2009 and 2016 was towards payment of staff salaries making up over 70% of the overall cost. Another heavy contributor to the large cost burden was software licensing which also took up a combined 24% of the total cost (Table 1). Use of a an opensource EMR architecture led to a total cost of USD 806,289 (Table 3) as there was no need to licensing of most of most of the packages used by the system.

The results are first presented without provision for depreciation and annuitization.

Development (2009-2010)

Hardware costs

The hardware here included 3 personal computers for developers (USD 2100), 3 switches (USD 600) and approximately 200 metres of cables (USD 1000), one power backup generator (USD 2500), one 16 core processor, 64 gigabyte random access memory (RAM),

10 terabyte server which was approximated to be 40% used by the EMR (USD 5702.4) and 3 Uninterruptible power supply (UPS) (USD 300). These cost a combined USD 12,402.4.

Software purchase and license

Several licenses were required for this EMR and these included; Kaspersky (USD 458), Visio studio ultimate (USD 15,698), Resharper (USD 1,168), SQL 2005 license (USD 199,992). These cost a combined USD 217,316.

Human resource

The institution recruited several key personnel to design, build and manage the EMR system. These included developers (2 local and 2 international consultants), developers, and data managers among others. The human resource costs also included the wages of health providers including a nurse and doctor who participated in the design and championing of the system. Human resource cost a combined USD 466,745.79.

Utilities

Utilities included electricity and this cost USD 124.8 over the 2 years. These utilities included charges for electricity used to run and maintain the system.

Deployment and maintenance of the EMR

Hardware costs

The hardware included 32 personal computers for point of care (USD 22,400), UPS (USD 3,200), 488 backup tapes (USD 3,672) and one router (USD 3000) and these cost a combined USD 32,272 from January 2011 to December 2016.

Software

The software cost a combined USD 43,359 and this went towards Visio studio 2010 Ultimate (USD 22,794), Resharper (USD 2,334), Windows license (10,239.68) and Kaspersky anti-virus (USD 7,992).

Human resource

The human resource included 2 IT support staff, 2 data managers, 2 developers, and the providers who championed and trained other providers on how to use the EMR and these costs USD 290,587.1.

Utilities

The utilities cost a combined USD 3,652.1. The item considered under utilities was electricity consumption.

Table 1: Costs incurred in the development, implementation and maintenance of the EMR over the study period

Cost	Item	Year								
		2009	2010	2011	2012	2013	2014	2015	2016	Total cost
System development	Salaries and wages	244,258.92	222,486.87	-	-	-	-	-	-	466,745.79
	Software licensing	212,769.00	4,547.00	-	-	-	-	-	-	217,316.00
	Hardware	8,102.40	4,300.00	-	-	-	-	-	-	12,402.40
	Utilities	67.88	56.91	-	-	-	-	-	-	124.79
Deployment and maintenance	Salaries and wages	-	-	65,114.95	57,846.38	45,804.81	43,362.39	39,445.13	39,013.50	290,587.14
	Software licensing	-	-	15,370.68	5,520.00	5,520.00	5,520.00	5,520.00	5,520.00	41,025.68
	Hardware	-	-	29,212.00	612.00	612.00	612.00	612.00	612.00	32,272.00
	Utilities	-	-	573.14	785.36	760.11	711.40	650.36	676.98	4,157.35
Total		**465,198.20**	**231,390.78**	**110,659.76**	**64,763.74**	**52,696.92**	**50,205.79**	**46,227.48**	**45,822.48**	**1,066,965.15**

Costs after annuitization and factoring in depreciation

Table 2: Annuitized costs

	Item	**Year**								
Development		**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total cost**
	Salaries and wages	244,258.92	222,486.87	-	-	-	-	-	-	466,745.79
	Software licensing	212,769.00	4,547.00	-	-	-	-	-	-	217,316.00
Deployment and maintenance	Salaries and wages	-	-	65,114.95	57,846.38	45,804.81	43,362.39	39,445.13	39,013.50	290,587.14
	Software licensing			15,370.68	5,520.00	5,520.00	5,520.00	5,520.00	5,520.00	42,970.68
Utilities (Dev't and maintenance)		67.88	56.91	573.14	785.36	760.11	711.40	650.36	676.98	4,282.14
Hardware (Dev't and maintenance)		1,703.70	2,650.46	9,076.23	9,076.23	9,076.23	9,076.23	9,076.23	9,076.23	62,596.43
Total		458,799.50	229,741.25	90,765.81	73,858.78	61,791.96	59,300.84	55,322.52	54,917.52	1,084,498.18

Estimated costs if ICEA was to be an OpenMRS customization

The estimated cost of running OpenMRS in the same facility was almost 20% lower than that required to develop and maintain the proprietary software.

Table 3: Estimated cost of running an open source EMR system in the same setting.

cost	**Item**	**Year**								
		2,009	**2,010**	**2,011**	**2,012**	**2,013**	**2,014**	**2,015**	**2,016**	**Total**
Development	salaries and wages	244,258.92	222,486.87	-	-	-	-	-	-	466,745.79
	Hardware	8,102.40	4,300.00	-	-	-	-	-	-	12,402.40
Deployment and maintenance	Software licensing	-	-	-	-	-	-	-	-	-
	Salaries	-	-	65,114.95	57,846.38	45,804.81	43,362.39	39,445.13	39,013.50	290,587.14
	Hardware	-	-	29,212.00	612.00	612.00	612.00	612.00	612.00	32,272.00
	Utilities	67.88	56.91	573.14	785.36	760.11	711.40	650.36	676.98	4,282.14
Total		252,429.20	226,843.78	94,900.08	59,243.74	47,176.92	44,685.79	40,707.48	40,302.48	806,289.47

Cost variation over the years

Overall cost:

The overall cost of the inputs showed a downward trend with costs being highest in the earliest years and levelling out in the subsequent years (Figure 3).

