Training healthcare workers on the use of electronic medical records in HIV clinics in Kenya: An evaluation of three training models

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Abstract

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There is substantial evidence that use of electronic medical records (EMR) can improve the quality of health services, yet a number of recent studies have identified inadequate training in health informatics as a persistent barrier to the implementation of EMR in low-resource settings. From September 2012 to 2014, The International Training and Education Center for Health (I-TECH) trained 1,392 Kenyan healthcare workers on the use of EMR for point-of-care data entry using three distinct training models.

The study is a quantitative program evaluation of the three training models comparing cost, geographic coverage, and quality of training, as measured by pre- and post-tests. Paired t-tests were conducted to examine the changes in score from pre-test to post-test within training periods, and multiple linear regression was used to examine the associations between mean post-

test scores variable by the training model and adjusted for pre-test score, age, sex, province, and cadre. The three-day, on-site model was the least expensive and had the largest geographic range, and quality of training did not differ substantially by the training model. Shorter trainings were associated with learning loss in computer literacy. The trainings were particularly effective for nurses, who had the highest mean change scores ($p<0.001$) in comparison to other cadres.
Keywords: electronic medical records, EMR, training, Kenya, health workforce, I-TECH, health information systems, HIS

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1. INTRODUCTION

There is substantial evidence that use of electronic medical records (EMR) in low-resource settings can improve the quality of health services by supporting improvements in diagnoses and reductions in wait times, data errors, missed appointments, and medication errors [1,2,3]. EMR systems can also improve patient safety and clinical decision-making, especially in the context of rapidly changing clinical guidelines [2]. For HIV patients, EMR is associated with increased odds of initiating antiretroviral therapy (ART) [4] and reductions in missing CD4 results [1,2]. EMR can also be used to generate aggregate data more efficiently for research, administrative, and evaluation purposes [5,6].

There is widespread agreement that a skillfully trained health workforce is essential to the sustainable implementation of EMR systems [2,7]. Yet a number of recent studies have identified inadequate training in health informatics as a persistent barrier to the implementation of EMR in low-resource settings [2,7,8]. This lack of training includes low levels of computer literacy among clinical staff and a lack of appropriate training on point-of-care data entry and using EMR for clinical decision-making [7]. Insufficient training has also been linked to slow rates of EMR adoption by health facilities [9] and low levels of system use [5]. In a study conducted in fifteen countries in Africa, Asia, and South America, Forster et al. also noted a positive association between staff training and data quality for ART programs, such that data entry improved significantly with additional training [10].

From September 2012 to September 2014, The International Training and Education Center for Health (I-TECH) trained 1,392 Kenyan healthcare workers in four regions in Kenya to use KenyaEMR, an EMR system used for point-of-care data entry and clinical decision-making. Over the course of this 25-month period, I-TECH applied three different training delivery models that differed by the duration of training, location of training, and the profile of the trainers. This study evaluates whether the cost per trainee and per facility, geographical extent of health facility coverage, and the quality of training, measured by pre- and post-test scores, differed according to the training model.

2. METHODS

The study is a quantitative program evaluation comparing three distinct training models used by I-TECH to train healthcare workers in Kenya on the use of EMR for point-of-care data entry and clinical decision-making for HIV patients. Training models were compared based on three criteria: cost, coverage, and quality. Cost was defined as the cost of training per trainee and per facility. Coverage was defined as the geographic coverage of staff trainings, or the number of facilities in which at least one staff member was trained. Quality was defined as changes in knowledge of and attitudes towards EMR as measured by pre- and post-tests administered before and after the completion of training.

2.1 Cost

An analysis of training-related costs was conducted using internal I-TECH costing records coded by expenditure category, time period, and activity category, a code that identifies whether the cost was for curriculum development or for training delivery. Cost was calculated per trainee and per facility and stratified by location, including costs incurred in Kenya and costs incurred at the I-TECH headquarters in Seattle, Washington.

2.2 Coverage

Geocodes were provided by the Kenya Ministry of Health (Kenya MoH), and ArcGIS was used for mapping and analysis.

