Journal of Health Informatics in Africa

12th Health Informatics in Africa Conference (HELINA 2019)
Peer-reviewed and selected under the responsibility of the Scientific Programme Committee

Cost Analysis of an Electronic Medical Record System at an Urban Clinic in Kampala, Uganda

Bonny E Balugaba,[a,b*] Simon K Ruttoh,[a] Elizabeth K Ekirapa,[b] Abraham A Siika,[a] Martin C Were.[a,c]

[a] College of Health Sciences, Moi University, Eldoret 4606-30100, Kenya
[b] School of Public Health, Makerere University, Kampala, Uganda
[c] Vanderbilt University Medical Center, Nashville, USA

Background and Purpose: While the benefits of electronic medical record systems (EMRS) are well known, the costs associated with their implementation in resource-constrained settings are not well documented. Establishing such costs is crucial for sound decision-making regarding allocation of scarce resources. This study aimed at conducting a comprehensive cost analysis for developing, implementing and maintaining an EMRS in a resource-constrained setting.
Methods: The study was conducted at an urban HIV/AIDS clinic in Kampala, Uganda using an organizational perspective. A cost inventory was used to collect costs from original receipts and invoices, and vendor market prices used where receipts could not be accessed for the 8 years under study. All costs were converted to the equivalent US dollar value and those with a lifetime more than one year annuitized. A paper-based and an open-source record system were the comparators.
Results: The total direct cost of the system was USD 1,066,965 while an open-source instance would cost just over USD 800,000. The paper-based system cost was half the cost of the EMRS (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. The other major cost driver was software and licensing (20%, USD 258,341).
Conclusions: 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. Open-source systems have a potential to lower costs.

Keywords: Cost Analysis, Electronic Medical Record System, Developing Country

1 Introduction

Electronic Medical Record Systems (EMRs) are increasingly being utilized in developing countries to support care.[1] This is evident from the fact that countries like Kenya, Uganda, Mozambique and Nigeria are rolling out EMRs systems nationally within the public health sector to support care such as for HIV patients.[1] EMRs promise to improve efficiency, quality and safety of medical care delivery.[2] Furthermore, these systems have the potential to strengthen the health system, by improving use of data for decision making, and for reporting to the national level.

Implementation of these systems however comes at a cost. High EMRs costs have been shown to impact adoption of systems and subsequent success of EMRS implementations.[3] In low- and middle-income countries (LMICs) where resources are already constrained, strong justification is needed to allocate resources towards EMRs implementations, as opposed to using these resources for other proven health interventions. Cost evaluations of EMRs aid in the justification for implementing these systems, and provides relevant information to help decision-makers in allocating the limited resources.

*Corresponding author: School of Public Health, Makerere University, Kampala, Uganda. E-mail: bonnyenoc@gmail.com, Tel: + (256) - (784313161)
 J Health Inform Afr. 2019;6(2):84-89. DOI: 10.12856/JHIA-2019-v6-i2-260

To date, there is a dearth of rigorously conducted evaluations and publications on the costs of EMRs systems that are currently being deployed in LMIC-settings. While there has been strong focus on evaluating the benefits of EMRs on patient outcomes, data quality, reporting and other aspects, little has been done to assess the related costs. In this paper, we present a systematic evaluation of the cost of implementing an EMR system to support HIV care in Kampala, Uganda using an organizational perspective. We further compare these costs against a widely used open source system and also against the cost of a paper-based record system.

2 Materials and methods

2.1 Study Setting

This study was conducted at the Infectious Diseases Institute (IDI) in Kampala, Uganda. IDI is a not-for-profit organization with a strong emphasis on infectious diseases and provides care to People Living with HIV and other infectious diseases. Since December 2017, IDI has served over 50,000 adult patients. Prior to implementation of the EMR system, the institution used a paper based medical record system. In addition, the institution had a Microsoft Access based electronic aggregation system where summaries were entered by data entrants. From 2009 the clinic embarked on development and implementation of a home grown EMRS systems which was fully deployed.