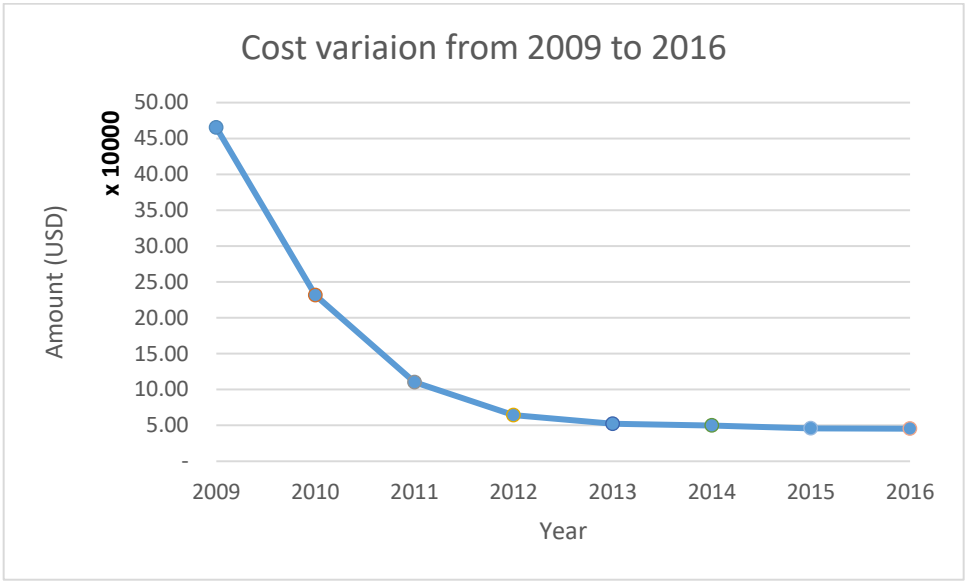


Figure 3: Variation of cost from development to deployment to maintenance

Variation of individual costs

All items had a general downward trend from inception to maintenance of the system (Figure 4).

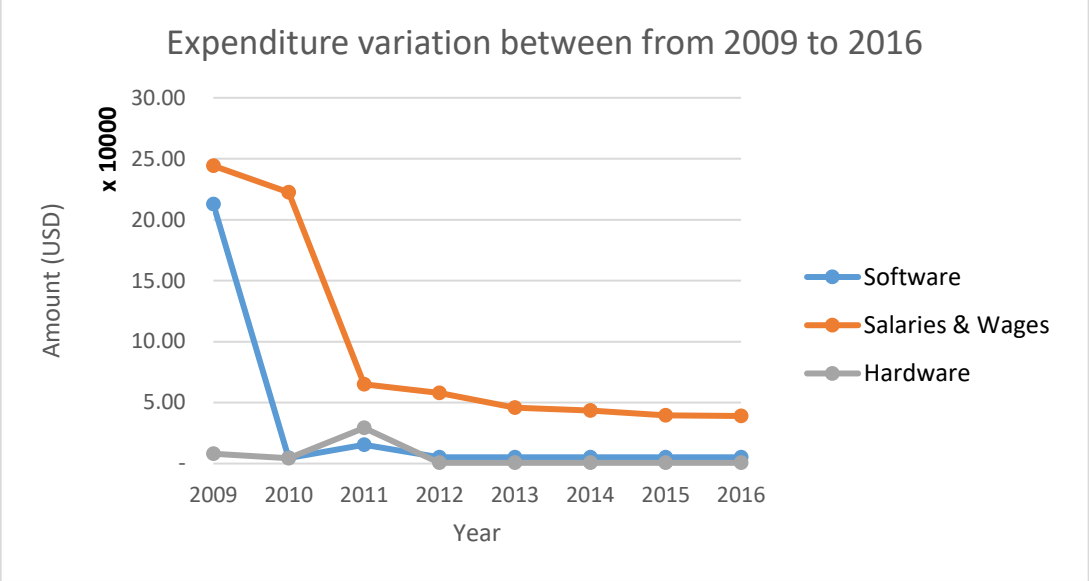


Figure 4: Variation of individual cost items from 2009 to 2016

Costs of running a paper based medical record system between 2009 and 2016.

From the extrapolation, running a sole paper based medical record system together with the MS Access database would cost a total of USD 512297 with over 85% of the costs going towards salaries and wages (Table 4). Research is a core component of the infectious diseases institute and therefore an estimate of how much would have been spent into data abstraction and retrieval was compiled with input from a key people from the research department.

Table 4: Cost of running a paper medical record system over the course of the study period

	2009	2010	2011	2012	2013	2014	2015	2016	Total
Stationery	16137.75	15047.82	12988.82	12383.59	11233.48	9323.83	7057.38	6681.86	90854.54
Personnel ($)	71566.54	62493.79	56738.24	56084.54	57202.76	51430.64	42173.05	41152.99	438842.6
Computers	4200.00	-	-	-	-	-	-	-	4200
Data extraction for research								9300.00	9300
Utilities	135.76	113.83	98.25	134.63	130.30	121.95	111.49	116.05	962.2706
Total	**92,040.04**	**77,655.44**	**69,825.314**	**68,602.766**	**68,566.54855**	**60,876.431**	**49,341.92**	**57,250.91**	**544159.4**

Cost variation for the paper based medical record system

The costs for the paper based medical record system also show a general downward trend over the years although the gradient is less than that shown by the EMR (Figure 5).

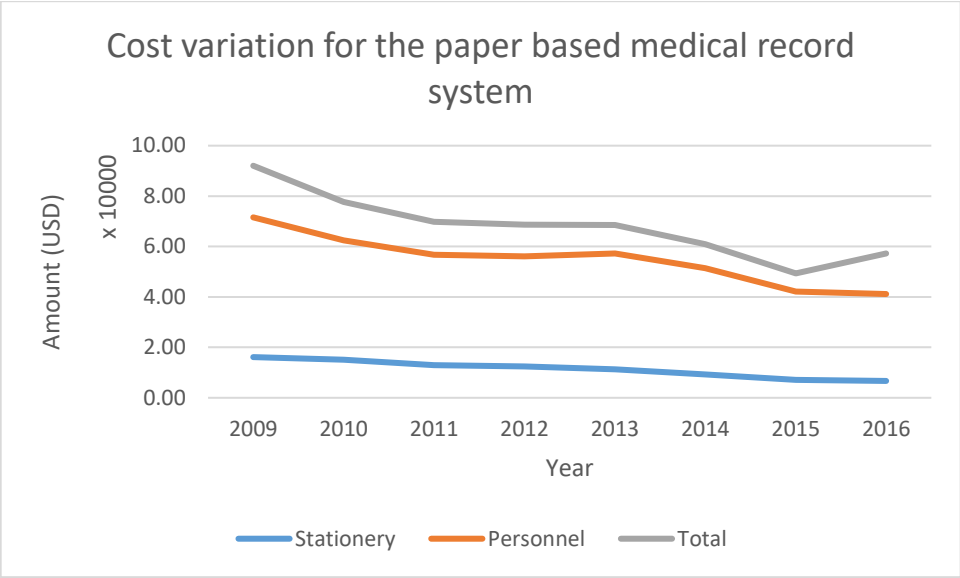


Figure 5: Variation of costs for the paper based medical record system

Chapter five

Chapter fives presents a discussion of the results presented in chapter four and relates them to findings from other studies as well as highlighting the implication of these findings.

