Science Journal of Public Health
2023; 11(5): 143-153
http://www.sciencepublishinggroup.com/j/sjph
doi: 10.11648/j.sjph.20231105.11
ISSN: 2328-7942 (Print); ISSN: 2328-7950 (Online)

Implementation of Kenya Electronic Medical Records (KenyaEMR): Costs and Efficiencies

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To cite this article:

Sebastian Kevany, Starley Shade, Chloe Waters, Nancy Puttkammer. Implementation of Kenya Electronic Medical Records (KenyaEMR): Costs and Efficiencies. *Science Journal of Public Health*. Vol. 11, No. 5, 2023, pp. 143-153. doi: 10.11648/j.sjph.20231105.11

Received: March 29, 2023; **Accepted**: May 22, 2023; **Published**: September 6, 2023

Abstract: *Background*: Electronic medical record (EMR) rollout is a key element of health systems strengthening activities. To facilitate national rollout and country ownership of KenyaEMR, we assessed costs associated with development and point-of-care implementation of KenyaEMR supported by the International Training and Education Center for Health (I-TECH) between April 2012 and September 2013. *Methods*: We reviewed and collated I-TECH costing records and considered KenyaEMR implementation costs through two lenses: (1) overall direct I-TECH project costs to characterize costs across resource category, activity and location; and (2) health facility-specific costs to estimate cost per facility and explore variation in costs across facilities. *Results*: KenyaEMR development and implementation during this period cost I-TECH US$3,803,810. Human resources represented the majority of costs (51%), followed by travel (25%), and equipment (10%). Deployment (34%), project management (33%), and training and capacity building (22%) made up the largest proportion of I-TECH KenyaEMR costs; software (9%) and curriculum (2%) development costs were lowest. In-country expenses made up 65.9% of costs; this proportion increased over time. I-TECH was able to initiate implementation in 204 facilities and complete an equivalent of 128 implementations. Implementation in a facility, from sensitization through installation and back data entry, cost an average of US$9,879. The cost per patient of KenyaEMR implementation decreased as the number of patients in a facility increased. Cost per patient was uniformly less than US$20 per patient in facilities with more than 700 patients. *Conclusions*: Human resources, rather than equipment and infrastructure, drove costs of KenyaEMR implementation. Implementation quickly transitioned to be country-led. We observed substantial economies of scale in implementation of KenyaEMR. Resource limited countries should prioritize of implementation of point-of-care EMRs facilities in larger health facilities. Additional research is needed to determine whether point-of-care EMRs improve efficiency or cost-effectiveness of HIV care and treatment in resource-limited settings.

Keywords: Electronic Medical Record, Cost, HIV, Resource Limited Settings, Health Systems, Kenya

1. Introduction

The rollout of electronic medical records (EMR) systems is a key element of health systems strengthening activities under the United States President's Emergency Plan for AIDS Relief (PEPFAR). [1] With a focus on (1) improved accessibility of data for clinical management of HIV-infected patients, (2) improved ability to trace and track patients enrolled in HIV treatment, and (3) improved efficiency and accuracy of HIV-related information management and reporting, these systems also have broader applicability for patient health management and surveillance beyond HIV. The International Training and Education Center for Health (I-TECH), at the University of Washington, is a PEPFAR technical assistance partner which works with national governments to develop skilled health workers and health systems in resource-limited contexts. I-TECH began activities to strengthen the health information system in Kenya in 2009. [2] The Ministry of Health (MOH) and Centers for Disease Control and Prevention (CDC) tasked I-TECH with customizing and implementing a point-of-care

electronic medical record system based on the Open Medical Record System platform. [3]

The goal of the KenyaEMR project was to deploy KenyaEMR in 300 health facilities in four geographic regions of Kenya (Central, North Rift, Nyanza, and Western). [4] The KenyaEMR project aimed to transform the existing paper-based medical records in the public health care sector into an up-to-date electronic system with a specific focus on the electronic capture of patient clinical encounter data in the context of broader health system goals such as provision of quality health services in a cost-effective manner, [5-7] efficient patient flow, [8-0] promotion of equity in access, financial risk protection, [11] and overall governance and stewardship of the health sector. [12, 13]

To better understand the costs associated with the introduction of the KenyaEMR system, I-TECH completed a costing evaluation in collaboration with the University of California, San Francisco. The evaluation determined: (1) macro-level I-TECH project costs during the initial period of EMR implementation, and (2) micro-level costs of I-TECH-supported activities at the health facility-level. Our analysis estimates and describes the overall total project costs incurred by I-TECH to support KenyaEMR implementation between April 2012 and September 2013 in order to understand cost drivers and average KenyaEMR implementation cost within health facilities. In-country costs at the health-facility level are also estimated to better understand the variability of costs across health facilities and how factors such as administrative level and number of current HIV-infected patients affected the cost.

2. Methods

2.1. Overall I-TECH Investments in Kenya

2.1.1. Data Collection

Our analysis includes data provided by I-TECH related to all costs recorded for KenyaEMR project activities between April 1, 2012, and September 30, 2013. Data were obtained from (1) an internal 'QuickBooks' accounting system for costs incurred in Kenya, and (2) the University of Washington's general ledgers, and I-TECH's 'Adaptive Planning' budget management software.