2.2 Study design

This was a retrospective quantitative study of the direct costs of EMRS implementation. The costs were compared with the calculated costs of a paper-based system at the same facility, and of an open-source system, OpenMRS,[5] that is widely adopted for HIV care within Ugandan public health facilities. Research is a core component of the IDI work and therefore an estimate of how much would have been spent into data abstraction and retrieval from the paper-based system was compiled with input from a key people from the research department.

2.3 Study approach

We use well-accepted metrics for evaluating the cost of the three systems for comparison, namely IDI EMRS system, paper-based system, and the OpenMRS system. Input metrics for costing were derived from those outlined in the systematic review on economic evaluation of health information systems conducted by Bassi et al.[6] Key cost input metrics included one-time implementation costs and the ongoing costs after initial implementation. One-time implementation costs were determined for: hardware and peripherals, network and telecommunication supplies, application development and deployment, configuration management, packaged and customized software, project planning, contract negotiations, procurement, initial IT support costs, costs of converting retrospective data, initial user training, end-user project management, facility upgrades, office accommodations, site assessment costs, transition costs, and quality assurance costs. Ongoing costs included software maintenance, upgrades and subscriptions, system maintenance, hardware and equipment replacement, salaries of IT and end-user staff, ongoing training, facilities rental and utilities, EMRS consultant costs, other personnel costs, reviews and audits and ongoing operating costs.

2.4 Data Collection

Where available, cost data were retrieved from financial records from the accounts department of the institution. Where original receipts or invoices were not available, prevailing market rates from local suppliers were used, averaging quotations from three suppliers. If the item did not exist in the local market, online vending sites like Amazon and eBay were considered to provide information on the cost of the item.

To determine time personnel costs related to the system under evaluation, a modified Delphi technique with key informants to determine the percentage of time staff spent towards system development,

 J Health Inform Afr. 2019;6(2):84-89. DOI: 10.12856/JHIA-2019-v6-i2-260

deployment and maintenance.[7] Government documents from the ministry of Public Service of Uganda were also reviewed to provide salary and wage rates and employee benefits as well as job descriptions. All costs were recorded on cost inventories that was as designed by the research team and the study was approved by the Moi University Institutional Review and Ethics Committee and permission to conduct the study was sought from the top management from IDI, and from within each relevant department in IDI through its head of department.

2.5 Data Analysis:

The study looked at costs and savings from the organizational (implementer's perspective) and only looked at the direct financial effects without considering value placed on non-financial outcomes as these were beyond the scope of this evaluation. 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. For reporting, all costs were converted into US dollar using the mid-year rate for each of the individual years. Costs with a lifetime of greater than one year were annuitized using a well-accepted annuitization formula by Drummond et al., and using an annuity factor of 0.823 and interest of 4% per Drummond et. al's recommendation. Depreciation rates, were calculated using a reducing balance depreciation rate of 40% was used as per recommendation by the Uganda

3 Results

3.1 IDI EMRS Costs

Costs are provided for the evaluation period between 2009 and 2016. Total actual direct costs for development, deployment and maintenance of the home-grown EMRS at IDI during this period came to USD 1,066,965 (**Error! Reference source not found.**). When annuitization and depreciation is applied, this cost comes to 1,084,498.18. 71% of the overall costs went to staff salaries, and 24% to software licensing. Salary costs were largely associated with recruitment with two international consultants, two local developers, two IT support staff and data managers. Additional costs included the wages of health providers including a nurse and doctor who participated in the design and championing of the system. Hardware bought included personal computers (USD 24,500), switches (USD 600) and cables (USD 1000), a power backup generator (USD 2500), one 16 core processor, 64 gigabyte random access memory (RAM), 10 terabyte server, and 3 Uninterruptible power supply (UPS) (USD 300). Several licenses were required for the EMR and these included; Kaspersky (USD 458), Visio studio ultimate (USD 15,698), ReSharper (USD 1,168), SQL 2005 license (USD 199,992). Utility costs primarily included electricity costs.