Discussion

The direct costs of EMR systems were over one million US dollars from development and deployment to maintenance for a period of 5 years. This cost is relatively low (USD 1,066,965) compared to the costs of somewhat similar systems in the developed world reported by other studies that reported figures more than twice this price (Choi et al., 2013; Tseng et al., 2018). This is attributable to the difference in study settings and the difference in economies where features that might be considered as primary needs might be different between the developed and developing world. One such feature is the personal health record among other features that many developed country EMR systems have (Ranji et al., 2013; Taylor et al., 2002). The costs reported here are however higher than those reported form a study in the United states that reported an average of USD 162,000 for a physician practice(Fleming et al., 2011) and this difference could be attributable to the fact that US study was focused on smaller health care settings. This therefore implies that developing countries have their own unique needs that need to be studied and understood before any EMR system is implemented. There is a need for local evidence for the success of EMR systems in the developing world.

The main drivers of cost were salaries and wages which accounted for over 70% of the direct cost followed by software licensing with over 20%. Contrary to what would be expected, hardware accounted for the smallest portion of the cost burden. These findings are similar to those of a study (Arias-Vimarlund, Ljunggren, & Timpka, 1996) that also reported that human resource costs accounted for the highest portion of the costs. For this institution, the costs could have been driven by the fact that the system was built in-house and the fact that consultants had to be hired to design and develop the system in addition to the local human resource. With an opensource EMR, in this case OpenMRS at the same facility, the human resource costs are still the greatest contributor to the cost burden at over 60% of the total cost. This, therefore, implies that for an EMR system to be set up and maintained, thorough thought needs to be put into the human resource needs of the system. One of the key factors that could be leading to many of the systems not surviving beyond the pilot stage could the fact that implementers might be thinking that with hardware put in place, the other factors will automatically workout, yet this study communicates otherwise.

Another great contributor to the cost burden was on software purchase and licensing taking up a combined 24% of the costs. This is attributable to the fact that this EMR was built using Microsoft packages which are proprietary(Economides & Katsamakas, 2006). This meant that costs had to be incurred for the initial purchase and annual license renewals. This, however, could be minimized if a system deployed is made of open source packages or is completely open source as is the case with OpenMRS or Bahmni an OpenMRS distribution as these have also been shown to be equally as effective. Using an open source EMR would reduce the budget by over 20% and this would lead to tremendous cost savings. The presents

an opportunity for the developing world health facility managers to utilize open source packages while still attaining the benefits of any other proprietary EMR systems. OpenMRS and other open source EMRs have been reported to be equally as effective in many developing country settings with point of care functionality among other functionalities(Economides & Katsamakas, 2006; Genberg et al., 2018; Tweya et al., 2016; Waters et al., 2010).

There is an interesting trend in costs with time. The costs of the system were higher at onset (USD 252,429.20) but there is a general downward trend of these costs with time with the total cost in 2016 being just 16% of the costs incurred at the start (2009). This is attributable to the fact that at onset, both hardware and software must be procured, and the full-time equivalent contribution of the staff was high with staff contributing between 50 to 100% of their time to the EMR and this went on reducing over time to around 20-50% time contribution. This is similar to findings from other studies although most of these were conducted in the developed world (Adler-Milstein et al., 2007; Choi et al., 2013).

In comparison to the cost of running a paper based medical record system, maintaining a paper based medical record system between 2009 and 2016 cost less than 50% of amount required to develop, implement and maintain the electronic medical record system (USD 513259). This is similar to findings from other studies that also reported increments in expenditure due after implementing EMRs(Arias-Vimarlund et al., 1996; Tseng et al., 2018). The added costs are due to need for more specialties to manage the system hence creating new job openings and hence more is spent on salaries and wages. The EMR also came with

need for procurement of new infrastructure (hardware and software), increments in electricity consumption as highlighted under the results section.

However, in a cost minimization analysis, the costs could have been reduced by over 20% (total cost for ICEA – USD 1,066,965 as compared to USD 806,289 for a hypothetical OpenMRS EMR in the same institute using the same rates) if the system had been built using open source packages quoting OpenMRS as a reference. That would imply that the annual licenses and initial purchases would not be incurred, and all capital inputs would have gone into human resource, infrastructure and other recurrent costs. The system had a high initial capital investment given the fact it was built in-house. This is similar to findings from other studies that reported EMR systems costing millions of dollars to set up and maintain (Choi et al., 2013; O'Neill Hayes, 2015; Welch et al., 2007). The relatively higher initial investment is attributable to the fact that the system was built from scratch using Microsoft packages which are proprietary.

Chapter six

Chapter six presents the conclusions from the study as well as recommendations to different stakeholders.

6.1 Conclusion

EMRs have high costs (over one million USD) and these costs reduce over the years with the highest cost driver being human resource that contributes over 70% of the cost burden. Adoption of open source EMRs has the potential to lower costs by over 20% especially towards software licensing and therefore these could be ideal for many low resource settings that have limited resources and competing health priorities.

6.2 Recommendations

Health care institution managers and government

These findings indicate a need for building of local staff capacities in the low resource settings since this institution had to go as far as hiring international consultants to help set up the EMR. This meant higher expenses which wouldn't have been incurred if local competent manpower was available.

With the advancements and improvements in open source packages and programmes, low resource settings should consider taking them up as this would help offset the costs for the annual licenses that many of the proprietary programs and packages require.

There is also a need for better record keeping of all operations and procedures so that information is readily available whenever needed for research and other administrative decisions.

Researchers

There is need for more comprehensive studies focusing on economic analysis of EMRs in resource limited settings especially sub-Saharan Africa given the variation in challenges faced as compared to those in the developed countries. More rigorous methodologies like cost benefit analyses and cost effectiveness analyses need to be conducted to generate more evidence for EMR systems thereby empowering decision makers in low- and middle-income countries.