2.1.2. Analysis

(i). Allocation of Costs

(a) Overall Costs

Data were coded based on expenditure category (personnel, travel, services, supplies, equipment and facilities) and activity category (software development, curriculum development, training and capacity building, deployment and project management). Appendix I includes a description of expenditure and activity categories.

We did not classify costs as fixed or recurring as many costs that would traditionally be classified as fixed are instead recurring costs in the context of KenyaEMR implementation. For example, in a traditional analysis, software development and employee training costs might be classified as fixed costs, since they would occur prior to implementation. In contrast, the KenyaEMR project embraced agile (i.e. iterative) software development so that the product could grow in functionality to meet stakeholder needs. In this context, costs for software development, as well as costs for curriculum development, national and regional awareness raising, and training and capacity building associated with these software changes are all considered as recurring costs, since they were required to maintain the relevance of KenyaEMR in the Kenyan context.

(b) Costs by Location

We attributed costs as in-country (Kenya) or headquarters (Seattle) based on the location of the expenditure.

(c) Costs by Time Period

We attributed costs based on the time period: period I (April–September, 2012, Early Software Development); period II (October 2012–March 2013, Model Site Implementation); and period III (April–September, 2013, Implementation Scale-up).

(ii). Assessment of Outcomes

We identified key milestones towards achievement of an EMR implementation and assessed achievement of each milestone at each site during the observation period. These milestones included: (1) completion of site readiness assessments, (2) completion of health manager training, (3) completion of site personnel training, (4) completion of on-site mentor training, (5) completion of deployment, and (6) initiation of legacy data migration. As sites were at various stages of implementation at the end of the observation period, it was important to be able to account for partial completion of some but not all of the six milestones in order to estimate cost per full implementation. We engaged in a consensus procedure to assign weights to each milestone, representing the contribution of each milestone towards a full KenyaEMR implementation, as follows: readiness assessment completed (20%), health manager trained (10%), end-users trained (10%), on-site mentor trained (10%), EMR deployed (30%), and data migration initiated (20%). Sites were assigned scores based on whether they had completed each milestone at the end of each period. These scores were then combined to estimate the number of 'full EMR implementation equivalents' completed during each period.

(iii). Cost Per Implementation

We computed overall cost per implementation and cost per implementation phase by dividing costs per implementation period by the estimated number of implementations completed at the end of each intervention period.

Health Facility-Level Investments in KenyaEMR.

2.2. Data Collection

2.2.1. I-TECH Kenya Direct Costs

These analyses include costs incurred by I-TECH for KenyaEMR project activities at the health facility-level in the

Western Region between April 1, 2012 and September 30, 2013. The Western Region was chosen because: (1) KenyaEMR had been implemented in a significant number of sites (n=35); and (2) findings from this region were felt to be most informative and relevant for policy makers in terms of understanding of the costs of new EMR implementations in other parts of Kenya. Data on direct I-TECH in-country expenses were obtained from an internal 'QuickBooks' accounting system.

2.2.2. Health Facility Characteristics

We used administrative and programmatic data to characterize health facilities and Kenya EMR implementation as follows:

Type of health facility includes dispensary, health centre, sub-district hospital, district hospital and other hospital. Information on categorization of health facilities was obtained from the Kenya Ministry of Health Master Health Facility List (http://www.ehealth.or.ke/facilities/).

Number of HIV patients: Number of current HIV-infected patients. This information was collected during site readiness assessment.

Number of trainees: Number of health facility employees trained to support KenyaEMR implementation.

Time to KenyaEMR implementation: Within each health facility, KenyaEMR implementation comprised several activities that occurred in a semi-linear fashion: site readiness assessment, health manager sensitization training, end-user training, identification and training of on-site mentor, installation and configuration, and data migration and back data entry. Time to KenyaEMR implementation was defined as the period between date of initiation of KenyaEMR implementation (assumed to be 30 days before site assessment) and date of completion of KenyaEMR implementation (assumed to be 60 days after installation).

2.3. Cost Allocation

We identified a total of 3,318 transactions related to KenyaEMR implementation during the period of interest. Documentation of individual expenses was reviewed to assess whether they could be allocated to an individual health facility, a group of health facilities, an individual region, or more than one region. Only those expenses that were either entirely or partially allocated to the Western Region (N=3002) are included in this analysis. A detailed description of allocation of costs across health facilities is included in Appendix II.

2.4. Analysis

We employed descriptive statistics to characterize health facilities and costs by health facility based on type of health facility, number of HIV-infected patients (patient volume), number of individuals trained to support KenyaEMR implementation (staff size), and duration of time needed to implement KenyaEMR. We also displayed and modelled the relationship between average cost per patient and patient volume in each health facility to assess economies of scale. We conducted sensitivity analyses to explore the effect of extending the assumed period of KenyaEMR implementation by 30 days. All costs are represented in US dollars, based on the Kenya Shilling-US dollar bid rate (QANDA) for each transaction date.

