I-TECH
International
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Center for Health

A Review of Key Investments in the KenyaEMR Electronic Medical Record System

Under the President's Emergency Plan for AIDS Relief (PEPFAR)

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BACKGROUND

The rollout of standards-based electronic medical records systems (EMR) has become a key element of health systems strengthening activities supported by the Centers for Disease Control and Prevention (CDC) and the International Training and Education Center for Health (I-TECH) in Kenya. In order to facilitate national rollout of EMRs, and to foster country ownership of the KenyaEMR project, we assessed the costs associated with KenyaEMR implementation supported by ITECH between April 2012 and September 2013.

METHODS

Overall Direct I-TECH Costs

We collected information through review and collation of I-TECH costing records provided by Seattle and Nairobi office staff. Transactions were coded based on expenditure category (personnel, travel, services, supplies, equipment and facilities), activity category (project management, curriculum development, training and capacity building, and development and deployment), location of expenditure (Kenya and Seattle), and time period (early software development, model site implementation, and implementation scale-up). The number of EMR implementations achieved was estimated by assigning weights to each stage of EMR implementation and then scoring each site based on stages of implementation completed during the observation period (including EMR readiness assessment, health manager training, champion/end-user training, mentorship, deployment, and data migration, support for use—e.g. reporting, decision support, cohort reports, individual patient outcomes) to create 'full EMR implementation equivalents' achieved. We then estimated average cost per KenyaEMR implementation.

METHODS SUMMARY

The analysis considered KenyaEMR implementation costs through two lenses:

1. Overall direct I-TECH project costs, yielding an average cost per site.
2. Health facility-specific costs based upon allocation of costs to individual facilities, yielding estimates showing the variation in costs across facilities.

Health Facility-Level Direct I-TECH Costs

We assessed in-country direct I-TECH costs associated with KenyaEMR implementation in 35 health facilities in the Western Region. The Western Region was chosen for having an implementation cost profile that was thought to be somewhat similar to other Regions of Kenya where KenyaEMR implementation was planned. Transactions were assigned to individual health facilities, groups of health facilities, all sites in the Western Region or all sites in multiple regions based on documentation for individual expenses. For transactions either entirely or partially

assigned to all sites in the Western Region, costs were assigned proportionally, based on the number of sites actively engaged in KenyaEMR implementation during the month of the transaction. For the purpose of cost allocation, active engagement in KenyaEMR implementation was defined as involvement in activities beginning 30 days prior to site readiness assessment, and ending 60 days after KenyaEMR installation. We characterized costs within each health facility based on type of health facility, number of HIV-infected patients, and number of individuals trained to use or support KenyaEMR. We also summarized costs by health facility, patient, trainee, and calendar period. Sensitivity analysis conducted to assess the effect of assuming different durations of active engagement in KenyaEMR implementation had little effect on observed results.

RESULTS

Overall Direct I-TECH Costs

KenyaEMR implementation was associated with a total direct cost of $3,803,810 during the observation period. Costs were predominantly associated with human resources (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 development and curriculum development costs were lowest. In-country expenses made up the majority of costs (65.9%). The proportion of costs incurred in country increased over time. Using weights for each stage of implementation, we estimated an equivalent of 30.2 implementations occurred during period II (Oct 2012 - Mar 2013) at an average cost of $52,854, and an equivalent of 97.3 implementations occurred during period III (Apr 2013 – Sept 2013) at an average cost of $16,926.

Health Facility-Level Direct I-TECH Costs

KenyaEMR implementation was associated with health-facility level costs of $345,748 across 35 health facilities in the Western Region. The average implementation cost per site was US$9,879 (standard deviation = US$6,028). The number of HIV-infected patients in care in participating health facilities ranged from 35 to 6,000, the number of health facility staff trained to support KenyaEMR implementation ranged from 1 to 21, and the number of days actively engaged in KenyaEMR implementation during the timeframe of the study ranged from 30 to 224.

In general, the number of HIV-infected patients in care, number of health facility staff trained to support KenyaEMR implementation, and days actively involved in KenyaEMR implementation increased as the health facility level increased. We observed a strong relationship between cost per HIV-infected patient and current number of HIV-infected patient in care at the health facility. Average cost per HIV-infected patient is high for small facilities, and sharply lower for the larger facilities. In addition, despite a small sample of facilities for the Western regions, facility size seems to have fairly robust explanatory power for cost variation. In contrast, we observed no discernible relationship between cost and number of staff trained.

DISCUSSION

Overall Direct I-TECH Costs

The overall costs of KenyaEMR implementation are driven by human resources, rather than by the purchasing of equipment, as might be expected in a technological intervention. The proportion of costs associated with project management declined substantially over time, and the average cost per full EMR implementation decreased with time and scale-up, indicating increases in efficiency. The share of in-country costs increased over time. There is a continued need to focus on 'in-country ownership', with an emphasis on transferring leadership to Ministry of Health and Implementing Partner staff in development, training, deployment, support, and maintenance of KenyaEMR.

Health Facility-Level Direct I-TECH Costs

We observed substantial economies of scale and scope in the health facility-level costs of KenyaEMR implementation. 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.

KEY FINDINGS

- Overall costs of KenyaEMR implementation were driven by human resources rather than equipment.
- The share of in-country costs increased over time.
- The average implementation cost per facility was US$9,879.
- There was little variability in cost of EMR implementation per patient for sites with more than 700 patients.
- Further work to evaluate cost and cost effectiveness of EMR implementation is needed.

We observed very little variability in cost per patient within Sub-District and District Hospital with greater than 700 current HIV-infected patients, where costs were uniformly less than $20 per patient. The variability in cost per patient was greatest within the health facilities with fewer than 700 current HIV-infected patients. This occurred because when costs are allocated equally across multiple health facilities, they disproportionately impact cost per patient within smaller health facilities. Additional research is needed to estimate the incremental costs associated with implementing in smaller health facilities located geographically close to larger health facilities. Future evaluation of costs during the post-deployment stage, covering system maintenance and support, would also be valuable and informative to the Kenya Ministry of Health.

There may be some level below which it is not efficient to implement KenyaEMR in its current form. For health facilities with fewer than 300 current HIV-infected patients, we estimated the cost of KenyaEMR implementation at greater than $50 per current HIV-infected patient. Given the difficulty of maintaining staffing, and, therefore, skills associated with KenyaEMR implementation, within these settings, 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 simple a simple web-based interface and phone or tablets for data entry in these smaller settings.