Developers and health Informaticians

There is a need to explore cheaper solutions that can be adopted by the developing world with a minimal cost burden. One such option is the development and adoption of mobile device supported systems as mobile phone penetration is increasing in these low resource settings which presents a unique opportunity for EMR system.

6.3 Study challenges

The main challenge encountered in this study was lack of proper documentation for the implementation process and the subsequent costs incurred.

6.4 Study limitations

This study was based on the organizational perspective but perhaps a clearer picture would be given if a societal perspective had been adopted.

References

Adler-Milstein, J., Bu, D., Pan, E., Walker, J., Kendrick, D., Hook, J. M., . . . Middleton, B. (2007). The cost of information technology-enabled diabetes management. *Disease Management, 10*(3), 115-128.

Ajami, S., & Arab-Chadegani, R. (2013). Barriers to implement Electronic Health Records (EHRs). *Materia Socio-Medica, 25*(3), 213-215. doi: 10.5455/msm.2013.25.213-215

Akanbi, M. O., Ocheke, A. N., Agaba, P. A., Daniyam, C. A., Agaba, E. I., Okeke, E. N., & Ukoli, C. O. (2012). Use of Electronic Health Records in sub-Saharan Africa: Progress and challenges. *Journal of Medecine in the Tropics, 14*(1), 1-6.

Arias-Vimarlund, V., Ljunggren, M., & Timpka, T. (1996). *Implementation of computer-based patient records in primary care: the societal health economic effects.* Paper presented at the Proceedings of the AMIA Annual Fall Symposium. Washington,DC.: AMIA Annual Fall Symposium.

Bank of Uganda. (2017, June 18). *Exchange Rates*.Kampala: Bank of Uganda. Retrieved from https://www.bou.or.ug/bou/collateral/exchange_rates.html

Bartlett, D. L., Molinari, N.-A. M., Ortega-Sanchez, I. R., & Urquhart, G. A. (2006). Economics of immunization information systems in the United States: assessing costs and efficiency. *Cost Eff Resour Alloc, 4*(1), 15.

Bassi, J., & Lau, F. (2013). Measuring value for money: a scoping review on economic evaluation of health information systems. *Journal of American Medical Informatics Association, 20*(4), 792-801. doi: 10.1136/amiajnl-2012-001422

Bates, D. W., & Bitton, A. (2010). The future of health information technology in the patient-centered medical home. *Health Affairs, 29*(4), 614-621.

Bell, B., & Thornton, K. (2011). From promise to reality: achieving the value of an EHR: realizing the benefits of an EHR requires specific steps to establish goals, involve physicians and other key stakeholders, improve processes, and manage organizational change. *Healthcare Financial Management, 65*(2), 51-57.

Blumenthal, D. (2009). Stimulating the adoption of health information technology. *New England journal of medicine, 360*(15), 1477-1479.

Byford, S., & Raftery, J. (1998). Perspectives in economic evaluation. *BMJ (Clinical research ed.), 316*(7143), 1529-1530. doi: 10.1136/bmj.316.7143.1529

Byrne, C. M., Mercincavage, L. M., Pan, E. C., Vincent, A. G., Johnston, D. S., & Middleton, B. (2010). The value from investments in health information technology at the US Department of Veterans Affairs. *Health Affairs, 29*(4), 629-638.

Castelnuovo, B., Kiragga, A., Afayo, V., Ncube, M., Orama, R., Magero, S., . . . Kambugu, A. (2012). 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, 7*(12), e51631.

Choi, J. S., Lee, W. B., & Rhee, P.-L. (2013). Cost-Benefit Analysis of Electronic Medical Record System at a Tertiary Care Hospital. *Healthcare Informatics Research, 19*(3), 205-214. doi: 10.4258/hir.2013.19.3.205

Christensen, T., & Grimsmo, A. (2008). Instant availability of patient records, but diminished availability of patient information: a multi-method study of GP's use of electronic patient records. *BMC medical informatics and decision making, 8*(1), 12.

Control, C. f. D., & Prevention. (2008). Effect of electronic laboratory reporting on the burden of lyme disease surveillance--New Jersey, 2001-2006. *MMWR. Morbidity and mortality weekly report, 57*(2), 42.

DesRoches, C. M., Campbell, E. G., Rao, S. R., Donelan, K., Ferris, T. G., Jha, A., . . . Shields, A. E. (2008). Electronic health records in ambulatory care—a national survey of physicians. *New England journal of medicine, 359*(1), 50-60.

Drummond, M. F., Sculpher, M. J., Claxton, K., Stoddart, G. L., & Torrance, G. W. (2015). *Methods for the economic evaluation of health care programmes*. Oxford: Oxford university press.

Economides, N., & Katsamakas, E. (2006). Two-sided competition of proprietary vs. open source technology platforms and the implications for the software industry. *Management Science, 52*(7), 1057-1071.

Eysenbach, G., & Jadad, A. R. (2001). Evidence-based Patient Choice and Consumer health informatics in the Internet age. *Journal of Medical Internet Research, 3*(2). doi: 10.2196/jmir.3.2.e19

Fleming, N. S., Culler, S. D., McCorkle, R., Becker, E. R., & Ballard, D. J. (2011). The financial and nonfinancial costs of implementing electronic health records in primary care practices. *Health Affairs, 30*(3), 481-489.

Fraser, H. S., Biondich, P., Moodley, D., Choi, S., Mamlin, B. W., & Szolovits, P. (2005). Implementing electronic medical record systems in developing countries. *Informatics in primary care, 13*(2), 83-96.

Gans, D., Kralewski, J., Hammons, T., & Dowd, B. (2005). Medical groups' adoption of electronic health records and information systems. *Health Affairs, 24*(5), 1323-1333.

Genberg, B. L., Lee, H., Hogan, J. W., Some, F., Wachira, J., Wu, X. K., & Braitstein, P. (2018). Point of Diagnosis and Patient Retention in HIV Care in Western Kenya. *JAIDS Journal of Acquired Immune Deficiency Syndromes, 78*(4), 383-389.

Girosi, F., Meili, R. C., & Scoville, R. (2005). *Extrapolating evidence of health information technology savings and costs*. Kampala: Rand Corporation.