3. Results

3.1. Overall Costs

KenyaEMR development and implementation cost I-TECH US$3,803,810 between March 2012 and September 2013. KenyaEMR was at least partially implemented (site readiness assessment completed) in 203 sites. Personnel (51%), travel (25%), and equipment (10%) made up the majority of project costs. Facilities (6%), services (6%), and supplies (2%) were minority expenditures. Project management made up one-third of overall costs. Pre-implementation activities, including software (9%) and curriculum development (2%), made up only a small proportion of costs, while implementation activities—including training and capacity building (22%) and deployment (34%) — dominate.

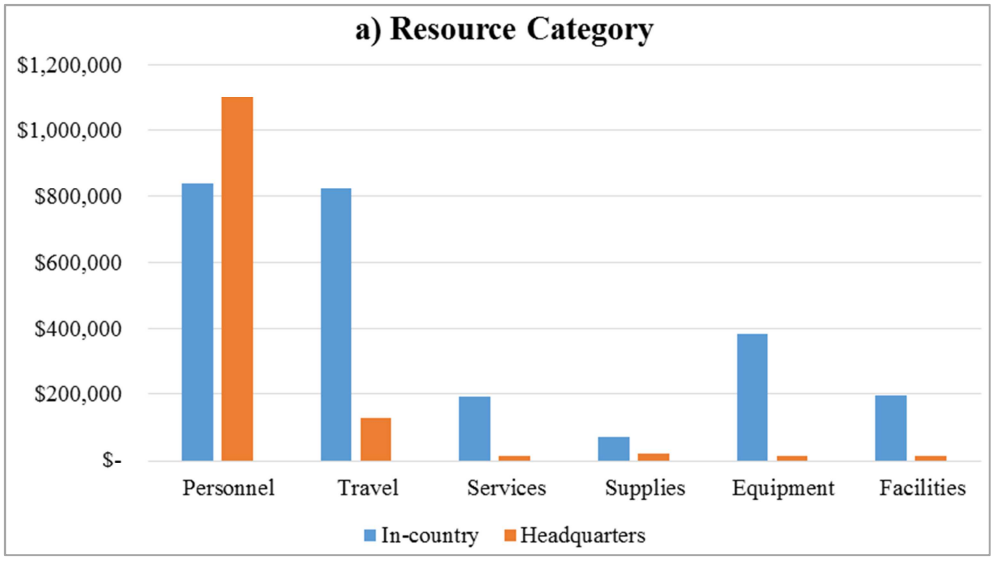
3.2. Cost by Location

In-country costs account for almost two-thirds of all KenyaEMR costs (Table 1 and Figure 1). In-country costs were dominated by personnel and travel, followed by equipment, services and site rental; while at headquarters, costs were almost exclusively associated with personnel and travel costs (Figure 1a). In-country activity costs focused on deployment, followed by program management and training and capacity building, while headquarter activity costs focused on program management followed by software development, deployment and training and capacity building (Figure 1b). We observed a substantial increase in the proportion of costs that were incurred in-country over time, while headquarter costs plateaued during phases II and III (Figure 1c).

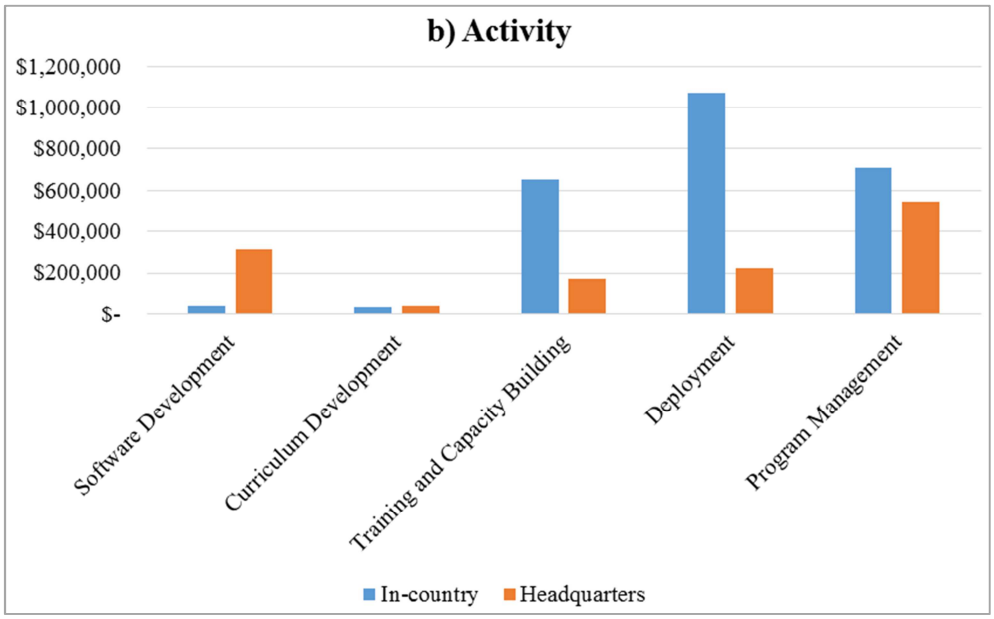
Table 1. *Overall Cost by Location.*

	Kenya		Headquarters		Total	
	$	%	$	%	$	%
Overall Costs	2,507,468	65.9%	1,296,342	34%	3,803,810	100%
Resource Category						
Personnel	839,932	34%	1,102,092	85%	1,942,024	51%
Travel	822,401	33%	128,905	10%	951,306	25%