INTRODUCTION

THE KenyaEMR INTERVENTION

The rollout of standards-based electronic medical records systems (EMR) has become a key element of health systems strengthening activities under the United States President's Emergency Plan for AIDS Relief (PEPFAR). The Kenya Electronic Medical Records system ('KenyaEMR') intervention represented a significant investment in Kenya's health information system. The KenyaEMR project was supported by PEPFAR through a cooperative agreement between the Health Resources and Services Administration (HRSA) of the U.S. government and the International Training and Education Center for Health (I-TECH). The project was further overseen by the Centers for Disease Control and Prevention (CDC) Kenya, Strategic Information Division and the Ministry of Health-led EMR Technical Working Group.

I-TECH has been involved in strengthening the health information system in Kenya since 2009. I-TECH provided technical assistance to the Kenya Ministry of Health (MOH) to define national technical and functional standards for patient-level medical record systems. Once these standards were approved, the MOH and the CDC tasked I-TECH with the customization and implementation of an electronic medical record system based on one of the four recommended platforms, Open Medical Record System (OpenMRS, http://openmrs.org/). The original KenyaEMR project goal at the outset of the project in 2011 was to deploy KenyaEMR in 300 health facilities in four geographic regions of Kenya (Central, North Rift, Nyanza, and Western).

The KenyaEMR project aimed to transform the existing paper-based medical records system 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 such broader health system goals as provision of quality health services in a cost-effective manner (Tierney, et al., 1997; Poissant, 2005; Pizziferri, et al., 2005), efficient patient flow (Were, et al., 2008; Castelnuovo, et al., 2009; Wanyenze, et al., 2010) promotion of equity in access, financial risk protection (Uslu & Stausberg, 2008), and overall governance and stewardship of the health sector (Miller, et al., 2005; Government of Kenya, 2009).

In turn, anticipated health and efficiency outcomes included: (1) improved patient care through real-time health care provider access to up-to-date medical records, assisting such efforts as improving antiretroviral adherence; (2) reduced wait times for patients; (3) reduced administrative burden on clinicians; (4) improved transferability of patient records within and across Kenyan health facilities, as required (Forster et al 2008); and (5) improved data confidentiality (UNAIDS 2007).

COSTING EVALUATION OVERVIEW

In order to better understand the costs associated with the introduction of the KenyaEMR system, I-TECH carried out a costing evaluation in collaboration with the University of California San Francisco. The evaluation determined: (1) the macro-level I-TECH project costs during the initial period of EMR implementation, and (2) the micro-level costs of I-TECH-supported expenditure at the site (or health facility) level. Part 1 of this report covers the overall macro-level I-TECH costs of the EMR intervention, and gives a picture of the average cost of EMR implementation per facility. Part 2 of this report covers a 'micro-costing' analysis, which intends to build a more detailed understanding of I-TECH investments required at the site level to support EMR implementation, by documenting the variability in costs across facilities. The report covers costs associated with KenyaEMR implementation supported by I-TECH between April 2012 and September 2013. The findings of the report are intended to inform national EMR rollout, and efforts to encourage country ownership of EMR systems, by presenting evidence on the inputs necessary to support EMR deployment and implementation.

LIMITATIONS OF THE PRESENT EVALUATION

Our cost evaluation is limited in several important ways. First, the evaluation considered only the KenyaEMR system; it did not consider costs of implementing other EMRs, such as IQCare or C-PAD, in Kenya. Second, we only captured I-TECH direct costs of KenyaEMR implementation. We were not able to capture in-kind costs incurred by the Ministry of Health or other PEPFAR implementing partners. Third, this analysis includes only KenyaEMR project costs through September 2013, reflecting a timeframe that was still fairly early in the EMR implementation experience for KenyaEMR sites. Further work is needed to establish on-going support and maintenance costs for the system. A proposed national cost-effectiveness study will be able to explore a more complete set of costs, for multiple EMR systems, from the Ministry of Health or limited societal perspective. Still, the current study provides useful information on cost drivers in EMR implementation and on variability of costs across different types of facilities. The study is also useful to inform the design of the more comprehensive national cost-effectiveness study.

PART 1. OVERALL I-TECH INVESTMENTS IN KenyaEMR

INTRODUCTION

The purpose of this section of the report is to estimate the overall total project costs incurred by I-TECH to support KenyaEMR implementation. These analyses will help us understand cost drivers and average cost of KenyaEMR implementation within health facilities. The results of this report will inform policy makers and program managers about investments needed to support EMR rollout.

The development and implementation of KenyaEMR has been characterized by three periods: 1) April–September 2012, covering project preparation and early software development; 2) October 2012–March 2013, covering model site implementation; and 3) April–September 2013, covering implementation scale-up.

Period I included development of the initial version of KenyaEMR (led by Seattle-based staff and consultant software developers), establishment of an office in Nairobi to house I-TECH Kenya staff, hiring of I-TECH Kenya staff, and engagement with national and regional health information officers to raise awareness about the project and to prepare for implementation. This phase also included development of training and mentoring curriculum. These curricula were adapted from previous curricula, which had been developed to guide training and mentoring under a generalized implementation of patient-level electronic medical record systems.

Period II focused on implementation in 15 sites that were chosen as well suited for KenyaEMR implementation. This phase served as a pilot for the broader rollout of KenyaEMR, during which I-TECH built the capacity of Kenyan staff to lead all phases of implementation. Although this phase focused on implementation in the 15 model sites, I-TECH staff initiated implementation procedures in many other sites, since implementation in the model sites required more time than initially anticipated in order for MOH to make infrastructure improvements in health facilities, and for I-TECH to procure computer equipment and supplies.

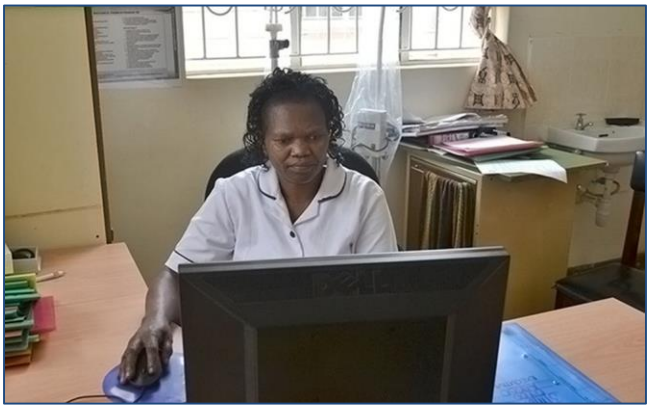
Period III focused on the broader rollout of KenyaEMR. The MOH and CDC tasked I-TECH to implement KenyaEMR in a total of 300 health facilities in four regions during a two-year period. This phase was characterized by collaboration with other PEPFAR-funded implementing partners in many implementation activities in order to facilitate such a large-scale rollout of KenyaEMR.