2.3 Quality

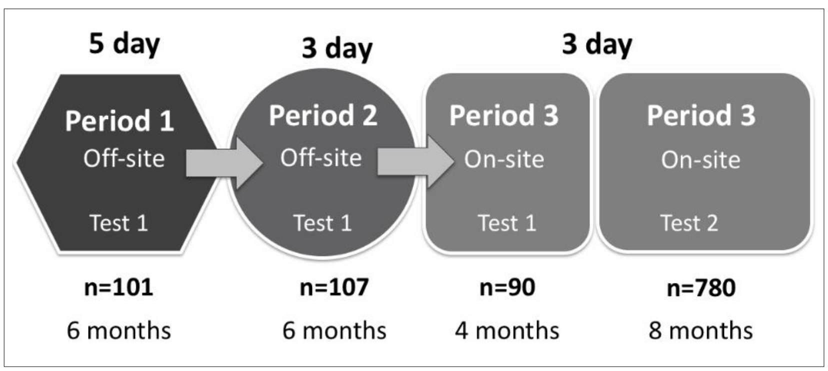
Trainings were conducted from September 1, 2012 to September 30, 2014 in the Central, Nyanza, Rift Valley, and Western regions of Kenya as a part of an on-going partnership between I-TECH, the U.S. Centers for Disease Control, and the Kenya MoH. Because the training models were implemented sequentially, time period is used as a proxy for training model and the training models are referred to as Period 1, Period 2, and Period 3. A similar curriculum was used in all three periods, with a condensed version of the Period 1 curriculum used for the shorter trainings in Periods 2 and 3. Training models differed primarily in off-site versus on-site delivery and the length of the trainings. The training models are defined as:

Period 1 (September 1, 2012 – March 1, 2013): Healthcare workers who were identified as potential end users of KenyaEMR were trained off-site for five days on point-of-care data entry and EMR-based clinical decision-making. Trainings were conducted at hotels and the trainees were provided with reimbursements for travel and *per diem*. A pre-test was administered at the beginning of the first day of training, and an identical post-test was administered at the close of the fifth day. No trainings were conducted in March of 2013.

Period 2 (April 1, 2013 – September 30, 2013): The training curriculum used in Period 1 was condensed for delivery via a three-day training. Other aspects of the training, including off-site delivery at hotels, remained the same. A pre-test was administered at the beginning of the first day of training, and a post-test was administered at the close of the third day. The tests were identical to those used in Period 1.

Period 3 (October 1, 2013 – September 30, 2014): The training model used in Period 2 was converted to a three day, on-site training in which trainers delivered the trainings at the healthcare facilities where the trainees worked. As in Period 2, a pre-test was administered at the beginning of the first day of training, and an identical post-test was administered at the close of the third day.

Figure 1. Training models by length, location, and number of trainees



During all three periods, health facilities treating HIV-positive patients were evaluated for appropriate infrastructure to support EMR use, including regular electricity and security measures, and eligible facilities were asked to internally select healthcare workers to be trained. Trainees were chosen from a variety of cadres, including nurses, clinical officers, and health records information officers (HRIOs). During Period 3, trainees who demonstrated a strong aptitude and enthusiasm for the use of EMR were selected by consensus between trainers and trainees to complete an additional day of mentorship training in order to provide on-site technical support and promote use of KenyaEMR. The additional day of mentorship training was conducted after the completion of the post-test and was not included in the analysis.

2.4 Data collection

Paper-based pre- and post-tests were routinely administered by trainers at the start and end of each training. The tests were then collected and entered into Formhub, an electronic data collection tool, by I-TECH data entry personnel. Test 1 was administered in Periods 1 and 2 and the first four months of Period 3. As a result of on-going monitoring, Test 1 was then altered to create Test 2, which was administered for the remainder of Period 3. Test 2 contains more complex questions about EMR use and eliminates the Computer Skills section, in which trainees self-rated their abilities to perform basic tasks on a computer. Demographic data, including age, sex, level of education, cadre, and primary and secondary responsibilities, were collected from trainees by trainers and stored in the Training System Monitoring and Reporting Tool (TrainSMART), an open-source, web-based system for collecting training data. Information about health facilities was extracted from the Kenya Master Health Facility List, which is updated regularly and publicly available online.