Government of Uganda. (2015). *Health Sector Development Plan 2015/16 - 2019/20*. Kampala: Ministry of Health Uganda. Retrieved from https://www.health.go.ug/sites/default/files/Health%20Sector%20Development%20Plan%202015-16_2019-20.pdf.

Hassibian, M. R. (2013). Electronic Health Records Acceptance and Implementation in Developing Countries: Challenges and Barriers. *Razavi International Journal of Medicine, 1*(1), 11-16.

Hillestad, R., Bigelow, J., Bower, A., Girosi, F., Meili, R., Scoville, R., & Taylor, R. (2005). Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Affairs, 24*(5), 1103-1117.

Himmelstein, D. U., Wright, A., & Woolhandler, S. (2010). Hospital computing and the costs and quality of care: a national study. *The American journal of medicine, 123*(1), 40-46.

Hsu, J., Huang, J., Fung, V., Robertson, N., Jimison, H., & Frankel, R. (2005). Health information technology and physician-patient interactions: impact of computers on communication during outpatient primary care visits. *Journal of the American Medical Informatics Association, 12*(4), 474-480.

Jamoom, E. W., Patel, V., Furukawa, M. F., & King, J. (2014, March). *EHR adopters vs. non-adopters: Impacts of, barriers to, and federal initiatives for EHR adoption. In Healthcare* (Vol. 2, No. 1, pp. 33-39). Netherlands, Elsevier.

Jang, Y., Lortie, M. A., & Sanche, S. (2014). Return on Investment in Electronic Health Records in Primary Care Practices: A Mixed-Methods Study. *JMIR Medical Informatics, 2*(2), e25. doi: 10.2196/medinform.3631

Jarvis, B., Johnson, T., Butler, P., O'Shaughnessy, K., Fullam, F., Tran, L., & Gupta, R. (2013). Assessing the impact of electronic health records as an enabler of hospital quality and patient satisfaction. *Academic Medicine, 88*(10), 1471-1477.

Jones, S. S., Rudin, R. S., Perry, T., & Shekelle, P. G. (2014). Health information technology: an updated systematic review with a focus on meaningful use. *Annals of internal medicine, 160*(1), 48-54.

Kaushal, R., Jha, A. K., Franz, C., Glaser, J., Shetty, K. D., Jaggi, T., . . . Bates, D. W. (2006). Return on Investment for a Computerized Physician Order Entry System. *Journal of American Medical Informatics Association, 13*(3), 261-266. doi: 10.1197/jamia.M1984

Kim, E.-H., Stolyar, A., Lober, W. B., Herbaugh, A. L., Shinstrom, S. E., Zierler, B. K., . . . Kim, Y. (2009). Challenges to Using an Electronic Personal Health Record by a Low-Income Elderly Population. *Journal of Medical Internet Research, 11*(4), e44. doi: 10.2196/jmir.1256

Kiragga, A. N., Castelnuovo, B., Schaefer, P., Muwonge, T., & Easterbrook, P. J. (2011). Quality of data collection in a large HIV observational clinic database in sub-Saharan Africa: implications for clinical research and audit of care. *Journal of the International AIDS Society, 14*(1), 1.

Kumar, S., & Bauer, K. (2011). The business case for implementing electronic health records in primary care settings in the United States. *Journal of Revenue & Pricing Management, 10*(2), 119-131.

Levingston, S. (2012). *Opportunities in physician electronic health records: A road map for vendors*. Washington, D.C.: Bloomberg Government.

Liang, L., Wiens, M. O., Lubega, P., Spillman, I., & Mugisha, S. (2018). A Locally Developed Electronic Health Platform in Uganda: Development and Implementation of Streamline. *JMIR formative research, 2*(2), e20.

Mamlin, B. W., Biondich, P. G., Wolfe, B. A., Fraser, H., Jazayeri, D., Allen, C., . . . Tierney, W. M. (2006). Cooking Up An Open Source EMR For Developing

Countries: OpenMRS – A Recipe For Successful Collaboration. *AMIA Annual Symposium Proceedings, 2006*, 529-533.

Menachemi, N., & Collum, T. H. (2011). Benefits and drawbacks of electronic health record systems. *Risk Management and Healthcare Policy, 4*, 47-55. doi: 10.2147/RMHP.S12985

Miller, R. H., & Sim, I. (2004). Physicians' use of electronic medical records: barriers and solutions. *Health Affairs, 23*(2), 116-126.

Ministry of Finance Uganda. (2005). *Inventory of Tax Incentives in Uganda*. Kampala: Ministry of Finance Uganda. Retrieved from http://www.ugandainvest.go.ug/wp-content/uploads/2016/03/Inventory-of-Tax-Incentives-in-Uganda.pdf.

Ministry of Health Uganda. (2016). *Uganda National eHealth Policy*. Kampala: Ministry of Health Uganda. Retrieved from http://health.go.ug/sites/default/files/National%20eHealth%20Policy%202016_1.pdf.

Ministry of Public Service Uganda. (2018, July 21). *Job Descriptions and Specifications*. Kampala: Ministry of Public Service Uganda.Retrieved from https://publicservice.go.ug/resource-center/?wpdmc=job-descriptions.

Ministry of Public Service Uganda. (2018, October 3). *Salary Structures*. Kampala: Ministry of Public Service Uganda.Retrieved from https://publicservice.go.ug/resource-center/?wpdmc=salary-structures.

Mwotasubi Isaac, Ocaya Stephen, Charity Kyomugasho, Evelyn Akello, & Bazeyo., W. (2016). *Rollout Of Patients Electronic Management Records System In Uganda*

(UgandaEMR). Makerere University: Makerere University School of Public Health (METS project). Retrieved from https://drive.google.com/file/d/0B4jwP0ShI6fCT2VEVWlPT042YjRkOXBrNXU5WUtxel8yaHNv/view

Ndira, S., Rosenberger, K., & Wetter, T. (2008). Assessment of data quality of and staff satisfaction with an electronic health record system in a developing country (Uganda). *Methods of information in medicine*, *47*(06), 489-498.

O'Neill Hayes, T. (2015). *Are Electronic Medical Records Worth The Costs Of Implementation?* Paper presented at the American Action Forum. Washington. Elsevier

Odekunle, F. F., Odekunle, R. O., & Shankar, S. (2017). Why sub-Saharan Africa lags in electronic health record adoption and possible strategies to increase its adoption in this region. *International journal of health sciences*, *11*(4), 59-64.