The implementation of KenyaEMR at each site included multiple activities. Each site generally followed these steps in a semi-linear manner, but site implementation was staggered, so that, at any point in time, different sites could be found at different steps in the semi-linear process.

First, the MOH nominated sites for consideration based upon criteria recommended by the National EMR Technical Working Group, including type of facility, presence of HIV care and treatment services, volume of patients, and absence of an existing EMR. Then, I-TECH or another

implementing partner staff conducted a Site Readiness Assessment. This assessment was intended to identify the resources present and needed for KenyaEMR implementation, and included identification of infrastructure improvements and computer resources needed in the health facility.

Second, I-TECH staff conducted sensitization training with the Health Manager in each health facility to introduce the mechanics and potential benefits of KenyaEMR implementation, and to engage them as champions of KenyaEMR implementation in their health facility.



Third, I-TECH staff conducted training of end users (health facility staff). This training included both system support and use of KenyaEMR.

Fourth, I-TECH staff in conjunction with MOH identified and trained key staff in each health facility to serve as an on-site mentor. The on-site mentor's role was to ensure cascade training of other facility staff and to support smooth EMR operations.

Fifth, once infrastructure improvements were made by MOH, I-TECH staff procured equipment and installed the system. Sixth, health facility staff employed KenyaEMR for newly enrolled patients, while conducting retrospective data entry to migrate paper data to the electronic system for previously enrolled patients.

METHODS

Data Collection

This report 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) the internal I-TECH '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.

Analysis

Allocation of Costs

Data were coded based on expenditure category (personnel, travel, services, supplies, equipment and facilities), activity category (project management, curriculum development, training and capacity building, and development and deployment), location of expenditure (Kenya and Seattle), and time period (early software development, model site implementation, and implementation scale-up).

We did not classify costs as fixed vs. recurring costs; the classifications of fixed and recurring costs in this setting differ from those in a traditional economic analysis of implementation of a static EMR software product. 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 iterative software development, so that the product could grow in functionality to meet stakeholder needs, and could be responsive to changes in clinical practice guidelines. In this context, costs for software development, as well as for curriculum development, for national and regional awareness raising, and for training and capacity building associated with these software changes, all can be considered as recurring costs, since they were required to maintain the relevance of the KenyaEMR software in the Kenyan context.

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

Project Management

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

Curriculum Development

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

Training 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

The development activity included incremental development and customization of an 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. 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.

Location

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

Time Periods

We attributed costs based on the time period, as noted above: Period I (April–September, 2012); period II (October 2012–March 2013); and period III (April–September, 2013).

Assessment of Outcomes

We identified key milestones towards achievement of completion 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 approximate 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.

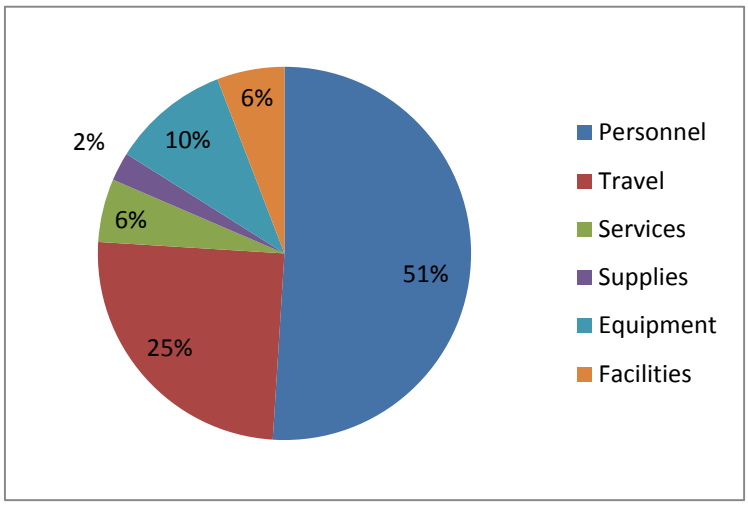
Cost per Implementation

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

RESULTS

Overall, KenyaEMR development and implementation cost I-TECH $3,803,810 between March 2012 and September 2013. During this time, KenyaEMR was at least partially implemented (site readiness assessment completed) in 203 sites.

Figure 1. Total Costs by Expenditure Category

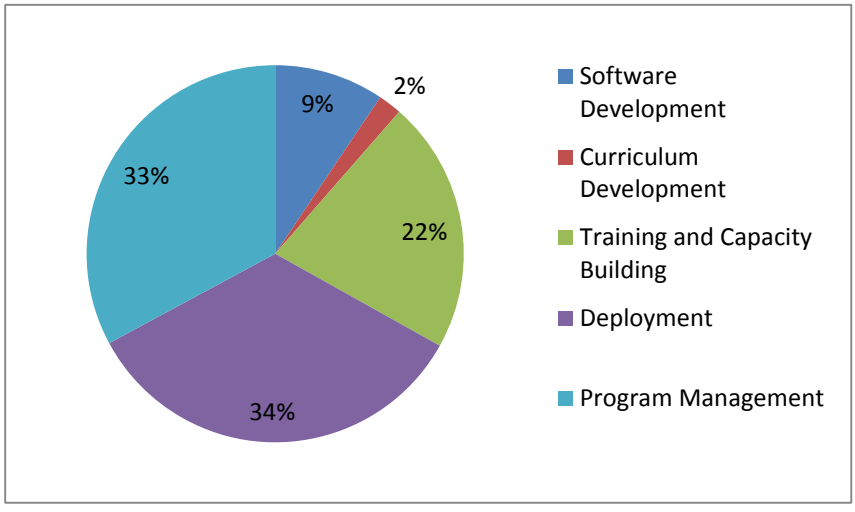


Costs by Expenditure Category

The distribution of costs across expenditure categories for KenyaEMR implementation is presented in Figure 1. KenyaEMR project costs were dominated by personnel, travel, and equipment. For personnel costs, salaries accounted for 33.0% of total combined headquarters and in-country project costs. For travel costs, per diems (including meals and incidental expenses) make up 17.4% of total I-TECH KenyaEMR project costs. For equipment costs, computer equipment accounted for 9.6% of total I-TECH EMR project costs.