2.5 Data analysis

Descriptive statistics are presented in frequency and percentages in order to identify the mean differences in pre- and post-test scores among groups with different demographic characteristics. Paired t-tests were conducted to examine the changes in score from pre-test to post-test within periods. Multiple linear regression was then used to examine the association between post-test scores and the independent variable of interest (training model) after adjustment for pre-test score, age, sex, region, and cadre. All tests were two-tailed and $p<0.05$ was considered statistically significant. Level of education and primary responsibility were excluded from the analysis due to a lack of reliable data. Stata 14 (Stata Corporation, College Station, TX) was used for data analysis.

Test questions were divided into three categories based on adult learning theory: Knowledge, Skills, and Attitudes. The Knowledge category includes questions pertaining to the use and limitations of EMR, including questions about data entry, troubleshooting, and clinical decision-making. In the Skills category, trainees self-rated their levels of computer literacy. The Attitudes category includes questions about the perceived utility of EMR and its relevance to patient care. Sample questions are included in **Table 1**:

Table 1. Examples of Knowledge, Skills, and Attitudes test questions

Knowledge	What are three ways to enter data into the KenyaEMR system?
	A. Typing text in a field B. Voice recoding of clinical notes C. Clicking on a radio button to select a single option D. Scanning completed forms E. Selecting options from a drop-down menu
Skills	Do you know how to use a mouse to click and "drag" an item?
	Yes/No/Unsure, but likely
Attitudes	Which of the following decisions can be made using health data entered into an EMR system?
	A. The number of nurses to have on duty on a particular day B. Where to conduct community outreach activities C. Changing a patient’s drug regimen D. Changing standard treatment and care guidelines

During on-going monitoring, I-TECH personnel determined that the three questions in the Attitudes category of Test 1 were not clearly worded, and those questions were excluded from the analysis. On Test 2, Attitudes questions were phrased clearly and were therefore included in the analysis.

Both Tests 1 and 2 contain a mix of true/false, fill-in-the-blank, and multiple choice questions. Responses were treated as correct or incorrect, with one point awarded for each correct selection. For multiple choice questions, partial credit was awarded for selection of any of the correct responses. For example, if a trainee was asked to “select all that apply” from a multiple choice question in which A and B were correct, the trainee received two points for selecting A and B or one point if only A or B was selected. This “partial credit” approach allowed us to capture smaller learning gains and to weight the additional understanding required to answer questions with multiple response choices.

Although the instrument change in Period 3 precludes a direct comparison of trainees who completed Test 1 with those who completed Test 2, we were able to compare the test results from Periods 1 and 2 with the test results of the sub-set of trainees who completed Test 1 during Period 3 (n=90) using a multiple linear regression model adjusted for period, pre-test score, and trainee characteristics. In an exploratory analysis, we also conducted a multiple linear regression to separately examine the association between post-test scores for Tests 1 and 2 and trainee characteristics including age, sex, province, and cadre. In this way, we indirectly and qualitatively compared patterns of associations between results and demographic characteristics across Tests 1 and 2.

3. ETHICAL APPROVAL

The study is a program evaluation and is not human subject research as determined by the University of Washington Institutional Review Board and the U.S. Centers for Disease Control and Prevention.

4. Financial disclosure

The work has been supported by The United States President's Emergency Plan for AIDS Relief (PEPAR) through the Health Resources and Services Administration, under award number U91HA0680, to the International Training and Education Center for Health (I-TECH) at the University of Washington.

5. Results

5.1 Cost

The cost of training per person and per facility declined by period (**Table 2**). In all periods, the majority of costs were for training delivery, as opposed to curriculum development, and were accrued in Kenya. No curriculum development costs were recognized in Period 2 as trainers used a shortened version of the Period 1 curriculum. Despite the longer training period in Period 3 (12 months), the total cost of the trainings fell from $602,342 in Period 1 to $491,432 in Period 3. Training delivery costs composed 93.0% of all costs, while curriculum development costs composed 7.0%.