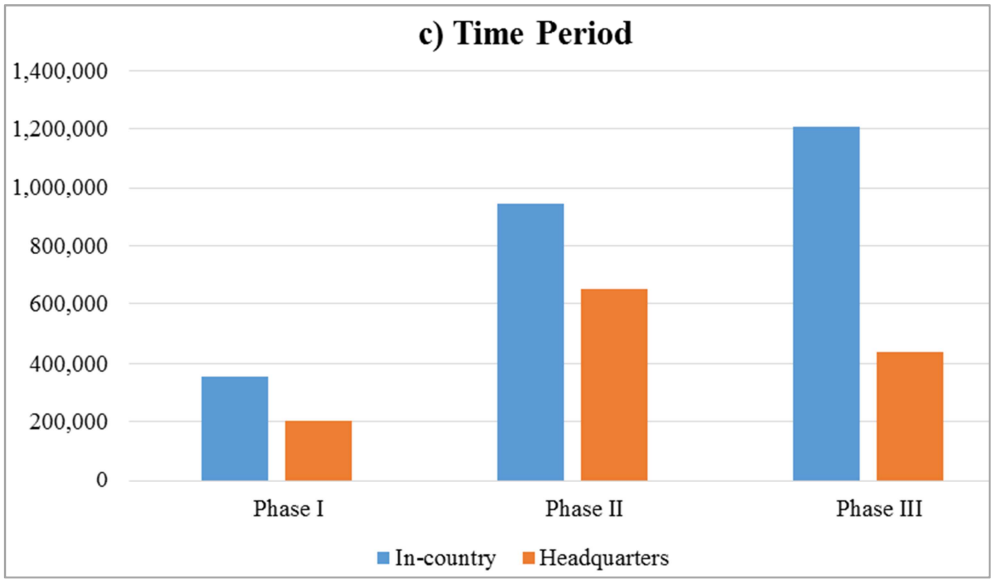
	Kenya		Headquarters		Total	
	$	%	$	%	$	%
Services	192,873	8%	14,560	1%	207,433	6%
Supplies	72,428	3%	20,819	2%	93,247	3%
Equipment	383,523	15%	15,910	1%	399,433	11%
Facilities	196,311	8%	14,056	1%	210,367	6%
Activity						
Software Development	4,3390	2%	314,754	24%	358,143	9%
Curriculum Development	34,279	1%	42,456	3%	76,735	2%
Training and Capacity Building	651,715	26%	172,889	13%	824,604	22%
Deployment	1,070,552	43%	223,765	17%	1,294,317	34%
Program Management	707,534	28%	542,478	42%	1,250,012	33%
Time Period						
Phase I	356,363	14%	204,380	16%	560,742	15%
Phase II	942,568	38%	653,631	50%	1,596,199	42%
Phase III	1,208,538	48%	438,331	34%	1,646,869	43%