Costs by Activity

Figure 2. Total Costs by Activity



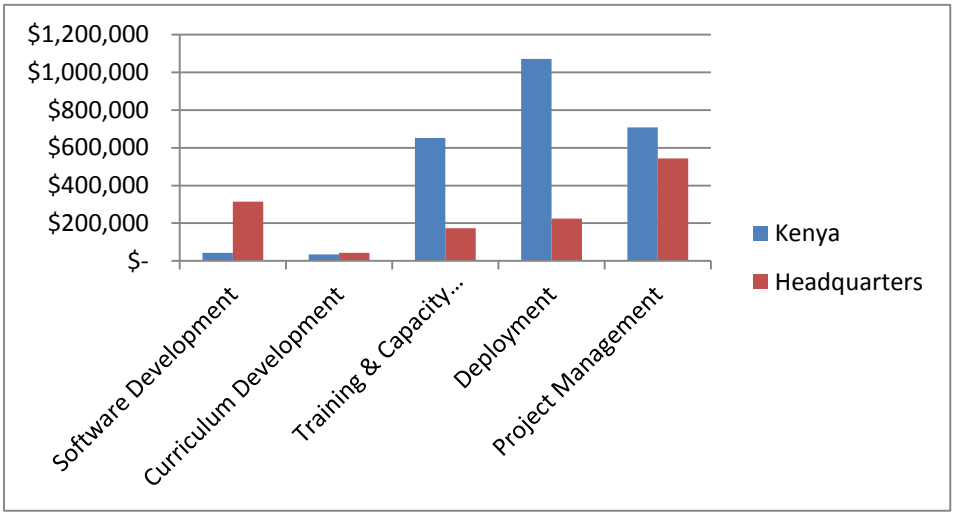
The distribution of costs across activities is presented in Figure 2. Project management made up one-third of overall costs. Pre-implementation activities, including software development and curriculum development made up only a small proportion of costs, while implementation activities—including training, capacity building, and deployment—dominate. For the deployment activity category, personnel costs (38.7%), equipment costs (28.2%), and travel costs (27.0%) dominate. In contrast, under the training and capacity building activity category, equipment costs account for only 1.2% of all training and capacity building costs, while personnel costs (33.9%), and travel costs (53.1%—43.4% of all training and capacity building costs being assigned to per diem costs) dominate.

Management is dominated by personnel costs (59.9%), services costs (11.7%), and office space rental (7.0%).

Costs by Location

Overall, in-country costs account for 65.9% of total KenyaEMR costs, while headquarters costs account for 34.1% of total KenyaEMR costs (Figure 3). Pre-implementation activities, including software and curriculum development, were led by headquarters staff; implementation activities, including training, capacity building, and deployment, were led by in-country staff.

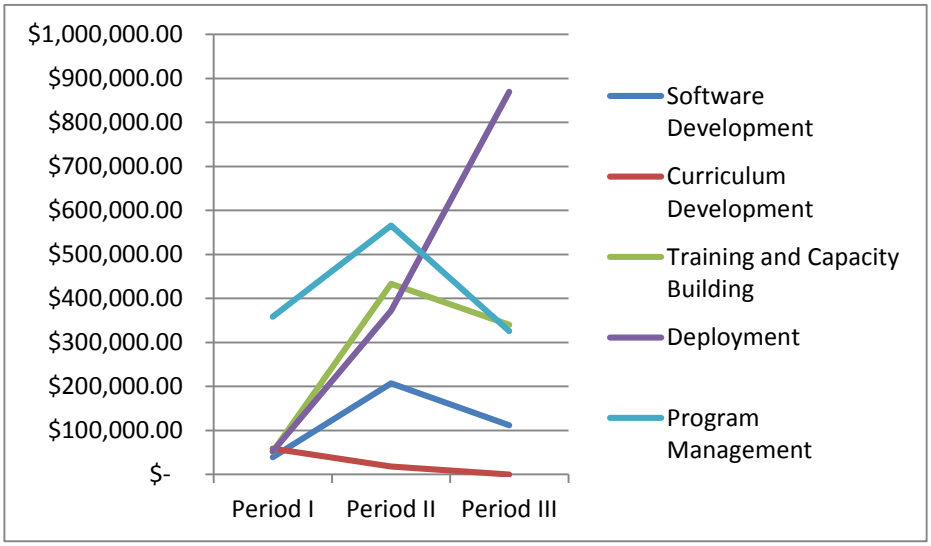
Figure 3. Costs by Activity and Location



Costs by Time Period

Overall, 14.7% of I-TECH KenyaEMR costs were expended during period I, 42.0% of costs during period II, and 43.3% of costs during period III. The distribution of costs varied substantially by activity category over time (Figure 4). Period I was dominated by management costs (43.5% in-country management; 20.5% headquarters management). Software development (7.0%), curriculum development (10.5%), and deployment (9.4%) made up similar shares of total KenyaEMR cost during period I.

Figure 4. Costs by Time Period and Activity



During period II, costs were again dominated by project management (18.3 % in-country management, 17.2% headquarters management), accompanied by a significant increase in

deployment as a share of total costs, to 23.3%. Software development and training and capacity building costs also increased to 23.3% and 27.1%, respectively, during period II. Curriculum development costs decreased from 10.5% to 1.1%, illustrating the completion of most elements of this activity during period I.

Finally, during period III, deployment costs increased again, to 52.8% of total KenyaEMR costs; management costs again decreased, to 19.8% of I-TECH KenyaEMR costs (10.5% in-country management, 9.3% headquarters management). Training and capacity building costs remained relatively stable compared to period II, decreasing to 20.6%. Software development costs decreased to 6.8%, as the majority of this activity is transferred in country.

Cost per Implementation

We estimated that an equivalent of 128.5 implementations occurred during the review period (Table 1). This corresponds to an overall cost per implementation of $29,604. As expected, 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 $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 'full implementation equivalents', at a cost per implementation of $52,854. Finally, during period III, we were able to complete an equivalent of 97.3 implementations, at a cost of $16,926 per implementation.

Table 1. **Cost per Implementation Equivalent—Overall, and by Time Period**

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**

DISCUSSION

These results represent one of the first efforts to estimate the cost of large-scale implementation of health information systems in a developing country setting. These results are important because they help us to understand the types and quantities of resources needed to implement health information systems, the resources required for each stage 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 results of this study may also be used to improve the efficiency of KenyaEMR implementation, to inform the national cost-effectiveness study planned to study implementation of health information systems in Kenya, and to guide implementation of health information systems in other resource-limited settings.