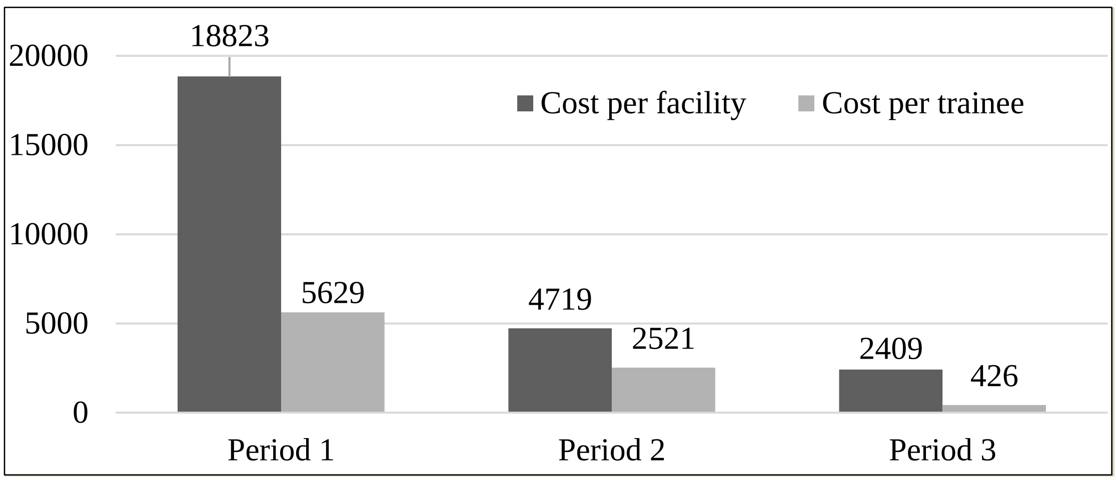
Table 2. Costs for curriculum development and training delivery by location in U.S. Dollars

	Mos.	**Facilities**	**n**	**Curriculum Development**			**Training Delivery**			**Total Costs**
				Kenya	Seattle	**Total**	Kenya	Seattle	**Total**	
Period 1	6	32	107	29,023	14,325	43,348	401,302	157,692	558,994	602,342
Period 2	6	70	131	0	0	0	236,941	93,364	330,306	330,306
Period 3	12	204	1,154	30,879	25,270	56,149	295,078	140,205	435,283	491,432
Total	24	306	1,392	59,902	39,595	99,497	933,321	391,262	1,324,583	1,424,080

Cost per trainee declined by 55.2% from Period 1 to Period 2, likely as a result of the decreased length of training, and by an additional 83.1% from Period 2 to Period 3 (**Figure 2**). When only training delivery costs were included in the analysis, the cost per trainee declined by 51.7% from

Period 1 to Period 2 and an additional 85.0% from Period 2 to Period 3. The cost per facility in which at least one healthcare worker was trained declined by 74.9% from Period 1 to Period 2 and by 48.9% from Period 2 to Period 3, or an average decline of $16,414 per facility from Period 1 to Period 3 (**Figure 2**).

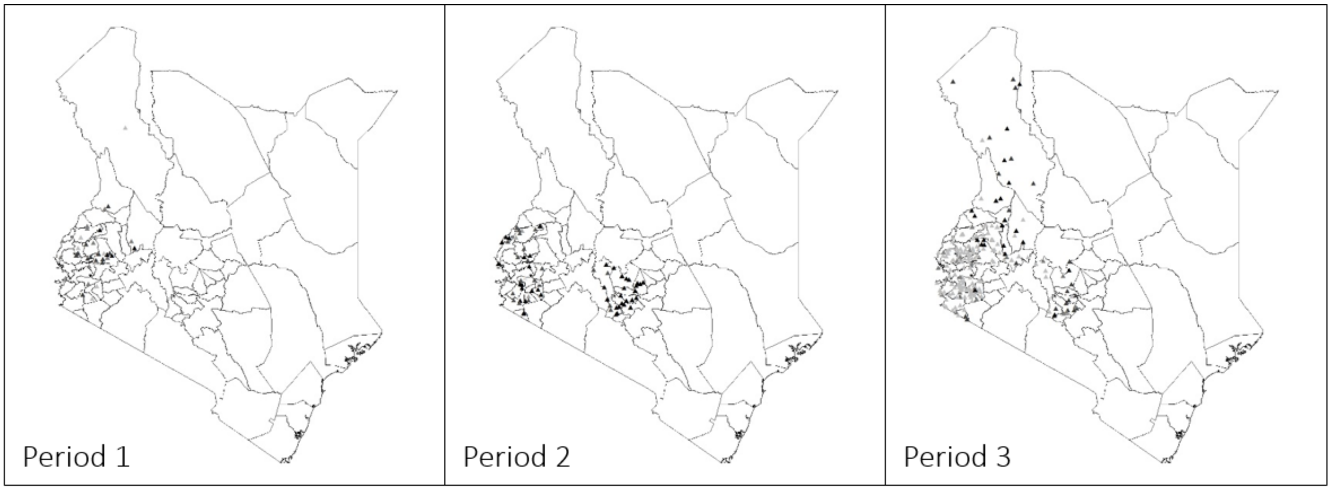
Figure 2. Cost per trainee and per facility in U.S. Dollars, by period