a) Resource Category



b) Activity



c) Time Period

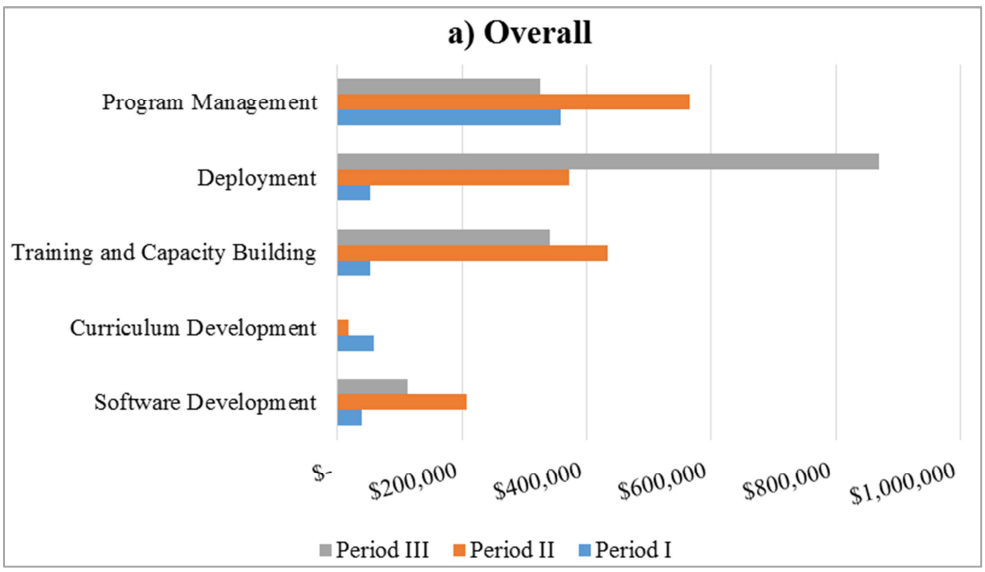
Figure 1. *Overall Cost by Location.*

3.3. Costs by Time Period

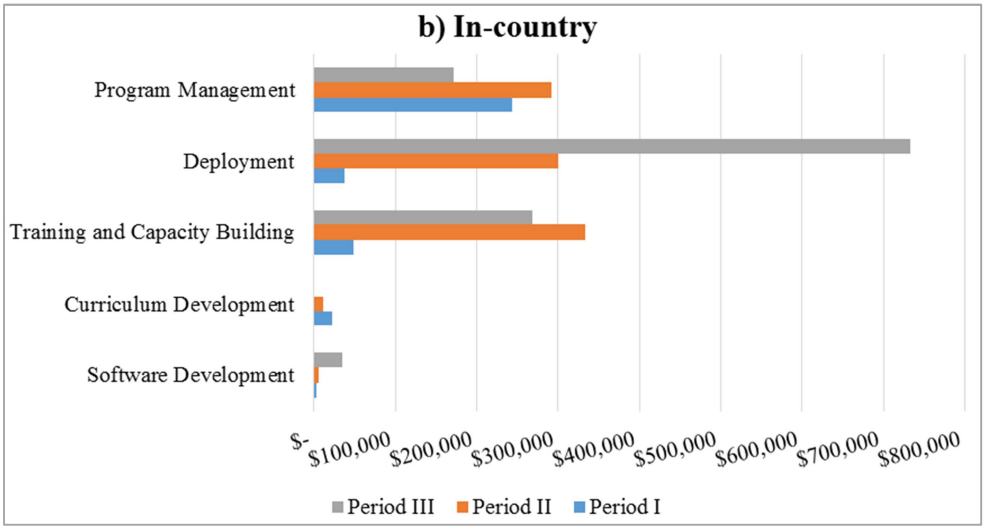
Costs increased over time (Table 2 and Figure 2). Phase I costs were dominated by program management both in-country and at headquarters. Software and curriculum development at headquarters represented minority costs. Phase II also included significant program management costs, but also included an emphasis on training and capacity building and model site deployment in-country and additional focus on software development at headquarters. Phase III costs were dominated by deployment, particularly in-country with less emphasis on training and capacity building and project management.

Table 2. *Overall Cost by Time Period.*

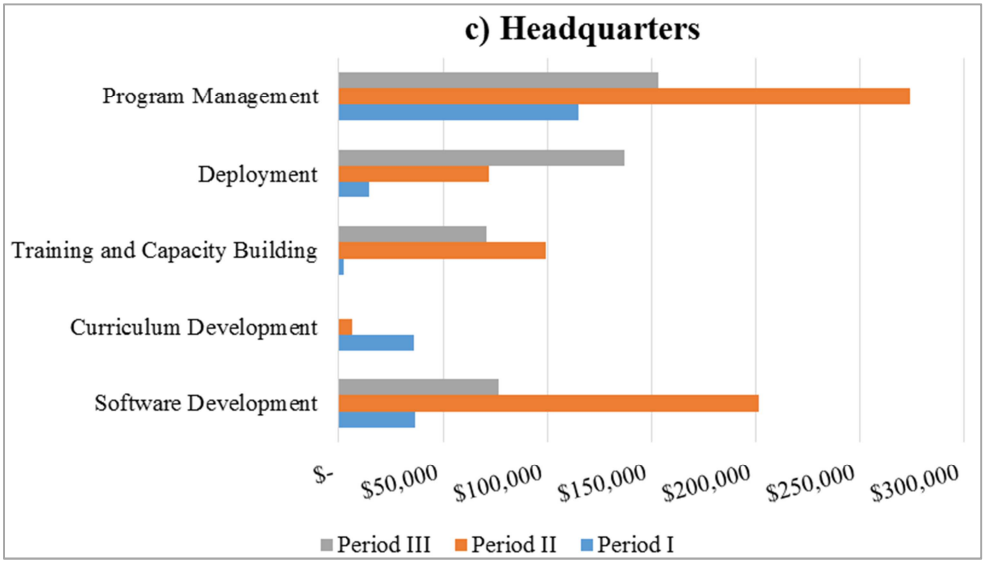
	Phase I April – September 2012		**Phase II October 2012 – March 2013**		**Phase III April 2013 – September 2013**	
	$	**%**	**$**	**%**	**$**	**%**
Overall	560,742	100%	1,596,199	100%	1,646,869	100%
Activity						
Software Development	39,246	7%	207,289	13%	111,608	7%
Curriculum Development	58,628	10%	18,107	1%	0	0%
Training and Capacity Building	51,667	9%	433,019	27%	339,917	21%
Deployment	52,467	9%	372,023	23%	869,826	53%
Program Management	358,734	64%	565,761	35%	325,518	20%
Activity and Location						
Kenya						
Software Development	2,830	1%	5,794	1%	34,766	3%
Curriculum Development	22,439	6%	11,840	1%	0	0%
Training and Capacity Building	49,064	14%	333,684	35%	268,967	22%
Deployment	38,132	11%	299,854	32%	732,566	61%
Program Management	243,897	68%	291,397	31%	172,240	14%
Headquarters						
Software Development	36,416	18%	201,495	31%	76,843	18%
Curriculum Development	36,189	18%	6,267	1%	0	0%
Training and Capacity Building	2,603	1%	99,336	15%	70,950	16%
Deployment	14,336	7%	72,169	11%	137,260	31%
Program Management	114,836	56%	274,364	42%	153,278	35%