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. Human resources, particularly in-country human resources, are key to each activity and phase of KenyaEMR implementation, including software and curriculum development, training and capacity building, deployment, and project management. Therefore, investment in human resource capacity building will be essential for any implementation of health information systems in resource-limited settings.

KenyaEMR implementation has required relatively modest pre-implementation, or fixed, costs associated with software and curriculum development, as well as national and regional sensitization, training, and capacity building. However, pre-implementation or fixed costs make up only a small proportion of the resources required to support KenyaEMR implementation. KenyaEMR implementation required additional recurring costs for software development needed to respond to changes in clinical practice guidelines, as well as for curriculum development, national and regional awareness raising, and training and capacity building associated with these software changes.

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 in the national health information architecture, including introduction of a national unique patient identifier, or introduction of routine health information exchange between KenyaEMR sites and county-level ‘eHubs’ for county-level data analysis. These activities would each require additional software development, associated curriculum development, national and regional awareness raising, and training and capacity building. Recurring implementation costs for human resources, travel expense, and other areas would be needed to support this type of on-going system development.

We observed a high degree of in-country leadership, or “’country ownership’ of KenyaEMR implementation. Almost two-thirds of KenyaEMR implementation costs were incurred in Kenya. The in-country team was primarily responsible for KenyaEMR implementation, including training,

capacity building, and KenyaEMR deployment. 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. Although much of the ongoing software development has been transferred to staff in Kenya, we anticipate that Seattle-based staff will continue to provide input and technical support on the overall architecture, as well as project and grants management.

The proportion of costs associated with Seattle-based based activities, including project management, declined substantially over time, indicating increases in efficiency and transition to in-country control over time. We hired a software developer in-country in order to begin transition of ongoing software development and management. We reduced the length of health manager and user trainings, and changed our mentoring model. This allowed us to conduct more trainings in health facilities with the constraints of available resources. Finally, we were able to reduce both in-country and Seattle-based resources devoted to project management. Each of these has led to increased efficiency and allowed in-country staff to deploy KenyaEMR in over 100 sites during the first six months of implementation scale-up.

PART 2. HEALTH FACILITY-LEVEL INVESTMENTS IN KenyaEMR

INTRODUCTION

The purpose of this section of the report is to estimate the in-country costs incurred by I-TECH to support KenyaEMR implementation at the health facility-level. These analyses will help us understand the variability of costs across health facilities and how factors such as administrative level (i.e., dispensary, health centre, sub-district hospital, and district hospital), number of current HIV-infected patients, number of staff trained to support the system, and time needed to implement KenyaEMR affect the cost of KenyaEMR implementation. The results of this report will inform policy makers and program managers about strategies for targeting sites for KenyaEMR implementation, and for limiting the variability in the cost of implementation.

METHODS

Data Collection

I-TECH Kenya Direct Costs

This report includes in-country 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. As defined in the initial report, which summarizes overall project costs, in-country project costs accounted for 65.9% of all KenyaEMR project expenditures during this period. 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 the internal I-TECH Kenya 'QuickBooks' accounting system.

KenyaEMR Implementation

Within each health facility, KenyaEMR implementation comprised several activities that occurred in a semi-linear fashion. As described above, these included: site readiness assessment, Health Manager sensitization training, end-user training, identification and training of on-site mentor, installation and configuration, and data migration and retrospective data entry. For this report, we used programmatic data to characterize KenyaEMR implementation in each health facility as follows:

- *Number of trainees*: Number of health facility employees trained to support KenyaEMR implementation.
- *Date of initiation of KenyaEMR implementation:* We assumed that initial engagement with health facilities preceded site assessment by 30 days. Therefore, the date of initiation of KenyaEMR implementation was defined as 30 days prior to site assessment.
- *Date of completion of KenyaEMR implementation*: We assumed that I-TECH support to a health facility continued for 60 days after KenyaEMR installation. Therefore, date of

completion of KenyaEMR implementation was defined as 60 days after KenyaEMR installation.

- *Duration of KenyaEMR implementation*: Defined as the period between the date of initiation of KenyaEMR implementation and the date of completion of KenyaEMR implementation, unless the observation period ended prior to 60 days after KenyaEMR installation. In this case, duration of KenyaEMR implementation was censored at the end of the observation period.
- *Active engagement in KenyaEMR implementation*: A site was defined as actively engaged in KenyaEMR implementation for the duration of KenyaEMR implementation.

Health Facility Characteristics

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

- *Type of health facility*: dispensary, health centre, sub-district hospital, district hospital, other hospital. We obtained information on categorization of health facilities 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.

Cost Allocation

We identified a total of 3,318 expense 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. Allocation of costs was conducted as follows:

- *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, then allocated to Western Region sites as defined above.

ANALYSIS

We employed descriptive statistics (median, mean, minimum, maximum, standard deviation) to characterize 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, as well as the relationship between average costs per trainee and staff size 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.

RESULTS

Health Facility Characteristics

Table 2 describes the characteristics of the 35 health facilities in the Western Region included in KenyaEMR implementation. The number of HIV-infected patients in care ranged from 35 to 6000, the number of health facility staff trained to support KenyaEMR implementation ranged from 1 to 21, and the number of days actively engaged in KenyaEMR implementation during the time frame of the study ranged from 30 to 224. In general, the number of HIV-infected patients in care, number of health facility staff trained to support KenyaEMR implementation, and days actively involved in KenyaEMR implementation increased as the health facility level increased.

Table 2. 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 [32–1,908]	3 [1–8]	95 [30–224]
Sub-District Hospital	11	7	1,120 [350–2,609]	4 [1–12]	103 [79–149]
District Hospital	7	6	2,541 [1,050–6,000]	6 [2–21]	127 [77–140]
Other Hospital*	1	1	4,512	12	68
Totals	**35**	**21**	**1,057 [32–6,000]**	**4 [1–21]**	**103 [30–224]**

** These facility levels contain only one site. Median and range values are equivalent*

Costs by Health Facility

Total non-personnel costs associated with KenyaEMR implementation within 35 health facilities in the Western Region was US$345,748. The average cost per site was US$9,879 (standard deviation = US$6,028). Table 2 includes a summary of costs by type of health facility. Cost per health facility ranged between $4,302 and $35,408, average cost per patient ranged between $2.61 and $183.45, and average cost per health facility staff member trained to support KenyaEMR implementation ranged between $1,098 and $6,900. Overall, the average cost per health facility increased as the health facility level increased. However, the average cost per patient and the average cost per health facility staff member trained to support KenyaEMR implementation decreased as the level of the health facility increased.