5.2 Coverage

The number of facilities in which at least one staff member was trained increased by period (**Figure 3**), with 32 facilities receiving training for at least one healthcare worker in Period 1, 70 facilities receiving training in Period 2, and 204 facilities receiving training in Period 3. During the first six months of Period 3, 98 facilities received training for at least one healthcare worker. The number of small facilities receiving training also increased in Period 3. During Period 1, the majority of facilities (62.5%) in which at least one healthcare worker was trained were Level 4 facilities, compared to 35.7% of facilities in Period 2 and 17.6% in Period 3. In Period 2, the majority of facilities were Level 3 (55.7%), while only 8.6% of facilities were Level 2. There was a large percentage increase in the number of Level 2 facilities trained in Period 3 (34.8%), while the majority of facilities were Level 3 (47.1%).

Figure 3. Health facilities in which at least one staff member was trained, by period



5.3 Quality

1,392 healthcare workers were trained during Periods 1 - 3, including clinical and non-clinical staff. Of those trainees, 1,088 (78.2%) completed both a pre-test and a post-test and were able to be matched with demographic information. Trainees who completed only one test or were not matched with demographic information were excluded from the analysis (21.8%). Of the 1,088 trainees included in the analysis, 298 (27.4%) were trained during the administration of Test 1 and 790 (72.6%) were trained during Test 2.

The majority of trainees were female (62.9%), with a total age range of 19 - 90 (**Table 3**). Trainees in Period 2 were slightly younger than trainees in other periods, with a mean age of 31 compared to 35 in Periods 1 and 3. Nurses (40.0%) and clinical officers (17.6%) comprised the majority of trainees. Respondents whose cadres were listed as "Other/Missing" were from a variety of cadres, including receptionists and nutritionists, although the majority were missing data (n=36). The largest group of trainees were from the Nyanza region (43.1%).

Table 3. Demographic characteristics of trainees, by period and test

	Period 1 – Test 1		Period 2 – Test 1		Period 3 – Test 1		Period 3 – Test 2	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Trainees	**101**	100.0	**107**	100.0	**90**	100	**790**	100.0
Female	61	60.4	67	62.6	51	56.7	505	63.9
Male	40	39.6	40	37.4	39	43.3	285	36.1
Age*								
Mean age	34.5	-	31.2	-	34.8	-	35.0	-
19 - 29	26	25.7	46	43.0	24	26.7	256	32.4
30 - 39	43	42.6	44	41.1	44	48.9	247	31.3
40 - 49	15	14.9	7	6.5	11	2.2	144	18.2
50+	6	5.9	4	3.7	9	10.0	57	7.2
Missing	11	10.9	6	5.6	2	2.2	86	10.9
Cadre*								
Nurse	39	38.6	29	27.1	39	43.3	328	41.5
Clinical Officer/Physician	38	37.6	27	25.2	22	24.4	108	13.7
HRIO/Data Clerk/Analyst	17	16.8	43	40.2	19	21.1	105	13.3
Counselor/Health Educator	0	0.0	3	2.8	2	2.2	123	15.6
Lab/Pharmacy Technician	4	4.0	3	2.8	1	1.1	71	9.0
Other/Missing	3	3.0	2	1.9	7	7.8	55	7.0
Region*								
Nyanza	23	22.8	44	41.1	60	66.7	342	43.3
Western	42	41.6	30	28.0	11	12.2	209	26.5
Rift Valley	36	35.6	0	0.0	19	21.1	175	22.2
Central	0	0.0	33	30.8	0	0.0	64	8.1

* Statistically significant difference in proportion by period at a level of $p<0.001$ by Chi2 test for equal proportions

Changes in test scores by period

The results of paired t-tests to examine mean differences in score within periods are shown in **Table 4**. Mean change scores were the highest in Period 1 and lowest in Period 2 in both the Knowledge and Computer Skills categories (**Table 4**). Mean changes in score were statistically significant at $p<0.001$ for all categories in all periods, indicating learning gains during the use of all three training models.