Ojo, A. I., & Popoola, S. O. (2015). Some correlates of electronic health information management system success in nigerian teaching hospitals. *Biomedical informatics insights*, *7*, 1-9. doi: 10.4137/BII.S20229

Pirnejad, H., Niazkhani, Z., van der Sijs, H., Berg, M., & Bal, R. (2008). Impact of a computerized physician order entry system on nurse–physician collaboration in the medication process. *International journal of medical informatics*, *77*(11), 735-744.

Poley, M. J., Edelenbos, K. I., Mosseveld, M., van Wijk, M. A., de Bakker, D. H., van der Lei, J., & Rutten-van Mölken, M. P. (2007). Cost consequences of implementing an electronic decision support system for ordering laboratory tests in primary care:

evidence from a controlled prospective study in the Netherlands. *Clinical chemistry, 53*(2), 213-219.

Poon, E. G., Jha, A. K., Christino, M., Honour, M. M., Fernandopulle, R., Middleton, B., . . . Blumenthal, D. (2006). Assessing the level of healthcare information technology adoption in the United States: a snapshot. *BMC medical informatics and decision making, 6*(1), 1.

Ranji, S. R., Rennke, S., & Wachter, R. M. (2013). Computerized Provider Order Entry With Clinical Decision Support Systems: Brief Update Review. California: University of California, San Francisco. https://pdfs.semanticscholar.org/3e1b/875907bfc949bf22b017315abfc455430905.pdf

Schmitt, K. F., & Wofford, D. A. (2002). Financial analysis projects clear returns from Electronic Medical Records: Demonstrating the economic benefits of an electronic medical record is possible with the input of staff who can identify the technology's benefits. *Healthcare Financial Management, 56*(1), 52-58.

Schoen, C., Osborn, R., Huynh, P. T., Doty, M., Peugh, J., & Zapert, K. (2006). On the front lines of care: primary care doctors' office systems, experiences, and views in seven countries. *Health Affairs, 25*(6), w555-w571.

Seebregts, C. J., Mamlin, B. W., Biondich, P. G., Fraser, H. S., Wolfe, B. A., Jazayeri, D, Musinguzi, N. (2009). The OpenMRS implementers network. *International journal of medical informatics, 78*(11), 711-720.

Sequist, T. D., Cullen, T., Hays, H., Taualii, M. M., Simon, S. R., & Bates, D. W. (2007). Implementation and use of an electronic health record within the Indian Health Service. *Journal of the American Medical Informatics Association, 14*(2), 191-197.

Simon, S. R., McCarthy, M. L., Kaushal, R., Jenter, C. A., Volk, L. A., Poon, E. G., . . . Bates, D. W. (2008). Electronic health records: which practices have them, and how are clinicians using them? *Journal of evaluation in clinical practice, 14*(1), 43-47.

Sood, S. P., Nwabueze, S. N., Mbarika, V. W., Prakash, N., Chatterjee, S., Ray, P., & Mishra, S. (2008). *Electronic medical records: a review comparing the challenges in developed and developing countries.* Paper presented at the Hawaii International Conference on System Sciences. Hawaii: Hawaii International Conference on System Sciences Proceedings of the 41st Annual.

Stausberg, J., Koch, D., Ingenerf, J., & Betzler, M. (2003). Comparing paper-based with electronic patient records: lessons learned during a study on diagnosis and procedure codes. *Journal of the American Medical Informatics Association, 10*(5), 470-477.

Tang, P. C., Ash, J. S., Bates, D. W., Overhage, J. M., & Sands, D. Z. (2006). Personal health records: definitions, benefits, and strategies for overcoming barriers to adoption. *Journal of the American Medical Informatics Association, 13*(2), 121-126.

Taylor, R., Manzo, J., & Sinnett, M. (2002). Quantifying value for physician order-entry systems: a balance of cost and quality. *Healthc Financ Manage, 56*(7), 44-48.

Thompson, A., Castle, E., Lubeck, P., & Makarfi, P. S. (2010). Experience implementing OpenMRS to support maternal and reproductive health in Northern Nigeria. *Studies in health technology and informatics, 160*(Pt 1), 332-336.

Tierney, W. M., Achieng, M., Baker, E., Bell, A., Biondich, P., Braitstein, P., . . . McKown, B. (2010). Experience implementing electronic health records in three East African countries. *Stud Health Technol Inform, 160*(Pt 1), 371-375.

Tierney, W. M., Rotich, J. K., Hannan, T. J., Siika, A. M., Biondich, P. G., Mamlin, B. W., . . . Sidle, J. E. (2007). The AMPATH medical record system: creating, implementing, and sustaining an electronic medical record system to support HIV/AIDS care in western Kenya. *Studies in health technology and informatics, 129*(1), 372.

Tseng, P., Kaplan, R. S., Richman, B. D., Shah, M. A., & Schulman, K. A. (2018). Administrative costs associated with physician billing and insurance-related activities at an academic health care system. *JAMA, 319*(7), 691-697.

Tweya, H., Feldacker, C., Gadabu, O. J., Ng'ambi, W., Mumba, S. L., Phiri, D., . . . Keiser, O. (2016). Developing a point-of-care electronic medical record system for TB/HIV co-infected patients: experiences from Lighthouse Trust, Lilongwe, Malawi. *BMC research notes, 9*(1), 146.

Uganda Bureau of Statistics. (2014). *National population and housing census 2014*. Kampala: Uganda Bureau of Statistics Kampala (Uganda). Retrieved from https://www.ubos.org/wp-content/uploads/publications/03_20182014_National_Census_Main_Report.pdf

Uganda Investment Authority. (2012). *Inventory of Tax Incentives in Uganda*. Kampala: Uganda Investment Authority (UIA). Retrieved from https://www.ugandainvest.go.ug/wp-content/uploads/2016/03/Inventory-of-Tax-Incentives-in-Uganda.pdf.

UgandaEMR. (2019, December 16). Uganda EMR (Patient Medical Record System). Kampala: UgandaEMR. Retrieved from http://emrportal.mets.or.ug/

Wang, S. J., Middleton, B., Prosser, L. A., Bardon, C. G., Spurr, C. D., Carchidi, P. J., . . . Sussman, A. J. (2003). A cost-benefit analysis of electronic medical records in primary care. *The American journal of medicine, 114*(5), 397-403.