Table 1. Costs of IDI EMRS development, implementation and maintenance (2009-2016)

Category	**Item**	**Year**								
		2009	2010	2011	2012	2013	2014	2015	2016	Total Cost
System development	Salaries	244,258	222,486	-	-	-	-	-	-	466,746
	Software	12,769	4,547	-	-	-	-	-	-	217,316
	Hardware	8,102	4,300	-	-	-	-	-	-	12,402
	Utilities	68	57	-	-	-	-	-	-	125
Deployment and maintenance	Salaries	-	-	65,114	57,846	45,804	43,362	39,445	39,013	290,587
	Software	-	-	15,370	5,520	5,520	5,520	5,520	5,520	41,025
	Hardware	-	-	29,212	612	612	612	612	612	32,272
	Utilities	-	-	573	785	760	711	650	676	4,157

 J Health Inform Afr. 2019;6(2):84-89. DOI: 10.12856/JHIA-2019-v6-i2-260

Total		**465,198**	**231,390**	**110,660**	**64,763**	**52,697**	**50,205**	**46,227**	**45,823**	**1,066,965**

The overall cost of the inputs for the IDI home-grown system showed a downward trend with costs being highest in the earliest years and levelling out in the subsequent years (**Error! Reference source not found.**).

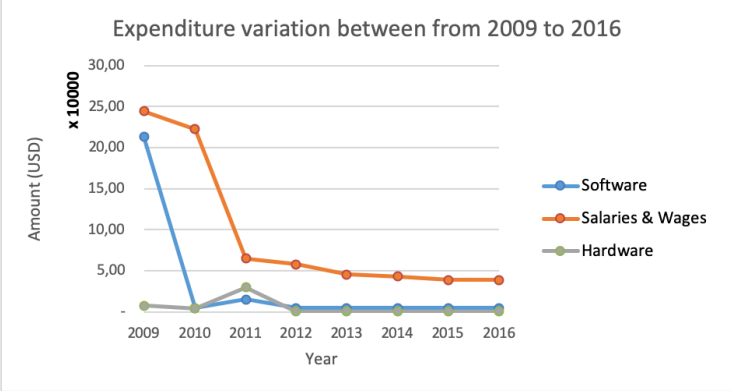

Figure 1. Variation of individual cost items for IDI EMRS from 2009 to 2016

3.2 OpenMRS and paper-based system costs

The calculated costs of running the open-source OpenMRS in the same facility over the same period was almost 20% ($806,290) lower than that required to develop and maintain the proprietary software at IDI even when using similar salary estimates for both systems (**Error! Reference source not found.**). This is because of the significantly lower costs related to system development and software for the open source system.

Table 2. Estimated cost of running an Open source EMRS 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	222,486	-	-	-	-	-	-	466,745
	Hardware	8,102	4,300	-	-	-	-	-	-	12,402
Deployment and maintenance	Software licensing	-	-	-	-	-	-	-	-	-
	Salaries	-	-	65,114	57,846	45,804	43,362	39,445	39,013	290,587
	Hardware	-	-	29,212	612	612	612	612	612	32,272
	Utilities	67	56	573	785	760	711	650	676	4,282
Total		**252,429**	**226,843**	**94,900**	**59,243**	**47,176**	**44,685**	**40,707**	**40,302**	**806,289**

The direct costs of running a paper-based system including stationery costs and data entry costs into an MS Access database came to USD 544,160 with over 85% of the costs going towards salaries and wages (**Error! Reference source not found.**).