Table 3. Summary of Costs by Facility Type

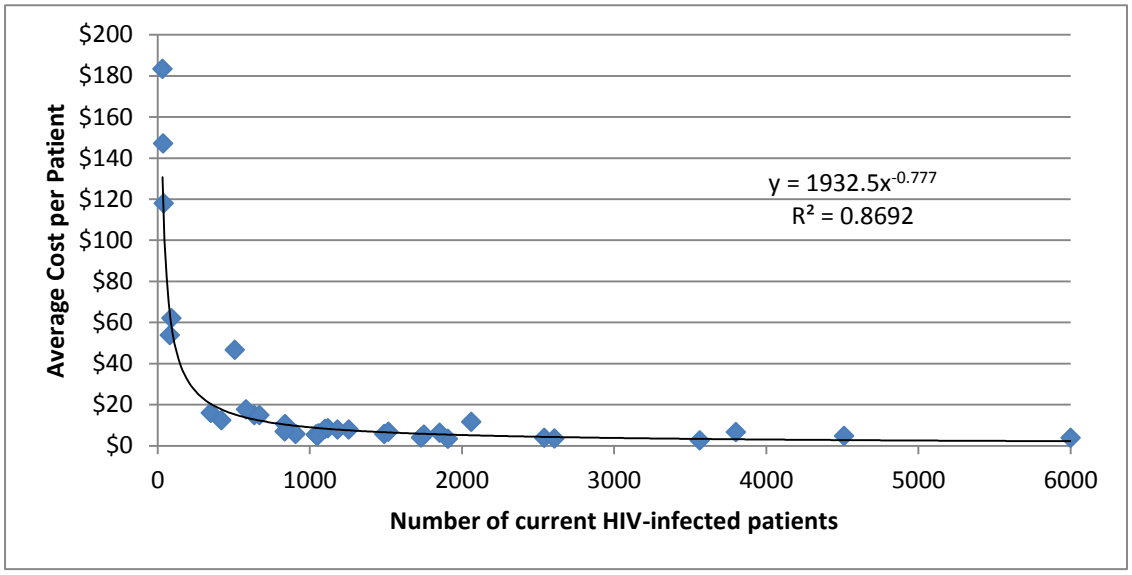
Facility Type	Cost per Facility median [range]	Cost per Patient median [range]	Cost per Trainee median [range]
Dispensary*	$5,147.24	$147.06	$1,286.81
Health Centre	$6,525.77 [$4,301.92–$23,575.43]	$12.45 [$3.42–$183.45]	$2,810.63 [$1,658.57–$6,900.31]
Sub-District Hospital	$9,329.10 [$5,147.24–$24,089.70]	$7.89 [$3.46–$17.74]	$2,112.83 [$1,397.35–$5,683.04]
District Hospital	$9,486.93 [$5,045.80–$25,408.10]	$4.81 [$2.61–$8.14]	$1,939.74 [$1,097.95–$4,474.78]
Other Hospital*	$21,592.77	$4.79	$1,799.40
Totals	**$8,949.56 [$4,301.92–$25,408.10]**	**$6.91 [$2.61–$183.45]**	**$2,238.78 [$1,097.95–$6,900.31]**

** These facility levels contain only one site. Median and range values are equivalent.*

Costs by Patient Volume

We observed a strong relationship between cost per HIV-infected patient and current number of HIV-infected patient in care at the health facility (Figure 5). Average cost per HIV-infected patient is high for small facilities, and sharply lower for the larger facilities. In addition, despite a small sample of facilities for the Western region (n=35 sites), facility size seems to have fairly robust explanatory power for cost variation (R^2=0.8692).

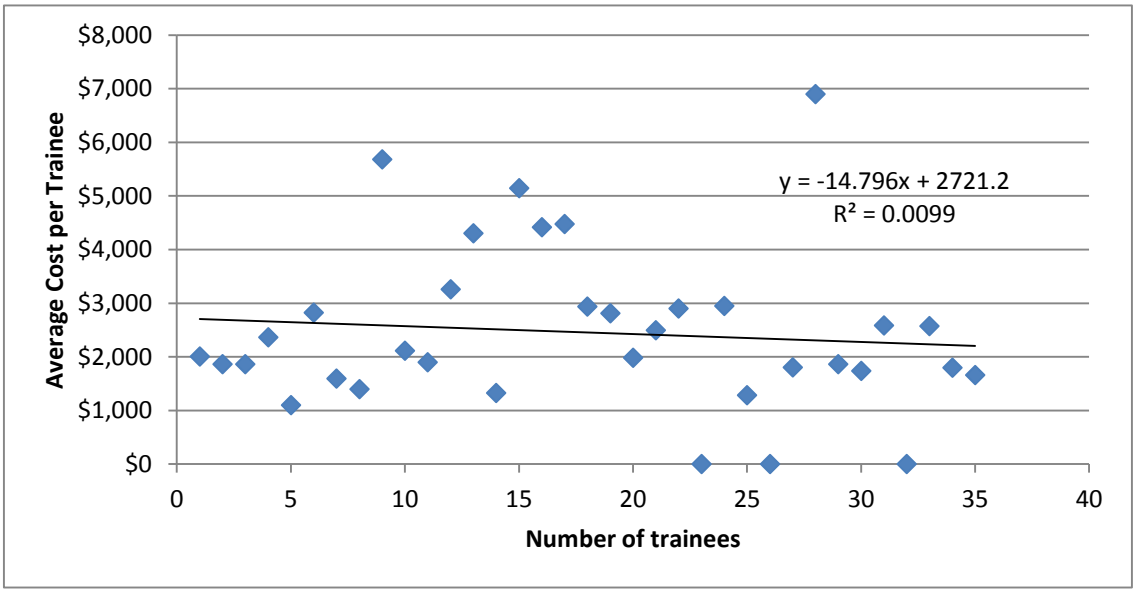
Figure 5. Average Cost per Patient by Number of Current HIV-infected Patients



Costs by Staff Size

In contrast, we observed no discernible relationship between cost and number of staff trained (Figure 6). In addition, some sites had not trained any staff during the study period, which resulted in some sites without average-cost-per-staff-trained metrics. The number of trainees had virtually no explanatory power for cost variation (R^2=0.0099).

Figure 6. Average Cost per Trainee by Number of Trainees



Costs by Time to Implementation

We observed moderate associations between costs and days needed to implement KenyaEMR. Total costs per health facility increased with increasing number of days to KenyaEMR implementation (Figure 7). We observed a bi-modal relationship between cost per current HIV-infected patient and

days needed to implement KenyaEMR, such that the lowest cost per current HIV-infected patient occurred within sites needing around 150 days to implement KenyaEMR (Figure 8).