Waters, E., Rafter, J., Douglas, G. P., Bwanali, M., Jazayeri, D., & Fraser, H. (2010). Experience implementing a point-of-care electronic medical record system for primary care in Malawi. *Stud Health Technol Inform, 160*(Pt 1), 96-100.

Welch, W. P., Bazarko, D., Ritten, K., Burgess, Y., Harmon, R., & Sandy, L. G. (2007). Electronic health records in four community physician practices: impact on quality and cost of care. *Journal of the American Medical Informatics Association, 14*(3), 320-328.

Were, M., Sutherland, J., Bwana, M., Ssali, J., Emenyonu, N., & Tierney, W. (2008). Patterns of care in two HIV continuity clinics in Uganda, Africa: a time-motion study. *AIDS care, 20*(6), 677-682.

Were, M. C., Emenyonu, N., Achieng, M., Shen, C., Ssali, J., Masaba, J. P. M., & Tierney, W. M. (2010). Evaluating a scalable model for implementing electronic health

records in resource-limited settings. *Journal of American Medical Informatics Association, 17*(3), 237-244. doi: 10.1136/jamia.2009.002303

Were, M. C., Shen, C., Bwana, M., Emenyonu, N., Musinguzi, N., Nkuyahaga, F., . . . Tierney, W. M. (2010). Creation and evaluation of EMR-based paper clinical summaries to support HIV-care in Uganda, Africa. *International journal of medical informatics, 79*(2), 90-96.

Williams, F., & Boren, S. A. (2008). The role of the electronic medical record (EMR) in care delivery development in developing countries: a systematic review. *Informatics in primary care, 16*(2), 139-145.

Wolfstadt, J. I., Gurwitz, J. H., Field, T. S., Lee, M., Kalkar, S., Wu, W., & Rochon, P. A. (2008). The effect of computerized physician order entry with clinical decision support on the rates of adverse drug events: a systematic review. *Journal of general internal medicine, 23*(4), 451-458.

Wu, R. C., Laporte, A., & Ungar, W. J. (2007). Cost-effectiveness of an electronic medication ordering and administration system in reducing adverse drug events. *Journal of Evaluation in Clinical Practice, 13*(3), 440-448. doi: 10.1111/j.1365-2753.2006.00738.x

Appendices

Appendix one: Consent form.

COST ANALYSIS OF AN ELECTRONIC MEDICAL RECORD SYSTEM AT AN URBAN CLINIC IN KAMPALA, UGANDA - AN ORGANIZATIONAL PERSPECTIVE Introduction.

Good morning/ afternoon Sir/madam. My name is _____ from Moi University. We are conducting a study to assess the costs and benefits of the provider-based system used currently at the Infectious Diseases Institute.

Purpose.

This study aims at assessing the costs required to implement the ICEA electronic medical record system and the benefits achieved with the use of this system. The information generated from this study will be used to guide stakeholders and IDI itself in smoothening of this system and with future implementations.

Procedure.

This study will employ several procedures that include interview of key informants and review of financial records. Key informants will be asked questions about the ICEA systems and the benefits that have been realized. The conversation will be recorded to capture all details, but the recording will be handled with high confidentiality by the principal investigator.

Benefits.

Your participation in this study will not earn you direct benefits but the finds will be helpful in guiding future decisions on implementation and expansion of electronic medical record systems in Uganda and beyond.

Risks.

This study poses no known risks to you.

Confidentiality.

All the information you provide will be kept strictly confidential. Consent forms will be kept separately from the other study materials, so it won't be possible to associate any form to a questionnaire. The tools will be securely stored under lock and key with the principal investigator.

Voluntary participation.

Your participation in this study is entirely voluntary. If you choose to participate in the study, you are also free to withdraw from it at any time should you wish not to continue.

Questions.

You are free to ask any questions before the interview starts or during the interview.

Contacts.

In case you have any questions concerning the study later you can contact the Principal Investigator, **Mr. Bonny Enock Balugaba** of Institute of Biomedical Informatics Moi University, on +256 784313161**.**

In case you have any questions about your rights as a participant in this study you can contact the Institutional Research and Ethics committee (IREC) Moi University P.O. Box. 3-30100 Eldoret, Kenya, Email: irec@mtrh.or.ke, Telephone: 0787723677

Statement of consent.

I have read or been informed about this research and had the opportunity to ask questions and my questions have been answered to my satisfaction. I hereby voluntarily consent to participate in the study and understand that I have the right to withdraw at any point.

Name of participant:

Signature/_____

Date: _____

Name of interviewer: _____

Signature: _____

Appendix two: Study tools

Tool 1. Cost of infrastructure and utilities

Infrastructure & Utilities			**Cost per unit: Provide the monetary cost per unit in USD**				
Where applicable, estimate the percent of time the infrastructure or utilities is used for EHR							Add any additional information for further clarification
Date (mm/dd/yy) (overwrite as appropriate)		**Basic Descriptive Information**					**Comments**
		Item Description	**No. Units**	**Unit Cost (in USD)**	**Percent for EHR**	**Costs (USD)**	
Start	End (if needed)		A	B	C	A x B x C	
		Hardware and peripherals				**$-**	
		Network and Telecommunication supplies				**$-**	
		Configuration management (interface, system) – e.g. setting up new users, forms etc.				**$-**	
		Software					
		Software license					

		Software upgrade				$-	
		Initial IT support costs				$-	
		Cost of converting retrospective data				$-	
		Facility upgrades - site renovation costs (e.g. grilles to secure the rooms, cost of furniture)				$-	
		Power back-up (generator)				$-	
		Furniture and related items				$-	
		Transition costs (costs of running 2 parallel systems in cases where there was a different EHR already in use)				$-	
		Software maintenance and upgrades (data refresh, software upgrade, software fees, interfaces, and other upgrades)				$-	
		Maintenance (system and power back-up maintenance)				$-	
		Utilities (water & electricity bills)					
		Facilities rental				$-	
		Hardware and equipment (hardware replacement, equipment replacement				$-	
		Office supplies (paper and toner etc..)				$-	
		Other cost not listed above				$-	