Table 4. Pre-test, post-test, and change scores by period and category

Category	Maximum Possible Score	Mean Pre-test	Mean Post-test	Mean Change (SD)	95% Confidence Interval for Change Score
Period 1 – Test 1 (n=101)					
Computer Skills	9.0	6.53	8.71	2.18* (1.99)	1.78 - 2.57
Knowledge	26.0	14.53	18.23	3.69* (2.95)	3.11 - 4.28
Total	35.0	21.07	26.94	5.87* (3.56)	5.17 - 6.57
Period 2 - Test 1 (n=107)					
Computer Skills	9.0	7.96	8.62	0.66* (1.56)	0.36 - 0.96
Knowledge	26.0	17.09	18.16	1.07* (3.52)	0.39 - 1.74
Total	35.0	25.05	26.78	1.72* (4.24)	0.91 - 2.54
Period 3 - Test 1 (n=90)					
Computer Skills	9.0	6.47	8.06	1.58* (2.05)	1.15 - 2.01
Knowledge	26.0	14.83	17.59	2.76* (2.98)	2.13 - 3.38
Total	35.0	21.31	25.64	4.34* (3.98)	3.51 - 5.17
Period 3 – Test 2 (n=790)					
Attitudes	10.0	7.05	8.02	0.96* (1.70)	0.84 - 1.08
Knowledge	30.0	17.86	21.36	3.50* (4.17)	3.21 - 3.79
Total	40.0	24.91	29.37	4.46* (4.13)	4.13 - 4.80

*Statistically significant at a level of $p<0.001$

Association between training models and test results

The results of a multiple linear regression analysis to examine the association between mean post-test scores on Test 1 variable by the training models and adjusted for pre-test score, age, sex, region, and cadre are presented in **Table 5**. In comparison to Period 1, Knowledge scores were slightly lower in both Periods 2 and 3, although the results were not statistically significant at $p<0.05$, indicating some consistency in Knowledge post-test scores across periods (**Table 5**).

Computer Skills scores, however, differed substantially by the training model. Adjusting for pre-test score, Computer Skills post-test scores were lower in Period 2 (-0.42 points) and in Period 3 (-0.65 points) than in Period 1, indicating smaller learning gains in computer literacy among trainees enrolled in the shorter trainings ($p<0.001$) (**Table 5**).

Table 5. Multiple linear regression of post-test Knowledge and Computer Skills scores (Test 1)

Variable	**Knowledge** (n=298)			**Computer Skills** (n=298)		
	Estimate	**Robust SE**	**95% CI**	**Estimate**	**Robust SE**	**95% CI**
Pre-test score	0.39^{***}	0.05	0.29 – 0.48	0.20^{***}	0.03	0.15 – 0.25
Age	-0.05^{*}	0.02	-0.09 - 0.00	-0.01	0.01	-0.03 – 0.00
Female	0.02	0.32	-0.62 – 0.66	0.07	0.09	-0.11 – 0.24
Period (ref. = Period 1)						
Period 2	-0.95	0.39	-1.73 - -0.18	-0.42^{***}	0.09	-0.60 - -0.24
Period 3	-0.39	0.39	-1.15 – 0.37	-0.65^{***}	0.13	-0.90 - -0.40
Region (ref. = Nyanza)						
Western	0.99^{*}	0.42	0.16 – 181	0.00	0.12	-0.24 – 0.24
Rift Valley/Central	0.04	0.39	-0.72 – 0.81	-0.08	0.11	-0.30 – 0.13
Cadre (ref. = Nurses)						
Clinical Officer/Physician	0.00	0.41	-1.09 – 0.72	-0.12	0.12	-0.37 – 0.12
HRIO/Data Clerk/Analyst	-0.41	0.43	-1.62 – 0.21	-0.06	0.12	-0.29 – 0.17
Other/Missing	-0.76	0.63	-2.76 – 0.00	-0.46	0.26	-0.97 – 0.06

*Statistically significant at a level of $p<0.05$; **Statistically significant at $p<0.01$; ***Statistically significant at $p<0.001$

Association between trainee characteristics and test results

Pre-test scores differed by age and sex (see **Appendix A**), with females scoring lower than males on the pre-test in all periods. However, females also exhibited greater mean change scores than males in all periods. Pre-test scores also declined by age group. Trainees aged 50 and older scored the lowest on the pre-test in both the Computer Skills and Knowledge categories, although they had the greatest mean change scores in Computer Skills of any age group.