Figure 7. Total Health Facility Costs by Time to Implementation

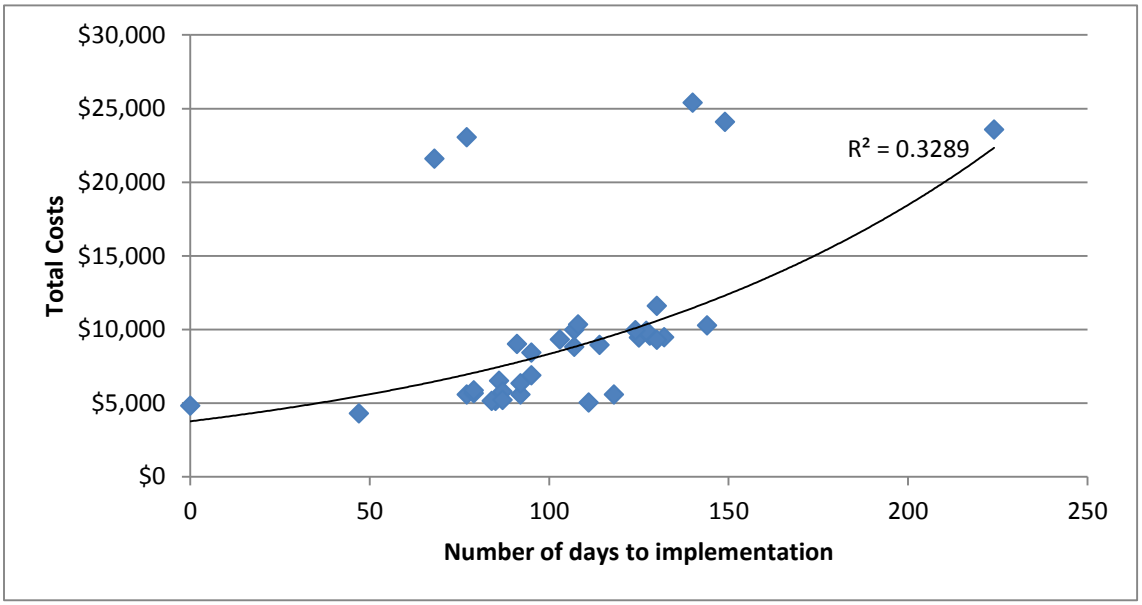
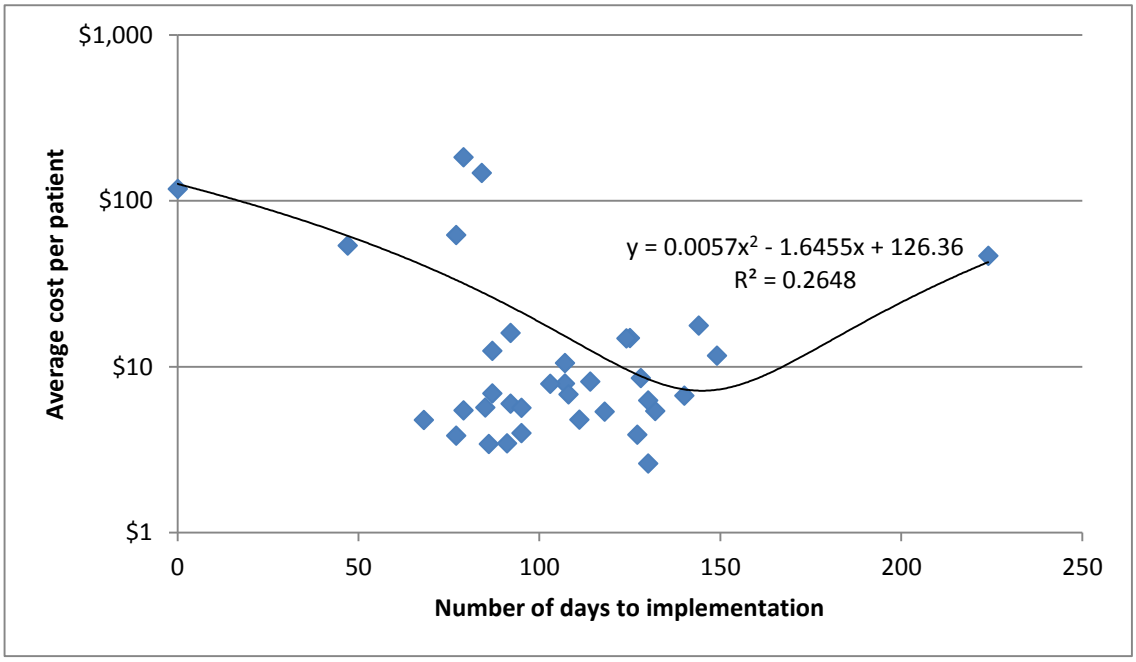


Figure 8. Average Cost per Current HIV-infected Patient in Care by Days to Implementation



Sensitivity Analyses

We conducted sensitivity analyses to explore the effect of extending the active period of implementation by one additional month (to a total of three months) after installation, as well as the effect of restricting analyses to only those sites which had completed implementation during the observation period. These sensitivity analyses had little effect on the observed results. Larger

sites (those with more current HIV-infected patients) were more likely to implement KenyaEMR earlier in the observation period. Therefore, for both sensitivity analyses, we observe larger total costs per site and lower costs per current HIV-infected patients, but the estimated cost per patient based on the size of the health facility was virtually identical (data not shown).

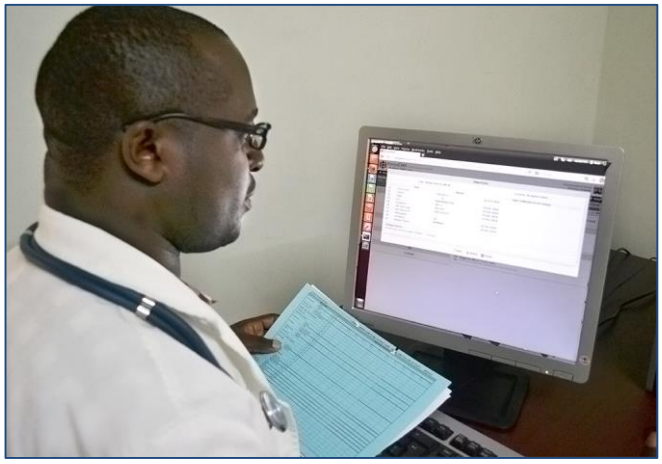
DISCUSSION

Economies of Scale

We observed substantial economies of scale and scope in the health facility-level costs of KenyaEMR implementation. 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. These findings are important for regional, district and national level planners in terms of determining: 1) total resources required for Kenya EMR; and 2) the sequence of Kenya EMR 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).