Table 3. Direct costs of running a paper medical record system (2009 - 2016)

Item	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Stationery	16,138	15,048	12988	12383	11233	9323	7057	6681	90,855
Personnel ($)	71566	62493	56738	56084	57202	51430	42173	41152	438,843
Computers	4200	-	-	-	-	-	-	-	4,200

 J Health Inform Afr. 2019;6(2):84-89. DOI: 10.12856/JHIA-2019-v6-i2-260

Data Extraction	9,300								9,300
Utilities	135	113	98	134	130	121	111	116	962
Total	**92,040**	**77,655**	**69,825**	**68,604**	**68,566**	**60,877**	**49,341**	**57,251**	**544,160**

4 Discussion

In this paper, we present the direct cost evaluation of implementing a home-grown EMRS in an LMIC to support HIV care. Even for a small implementation, these costs come to over a million dollars over a seven-year period. 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 that also reported that human resource costs accounted for the highest portion of the costs.[9]

From our study, it is evident that direct cost reductions could be achieved using an open source EMRS. However, open source does not mean 'free', as human resource costs still contributed to a large component of the costs. This observation highlights one of the key factors that could be leading to many of the implemented systems not being sustained beyond the pilot stage, as implementers might think that all they need to do is to put hardware in place, and that the other factors will automatically workout, only to realize that there are significant continued costs for maintaining these systems.[9]

We observed an interesting but expected trend in costs with time. The costs of the system were higher at the onset but there was 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 in 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.[10]

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. This is similar to findings from other studies that also reported increments in expenditure due after implementing EMRS. [9,11] These added costs are due to need for more specialist personnel to manage the system hence creating new job openings and more expenditure on salaries and wages. The EMRS also came with need for procurement of new hardware and software, increments in electricity consumption as highlighted under the results section. However, simple direct cost comparison between paper and EMRS miss the indirect costs of the various systems, with paper-based indirect costs potentially being higher. Further, the benefits of the EMRS systems are also not considered in direct cost calculations, and this might affect the equation as to whether to implement the EMRS instead of a paper-based system.

Our study is limited by the fact that it looked only at direct costs within one facility and for one system. Future work would look at comprehensive cost calculations and with the performance of a cost-benefit analysis. Other costing perspectives, such as a societal perspective could also be considered, especially for systems in use within the public sector.

Acknowledgements

This work was funded by NORHED program through the HITRAIN project (QZA-0484, HI-TRAIN). We want to express our appreciation to IDI for supporting this work.

Statement on conflicts of interest

The authors and funder had no competing interests regarding this work.

5 References

[1] Fraser HS, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P. Implementing electronic medical record systems in developing countries. Informatics in primary care 2005;13(2):83-96

[2] Paul G Shekelle CLG. Costs and benefits of health technology information - An updated systematic review: Southern California Evidence-based Practice Centre; 2009.
[3] Gans D, Kralewski J, Hammons T, Dowd B. Medical Groups' Adoption of Electronic Health Records and Information Systems. Health Affairs 2005;24:1323-33.
[4] Infectious Disease Institute. Available at https://www.idi-makerere.com/. Last accessed Jul-09-2019.
[5] OpenMRS. Available at https://openmrs.org/. Last accessed on Jul-09/2019.
[6] Bassi J, Lau F. Measuring value for money: a scoping review on economic evaluation of health information systems. Journal of the American Medical Informatics Association 2013.
[7] Fleming NS, Culler SD, McCorkle R, Becker ER, Ballard DJ. The financial and nonfinancial costs of implementing electronic health records in primary care practices. Health Affairs 2011;30(3):481-9.
[8] Drummond MF, Sculpher MJ, Claxton K, Stoddart GL, Torrance GW. Methods for the economic evaluation of health care programmes. Oxford university press; 2015.
[9] Arias-Vimarlund V, Ljunggren M, Timpka T. Implementation of computer-based patient records in primary care: the societal health economic effects. *Proceedings of the AMIA Annual Fall Symposium.* American Medical Informatics Association; 1996:503
[10] Choi JS, Lee WB, Rhee P-L. Cost-Benefit Analysis of Electronic Medical Record System at a Tertiary Care Hospital. Healthcare Informatics Research 2013;19(3):205-14.
[11] Tseng P, Kaplan RS, Richman BD, Shah MA, Schulman KA. Administrative costs associated with physician billing and insurance-related activities at an academic health care system. JAMA 2018;319(7):691-7.

 J Health Inform Afr. 2019;6(2):84-89. DOI: 10.12856/JHIA-2019-v6-i2-260