a) Overall



b) In-country



c) Headquarters

Figure 2. *Overall Cost by Activity and Time Period.*

3.4. Cost Per Implementation

We estimated that an equivalent of 128.5 implementations occurred during the review period (Table 3). This corresponds to an overall cost per implementation of US$29,604. Cost per implementation declined substantially over time. During period I, only 10 sites received health manager orientation. This corresponds to an equivalent of only one 'full implementation equivalent', at a cost per implementation of US$560,742. As this period represents almost exclusively pre-implementation activities, this figure should not be used to imply cost per implementation during this period. During period II, we completed an equivalent of 30.2 implementations, at a cost per implementation of US$52,854. Finally, during period III, we were able to complete an equivalent of 97.3 implementations, at a cost of US$16,926 per implementation.

Table 3. *Overall Cost per Implementation Equivalent.*

Implementation Milestone	Weight	Period I (April –September 2012)		Period II (October 2012-March 2013)		Period III (April –September 2013)		Overall	
		Sites	Implementation Equivalents	Sites	Implementation Equivalents	Sites	Implementation Equivalents	Sites	Implementation Equivalents
Readiness Assessment Completed	20%	0	0	55	11.0	145	29.0	200	40.0
Health Managers Trained	10%	10	1.0	61	6.1	81	8.1	152	15.2
End-Users (Site Personnel) Trained	20%	0	0	34	6.8	77	15.4	111	22.2
Deployment Completed	30%	0	0	13	3.9	90	27.0	103	30.9
Data Migration Initiated	20%	0	0	12	2.4	89	17.8	101	20.2
Total "Implementation Equivalents"			1.0		30.2		97.3		128.5
Total I-TECH Cost			560,742		1,596,199		1,646,869		3,803,810
Average I-TECH Cost per "Implementation Equivalent"					52,854		16,926		29,602

3.5. Health Facility Characteristics

Table 4 describes the characteristics of participating health facilities. HIV-infected patient load ranged from 35-6000, KenyaEMR-trained staff ranged from 1 to 21 individuals, and time to implementation ranged from 30-224 days. These numbers generally increased with increasing facility level.

Table 4. *Health Facility Characteristics by Facility Type.*

Facility Type	Number of health facilities	Number of completed implementations	Number of HIV patients median [range]	Number of Trainees median [range]	Days to KenyaEMR Implementation median [range]
Dispensary	1	0	35	4	84
Health Centre	15	7	670 [32-1908]	3 [1-8]	95 [30-224]
Sub-District Hospital	11	7	1120 [350-2609]	4 [1-12]	103 [79-149]
District Hospital	7	6	2541 [1050-6000]	6 [2-21]	127 [77-140]
Other Hospital	1	1	4512	12	68
Total	35	21	1057 [32-6000]	4 [1-21]	103 [30-224]

3.6. Costs by Health Facility Characteristics

Costs associated with KenyaEMR implementation in 35 health facilities in the Western Region totaled to US$345,748 with an average cost of US$9,879 per site (Table 5). Average cost per health facility increased by facility level; the average cost per patient and health facility staff member trained to support KenyaEMR implementation decreased by facility level. We observed a strong inverse relationship between cost per HIV-infected patient and current number of HIV-infected patients in care per health facility (Figure 3). Cost per patient for facilities with more than 700 patients was uniformly less than US$20 per patient, and facility size explained the majority of cost variation (R^2=0.8692). Finally, total costs per health facility increased with increasing number of days to KenyaEMR implementation, and the lowest cost per current HIV-infected patient occurred within sites needing around 150 days to implement KenyaEMR.

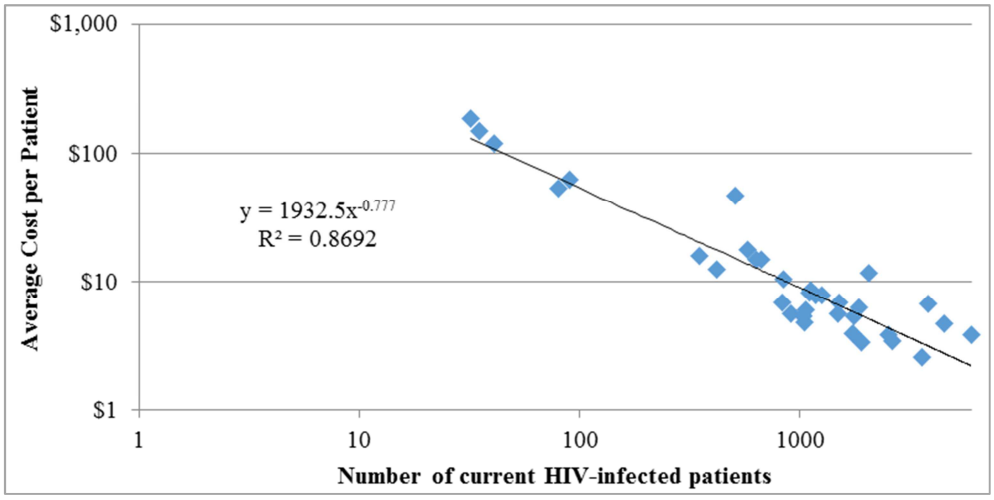


Figure 3. *Average Facility-level Cost per Patient by Number of HIV-infected Patients in Care.*