Costs per Site

The average cost of US$9,879 per site is consistent with parallel findings from the 'global analysis' of Kenya EMR costs. Although the global analysis presented average cost per site as approximately $20,000 per site, approximately $10,000 of these costs was generated at the Seattle or international headquarters level, which was excluded from this analysis of health facility-level costs. We observed very little variability in cost per patient within health facilities with greater than 700 current HIV-infected patients, where costs were uniformly less than $20 per patient. The variability in cost per patient was greatest within the health facilities with fewer than 700 current HIV-infected patients. This occurred because when costs are allocated equally across multiple health facilities, they disproportionately impact cost per patient within smaller health facilities. Additional research is needed to estimate the incremental costs associated with implementing in smaller health facilities located geographically close to larger health facilities, where proximity might bring efficiencies in resource allocation for EMR implementation, support and maintenance.



Key Cost Drivers

We reviewed a number of possible key drivers of costs at the site level. Of note, no association was found between number of trainees and costs per site, indicating that site-level costs are not

associated with such personnel investments. In addition, costs per site were not associated with 'time to implementation'. Conversely, key cost drivers at this site level included: (1) level of service delivery, and (2) number of HIV/AIDS patients at each site. These findings indicate that 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 data entry loads or to support point-of-care system use, 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.

CONCLUSIONS AND FUTURE WORK

LESSONS LEARNED: OVERALL COSTS

The overall costs of KenyaEMR implementation are driven by human resources, rather than by the purchasing of equipment as might be expected in a technological intervention. The results of this study suggest that I-TECH implementation of KenyaEMR required substantial initial project management and Seattle-based leadership to develop a project framework and workplan. The proportion of costs associated with project management declined substantially over time, and the average cost per full EMR implementation decreased with time and scale-up, indicating increases in efficiency.

It also suggests that in-country leadership has increased substantially through model site implementation and implementation scale-up. The share of in-country costs increased over time. There is a continued need to focus on 'in-country ownership', with an emphasis on transferring leadership to Ministry of Health and Implementing Partner staff in development, training, deployment, support, and maintenance of KenyaEMR. Additional planned changes in implementation to include Ministry of Health and Implementing Partner staff in development, training, deployment, support and maintenance of KenyaEMR will aide in the further transfer of 'ownership' of the project to in-country personnel.

Additional efficiencies in KenyaEMR implementation, which have occurred subsequent to the observation period, including reduction in the duration of trainings, and collaboration with implementing partners in all aspects of KenyaEMR implementation, will substantially reduce costs associated with broader KenyaEMR rollout. However, continued support for human resources and travel will be important to insure maintenance of high quality implementation of KenyaEMR.

LESSONS LEARNED: HEALTH FACILITY-LEVEL COSTS

We observed substantial economies of scale and scope in the health facility-level costs of KenyaEMR implementation. 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. We observed very little variability in cost per patient within Sub-District and District Hospitals with greater than 700 current HIV-infected patients, where costs were uniformly less than $20 per patient. These results suggest prioritization of KenyaEMR implementation in health facilities with greater than 700 patients. We observed substantially lower—and surprisingly stable—average costs per patient for KenyaEMR implementation in these larger settings.

The variability in cost per patient was greatest within the health facilities with fewer than 700 current HIV-infected patients. This occurred because when costs are allocated equally across multiple health facilities, they disproportionately impact cost per patient within smaller health

facilities. Additional research is needed to estimate the incremental costs associated with implementing in smaller health facilities located geographically close to larger health facilities. Future cost evaluation of the post-deployment stage would also be valuable and informative to the Kenya Ministry of Health.

There may be some level below which it is not efficient to implement KenyaEMR in its current form. For health facilities with fewer than 300 current HIV-infected patients, we estimated the cost of KenyaEMR implementation at greater than $50 per current HIV-infected patient. Given the difficulty of maintaining staffing, and therefore skills associated with KenyaEMR implementation, within these settings, 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 simple a simple web-based interface and phone or tablets for data entry in these smaller settings.

LIMITATIONS

The overall cost analysis is limited in two 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 Ministry of Health or other implementing partners. A proposed national cost-effectiveness study will be able to explore this more complete set of costs. Still, the current study is useful to inform the design of a more comprehensive national cost-effectiveness study. Second, this analysis includes only macro-level project costs through September 2013, reflecting a timeframe that was still fairly early in the EMR implementation experience for KenyaEMR sites. Further work is needed to establish on-going support and maintenance costs for the system.

The health facility-level cost analysis is also limited in several ways. First, the small number of sites used as our sample for this review and analysis is a possible limitation to the generalizability of the results of this work. Second, the distinct geographical focus of this review (all sites were located in the Western Province of Kenya) may also hinder generalizability of results at the broader national level. Third, the limited timeframe for our review period limited the inclusiveness of all possible Kenya EMR micro-costs. Fourth, the administrative records used for the analysis did not routinely allocate or assign many costs to specific facilities, and the rule set we devised for allocation of costs based upon 'active implementation' periods may have only approximated the true level investments to particular sites in some cases. Fifth, not all site-level costs were captured by our analysis. The variability in costs we observed may have been under or over-estimated, depending on such factors as the level of site readiness due to prior infrastructure investments, or the level of EMR implementation costs borne by the Ministry of Health or other stakeholders. A final limitation relates to the possible non-equal allocation of shared costs (e.g., group trainings) across health facilities. In our analysis, due to limitations on information, it was not possible to identify if such costs should have been allocated equally across sites independent of their location and size. Further analyses may determine if such shared costs should be allocated equally across sites.

FUTURE WORK

Our report summarizes I-TECH's direct costs for KenyaEMR implementation in four regions of Kenya. Future work is needed to estimate: 1) costs for implementation of other MOH-endorsed EMR systems in Kenya, such as IQCare or C-PAD; 2) costs borne by the Ministry of Health and other implementing partners in supporting EMRs; 3) costs of EMR implementation during a maintenance phase of implementation when EMR systems are highly mature (e.g., after 2-3 years); 4) efficiencies or cost savings which can be attributed to EMR use; and 5) health benefits resulting from EMR use. Future work in this area would enable a more comprehensive picture of societal costs, benefits, and cost-effectiveness of EMRs.

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