Tool 2. Costs incurred on personnel

Personnel			**Cost per unit: Provide the monetary cost per unit in USD**				
Where applicable, estimate the percent of time the personnel worked on EMR							Add any additional information for further clarification
		Basic Descriptive Information					
Date (mm/dd/yy) (overwrite as appropriate)		**Position Description**	**Number in Position**	**Monthly Loaded Salary (in USD)**	**Percent of time**	**Annual Cost**	**Comments**
Start	End ('SW' if still working)	Enter position description. For volunteers, list weekly hours per volunteer.	A	B	C	A x B x C	
		IT staff - technical				**$-**	
		IT staff - administrative				**$-**	
		IT staff - clinical				**$-**	

		EHRs Consultant				**$-**	
		Other personnel consultants				**$-**	
		Reviews and audits personnel				**$-**	
		Project manager				**$-**	
		Programmer (application development and deployment)				**$-**	
		Initial user training*				**$-**	*accounting for number of sessions, per diems, training material, accommodation, venue, training personnel costs
		Site assessments (transport, per diem allowances)				**$-**	
		Project planning				**$-**	
		Quality assurance and post implementation review				**$-**	
		Other initial personnel (non-specified recurrent) costs				**$-**	

List of cost categories per activity

Activity	Cost category	Data source	Description
Program Management	Personnel	Standard market rates	Project planning and oversight, contract negotiation, and procurement
	Travel costs		
Curriculum development	Consultant fees	standard market rates	Development of curriculum and materials for trainings
	Development of manuals		
	Printing		
	Stakeholders' meetings		
	Facilitators' Allowances		
	Training materials		
Development	Requirements gathering	Payroll data Receipts/accounting systems	Application development of the electronic medical record
	Office supplies (pens, paper, toner)		
	Telephone and internet / telecommunication		
	Transport and Freight		
	Office supplies (pens, paper, toner)		
	Software (including license and upgrade)		
	Salaries		
Deployment	User training	Payroll data Receipts/accounting systems	Installation of hardware and software, on-site support for implementation and migration of patient data, setting up new users, supervision, and data quality assistance,
	Equipment (computing hardware and furniture		
	Salaries		
Maintenance	Professional and conference fees	Payroll data	

	Software (including license and upgrade)	Receipts/accounting systems	Post implementation review, ongoing training and support, security personnel, ongoing hardware and software support
	Computers and other hardware		
	Internet		
	Salaries and allowance		

Appendix 3: Annuity table used

Annex 7.2 Discount tables

This annex contains discount tables for the present value of $1 (Table A7.2.1) and the present value of annuity of $1 in arrears (Table A7.2.2).

Table A7.2.1 Present value of $1

N	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091	0.9009	0.8929	0.8850	0.8772	0.8696
2	0.9803	0.9612	0.9426	0.9246	0.9070	0.8900	0.8734	0.8573	0.8417	0.8264	0.8116	0.7972	0.7831	0.7695	0.7561
3	0.9706	0.9423	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938	0.7722	0.7513	0.7312	0.7118	0.6931	0.6750	0.6575
4	0.9610	0.9238	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350	0.7084	0.6830	0.6587	0.6355	0.6133	0.5921	0.5718
5	0.9515	0.9057	0.8626	0.8219	0.7835	0.7473	0.7130	0.6806	0.6499	0.6209	0.5935	0.5674	0.5428	0.5194	0.4972
6	0.9420	0.8880	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302	0.5963	0.5645	0.5346	0.5066	0.4803	0.4556	0.4323
7	0.9327	0.8706	0.8131	0.7599	0.7107	0.6651	0.6227	0.5835	0.5470	0.5132	0.4817	0.4523	0.4251	0.3996	0.3759
8	0.9235	0.8535	0.7894	0.7307	0.6768	0.6274	0.5820	0.5403	0.5019	0.4665	0.4339	0.4039	0.3762	0.3506	0.3269
9	0.9143	0.8368	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002	0.4604	0.4241	0.3909	0.3606	0.3329	0.3075	0.2843
10	0.9053	0.8203	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632	0.4224	0.3855	0.3522	0.3220	0.2946	0.2697	0.2472
11	0.8963	0.8043	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289	0.3875	0.3505	0.3173	0.2875	0.2607	0.2366	0.2149
12	0.8874	0.7885	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971	0.3555	0.3186	0.2858	0.2567	0.2307	0.2076	0.1869
13	0.8787	0.7730	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677	0.3262	0.2897	0.2575	0.2292	0.2042	0.1821	0.1625
14	0.8700	0.7579	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405	0.2992	0.2633	0.2320	0.2046	0.1807	0.1597	0.1413
15	0.8613	0.7430	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152	0.2745	0.2394	0.2090	0.1827	0.1599	0.1401	0.1229
16	0.8528	0.7284	0.6232	0.5339	0.4581	0.3936	0.3387	0.2919	0.2519	0.2176	0.1883	0.1631	0.1415	0.1229	0.1069
17	0.8444	0.7142	0.6050	0.5134	0.4363	0.3714	0.3166	0.2703	0.2311	0.1978	0.1696	0.1456	0.1252	0.1078	0.0929

Source: Methods for the Economic Evaluation of health care programmes. Forth ed(Drummond et al., 2015).

Appendix 4: Dollar rates used for the cost conversion

Back to the Table of Contents

Foreign Exchange Rates

(Uganda Shillings per US $)

Year/Month	Bureau Weighted Average		Bureau Mid Rate	**Official Mid-Rate (Average)**	**Nominal Effective Exchange Rate**	**NEER INDEX (2010 = 100)**	**End of period**
	Buying Rate	Selling Rate					
2009	2,022.20	2,030.96	2,026.58	**2,030.49**	85.60	92.82	**1,899.71**
2010	2,170.24	2,179.44	2,174.80	**2,177.56**	92.22	100.00	**2,308.30**
2011	2,509.01	2,522.73	2,515.87	**2,522.75**	105.39	114.29	**2,490.99**
2012	2,493.89	2,504.29	2,499.09	**2,503.31**	100.65	109.14	**2,685.95**
2013	2,578.46	2,586.96	2,582.71	**2,586.46**	99.45	107.84	**2,527.96**
2014	2,590.19	2,599.30	2,594.75	**2,600.33**	96.71	104.87	**2,773.07**
2015	3,226.48	3,241.72	3,234.10	**3,245.54**	111.44	120.84	**3,377.01**
2016	3,406.55	3,421.89	3,414.22	**3,420.45**	113.34	122.90	**3,610.50**

Source: Bank of Uganda official website