The results of a multiple linear regression analysis to examine the association between mean post-test scores on Test 2 variable by the training models and adjusted for pre-test score, age, sex, region, and cadre are presented in **Table 6**. On both Tests 1 and 2, Knowledge scores declined by age: for each additional year of age, the mean post-test score on Test 2 was 0.08 points lower controlling for pre-test score ($p<0.01$) (**Table 6**). On Test 1, the mean Knowledge post-test score was 0.05 points lower ($p<0.05$) (**Table 5**).

Nurses exhibited the largest learning gains in comparison to all other cadres—a trend that was also present, but not statistically significant, on Test 1. In comparison to nurses, lower post-test scores in the Knowledge category were observed among HRIOs and data clerks (-0.74; *p*<0.05) and counselors, social workers, and health educators (-1.69, *p*<0.001) (**Table 6**). HRIOs and data clerks (-0.30; *p*<0.05) and counselors, social workers, and health educators (-0.77; p<0.001) also had lower post-test scores in the Attitudes category. In comparison to the Nyanza region, post-test scores in Rift Valley were low, with differences in Knowledge and Attitudes scores of -0.65 (*p*<0.05) and -0.47 (*p*<0.001) respectively. These results differed from the results of Test 1, in which post-test scores in the Western region were nearly one point higher than in Nyanza and there was no association with other regions (*p*<0.05) (**Table 5**).

Table 6. Multiple linear regression of post-test Knowledge and Attitudes scores (Test 2)

	Knowledge (n=790)			**Attitudes** (n=790)		
Variable	**Estimate**	**Robust SE**	**95% CI**	**Estimate**	**Robust SE**	**95% CI**
Pre-test score	0.39***	0.03	0.32 – 0.45	0.25***	0.03	0.19 – 0.31
Age	-0.08**	0.02	-0.11 - -0.05	-0.03***	0.01	-0.04 - -0.01
Female	-0.19	0.26	-0.71 – 0.33	0.13	0.10	-0.06 – 0.32
Region (reference = Nyanza)						
Western	0.47	0.32	-0.15 – 1.08	0.02	0.11	-0.20 - 0.23
Rift Valley	-0.65*	0.29	-1.21 - -0.08	-0.47***	0.12	-0.70 - -0.24
Central	0.38	0.38	-0.36 – 1.12	-0.09	0.16	-0.39 - 0.21
Cadre (reference = Nurses)						
Clinical Officer/Physician	-0.04	0.35	-0.72 – 0.64	0.05	0.13	-0.21 – 0.30
HRIO/Data Clerk/Analyst	-0.74*	0.37	-1.47 -0.01	-0.30*	0.15	-0.59 - -0.01
Counselor/Health Ed/Social Work	-1.69***	0.41	-2.49 - -0.88	-0.77***	0.15	-1.07 - -0.47
Lab/Pharm Technician	-0.03	0.52	-1.04 – 0.99	-0.13	0.16	-0.45 – 0.18
Other/Missing	-0.31	0.55	-0.38 – 0.77	-0.40*	0.20	-0.78 - -0.01

*Statistically significant at a level of *p*<0.05; **Statistically significant at *p*<0.01; ***Statistically significant at *p*<0.001

6. Discussion

There is a paucity of research on the role of workforce training in EMR implementation, including a lack of published evaluation studies and limited use of concrete metrics [3,7]. In addition, a 2012 literature review by Oluoch et al. concluded that limited computer literacy and health informatics training, especially for the extraction and analysis of data for research and clinical decision-making, remain major implementation challenges for EMR [1]. This study contributes to the literature on EMR implementation by providing a quantitative comparison of the length and locations of EMR trainings for healthcare workers.