Table 5. *Health Facility-level Costs by Facility Type.*

Facility Type	Cost per facility median [range]	Cost per Patient median [range]	Cost per Trainee median [range]
Dispensary	$5,147.24	$147.06	$1,286.81
Health Centre	$6525.77 [$4301.92-$23,575.43]	$12.45 [$3.42-$183.45]	$2,810.63 [$1658.57-$6900.31]
Sub-District Hospital	$9,329.10 [$5147.24-$24,089.70]	$7.89 [$3.46-$17.74]	$2,112.83 [$1397.35-$5683.04]
District Hospital	$9,486.93 [$5045.80-$25,408.10]	$4.81 [$2.61-$8.14]	$1,939.74 [$1097.95-$4474.78]
Other Hospital	$21,592.77	$4.79	$1,799.40
Total	$9878.51 [$4,301.92-$25,408.10]	$6.91 [$2.61-$$183.45]	$2,238.78 [$1097.95-$6900.31]

4. Discussion

4.1. Overall I-TECH Investment in KenyaEMR

To our knowledge, ours is the first study to estimate the cost of EMR development and implementation in a low resource setting. These results are important because they help to understand the types and quantities of resources needed to implement point-of-care health information systems, the resources required for each state of development and implementation, the degree to which we were able to employ a country-led program, and how the distribution of resources changes between phases of the project.

The overall costs of KenyaEMR implementation were driven by human resources and deployment, rather than by the purchasing of equipment and software development as might be expected in a technological intervention. In-country human resources are key to each activity and phase of KenyaEMR implementation, and investing in human resource capacity building will be essential for any implementation of health information systems in resource-limited settings.

We observed a high degree of in-country leadership with almost two-thirds of KenyaEMR implementation costs incurring in Kenya. The Seattle-based team was primarily responsible for pre-implementation activities, including defining software architecture and development framework, and adapting the national training curriculum for KenyaEMR implementation, as well as fiscal and grants management.

KenyaEMR implementation required additional recurring costs for software development needed to respond to changes in the clinical practice guidelines. KenyaEMR implementation will continue to require further investment in recurring costs for additional system development in areas such as: (1) supporting transition of system maintenance to health facility personnel; (2) supporting additional software development to encompass additional functionality and service areas; or (3) supporting evolution of KenyaEMR's role within the national health information architecture, including interoperability between KenyaEMR and other data systems.

4.2. Health Facility-Level Investments in KenyaEMR

We observed substantial economies of scope and scale. Cost per implementation declined substantially over time as efficiencies were identified and implemented. Although the total health facility-level costs of KenyaEMR implementation increased with increasing level of health facility, the average cost per HIV-infected patient declined dramatically as the level and size of the health facility increased. Within Sub-District and District Hospitals with greater than 700 current HIV-infected patients, costs were uniformly less than $20 per patient. In contrast, in health facilities with fewer than 300 current HIV-infected patients, we estimated the cost of KenyaEMR implementation at greater than US$50 per current HIV-infected patient. These findings are important for regional, district and national level planners in terms of determining: 1) total resources required for KenyaEMR; and 2) the sequence of KenyaEMR roll-out under constrained

budget scenarios, in which case health facilities with higher economies of scale (lower costs per patient) may necessarily be prioritized over sites with lower economies of scale (higher costs per patient).

Key cost drivers at this site level included: (1) level of service delivery; and (2) number of HIV/AIDS patients at each site. Sites with higher volumes of patients will require additional EMR investment and expenditure. Possible explanations for this link include: 1) the need for additional hardware equipment to cope with patient record updating; 2) the costs of data migration associated with each set of patient files and records; and (3) the greater need for operational support at higher levels of patient volume and health services complexity.

4.3. Limitations

The overall cost analyses are limited in several ways. First, we only captured I-TECH direct costs of KenyaEMR implementation. We were not able to capture in-kind costs including those incurred by the MOH or other implementing partners.

The administrative records used for our analysis did not routinely allocate many of the costs to specific facilities, and the rule set we devised for cost allocation based upon 'active implementation' periods may have only approximated the true level investments to particular sites in some cases. Furthermore, not all site-level costs were captured by our analysis. Variability in costs were observed and may have been under or over-estimated, depending on factors such as the level of site readiness due to prior infrastructure investments or the level of EMR implementation costs borne by the MOH or other donors. Another limitation relates to possible unequal allocation of shared costs (e.g. group trainings) across health facilities; due to limitations on information, it was impossible to identify if such costs should have been allocated equally across sites independent of their location and size. In addition, training costs (here represented as fixed costs) may have had, in subsequent years, a recurring component associated with staff turnover.

Second, the small number of sites, the distinct geographical focus, and the limited time frame of this review limit generalization of the study. These analyses include only macro-level project costs through September 2013, reflecting a timeframe that was still fairly early in the EMR implementation experience for KenyaEMR sites. Additional analyses are needed to establish on-going costs for maintenance of the system. The restricted time frame and costing methodology of this study limited the inclusiveness of all possible KenyaEMR micro-costs. Subsequent project developments suggest the value of further work on current qualitative and quantitative inputs. Based on our informal follow-ups, the relative roles and inputs of different entities including County governments, PEPFAR service delivery implementing partners, and EMR technical assistance partners have evolved significantly since 2013, meaning the share of in-country and international costs and the types of costs have also evolved.

4.4. Future Work

A national cost-effectiveness study has been proposed to explore a more complete set of EMR implementation costs through the maintenance phase across a wider array of settings. Still, the current study is useful to inform the design of a more comprehensive national costing and cost-effectiveness study.

Although beyond our present scope, future work might focus on modeling of costs for KenyaEMR under various scenarios for extension in other areas of primary care beyond HIV. Estimations of cost changes and performance improvements (if any) after switching from paper-based to EMR-based approach in the context of different treatment processes might also be explored. Assessment of the comparative cost effectiveness of investments in routine clinical information systems such as KenyaEMR, compared to other investments in health systems strengthening, are also of interest.

5. Conclusion

I-TECH implementation of KenyaEMR required substantial initial project management and Seattle-based leadership to develop a project framework and work plan. In-country leadership has increased substantially through model site implementation and implementation scale-up. Additional planned changes in implementation to include MOH and Implementing Partner staff in development, training, deployment, support and maintenance of KenyaEMR will aide in the further transfer 'ownership' of the project to in-country personnel. However, continued support for human resources and travel will be important to insure maintenance of high quality implementation of KenyaEMR.

These results suggest prioritization of KenyaEMR implementation in health facilities with greater than 700 patients. Additional efficiencies in KenyaEMR implementation, which have occurred subsequent to the observation period, included reduction in the duration of trainings, and inclusion of implementing partners in all aspects of KenyaEMR implementation, will substantially reduce costs associated with broader KenyaEMR rollout. [14] Our results also suggest that KenyaEMR should not be implemented in sites with fewer than 300 HIV-infected patients. Given the difficulty of maintaining staffing and, therefore, skills associated with KenyaEMR implementation within these settings, in these very small health facilities, we recommend maintenance of the paper-based system, or implementation of a basic electronic system to capture information included in registries and patient cards using a simple web-based interface and phones or tablets for data entry. [15]

Authors' Contributions

SK and SS conducted field work and developed the manuscript. NM and CW reviewed and advised.

Appendix

Appendix I. Expenditure Categories

Personnel costs included employee salaries and benefits, as well as costs for consultants involved in software development, training, and other aspects of the KenyaEMR development and implementation.

Travel included domestic and foreign airfare, per diem, and other incidental expenses.

Recurring services included utilities, telephone and Internet fees, transport and freight, professional dues and conference fees, and other payments for services associated with KenyaEMR development and implementation.

Capital equipment costs included computers and other durable equipment (e.g., furniture).

Space rental included payment for office space in both Seattle and Nairobi, as well as space rental for meetings, trainings, and conferences.

Activity Categories

Software development included incremental development of a point-of-care electronic medical record in accordance with *Kenya Standards and Guidelines for Electronic Medical Records* (NASCOP, 2012). This system was developed using the OpenMRS platform and international CIEL concept dictionary.

Curriculum development included adaptation of the generic national curriculum for KenyaEMR implementation, development of KenyaEMR-specific training materials (e.g., job aides), and dissemination of all training materials, in both printed and electronic (e.g., I-TECH and MOH websites) formats.

Training and Capacity Building included targeted knowledge, motivation, and skill development among several groups of stakeholders involved in KenyaEMR implementation: national and regional county health information offices, health managers, end users, and on-site mentors. The training strategy evolved over time. During periods I and II, I-TECH partnered with two local training institutes to deliver health manager, end-user, and mentor trainings via off-site workshops of two days, five days, and two-to-three days, respectively. During period III, trainings were shortened to one day for health managers and three days for end users.

Development and Deployment: Deployment included installation of computer equipment and software and on-site support for use of software and migration of patient data from paper ('Blue Card') forms.

Project management included project planning and oversight, operations and logistics coordination, and grants management.

Appendix II. Allocation of Costs to Health Facilities

Individual health facilities: 336 expenses were assigned to individual health facilities.

Multiple health facilities: 38 expenses were assigned to more than one health facility. These expenses were apportioned equally across named health facilities.

Western Region: The vast majority of transactions, 2,628, were assigned to the Western Region. These expenses were apportioned proportionally across facilities that were defined as actively engaged in KenyaEMR implementation during the month of the transaction. The proportion of an expense that was assigned to a site was based on the number of active sites during the month of the transaction, and the number of days during the month of the transaction that each site was actively engaged in KenyaEMR implementation (cost attributed to a particular site = expense amount * [number of active days during month of transaction for a particular site / total active days during month of transaction for all sites in Western Region]).

Multiple regions: 63 transactions were assigned to multiple regions. These transactions were apportioned equally across named regions and then allocated to Western Region sites as defined above.

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