In a 2014 systematic literature review, Fritz et al. identified 381 criteria in 47 published studies for the successful implementation of EMR in low-resource settings [7]. Of these 381 criteria, 37 (10%) pertained to staff training, which the authors identified as a necessary condition for success [7]. Approximately half of the training-related criteria described the initial computer literacy of users, while the remainder focused on the availability or quality of training in low-resource settings [7]. However, of the 381 success criteria identified, approximately one third lacked a corresponding concrete measure [7]. This gap in the literature has led to a limited understanding of the unique training needs of healthcare workers in low-resource settings, poor scalability of EMR pilot projects, and difficulty creating best practice recommendations [2].

Studies by Luna et al. and Ledikwe et al. also indicate that trained staff are often poorly geographically distributed [2,8]. The decline in training costs, from $5,629 per trainee in Period 1 to $377 in Period 3, indicates that an on-site model can be less expensive to deliver, even in highly dispersed geographic settings. The decline in cost was also related to the increase in coverage: by using a less expensive, shorter, on-site model for trainings, I-TECH was able to increase the geographic coverage of training delivery, including extending trainings to rural areas that are considerably removed from urban centers. The decline in cost and shift to an on-site model also allowed I-TECH to expand the program from 70 facilities during the six months of Period 2 to 102 facilities during the first six months of Period 3.

Finally, this study uses test scores to quantitatively evaluate the impact of distinct training models on healthcare workers. In all three models, healthcare workers showed statistically significant increases in their understanding of EMR. In addition, the absence of a statistically significant decline in Knowledge scores by training model indicates that neither shorter nor on-site training has a substantial negative impact on learning. This is a positive finding for organizations seeking to decrease costs or increase geographic coverage by delivering short, on-site trainings to introduce EMR to low-resource health facilities. However, smaller mean changes in Computer Skills during shorter trainings indicate that healthcare workers may need a longer time frame to increase their confidence or abilities to complete basic tasks on a computer, and participants in shorter training may require additional support in the long-term.

Limitations

The study is a program evaluation in which participants were not randomly selected, with statistically significant differences in age, cadre, and region between the training groups. Although we believe we have accounted for these differences by adjusting for demographic characteristics in the regression analyses, it is possible that the differences influenced the internal validity of the findings. As a result of incomplete data, 21.8% of trainees (n=304) were excluded from the analysis. It was also not possible to directly compare the largest group of trainees with those trained in other periods due to instrument change during Period 3. We were, however, able to compare test results from Periods 1 and 2 with a subset of Period 3. Finally, some costs were not recognized until shortly after they were accrued, so some costs accrued at the end of each period may have been incorrectly attributed to the subsequent period.

7. CONCLUSION

Together, the substantial reduction in cost, increase in geographic coverage, and consistent learning gains across periods indicate that is both less expensive and similarly effective to train healthcare workers on-site to use EMR in HIV clinics in low-resource settings. In addition, EMR trainings may be especially effective for nurses, who experienced comparatively large learning gains regardless of the training model. Given the critical role of nurses in caring for HIV-positive patients in sub-Saharan Africa, this is a promising finding for the implementation of EMR in low-resource settings.

8. DECLARATION OF CONFLICTING INTERESTS

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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APPENDIX A

	Period 1 - Test 1				Period 2 - Test 1				Period 3 - Test 1				Period 3 - Test 2			
	Knowledge		CS		Knowledge		CS		Knowledge		CS		Knowledge		Attitudes	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Total	14.5	18.2	6.5	8.7	17.1	18.2	8.0	8.6	14.8	17.6	6.5	8.1	17.9	21.4	7.1	8.0
Female	13.9	18.0	6.3	8.7	17.0	18.2	8.0	8.6	14.2	17.3	5.9	7.8	17.6	21.3	7.0	7.9
Male	15.6	18.6	6.9	8.7	17.3	18.1	7.9	8.6	15.7	18.0	7.2	8.4	18.4	21.5	7.2	8.2
Age																
19 - 29	14.7	18.8	7.1	8.9	17.1	17.8	8.5	8.7	14.5	18.3	7.4	8.5	18.7	22.4	7.3	8.3
30 - 39	15.0	18.4	6.4	8.7	17.3	18.1	8.0	8.5	15.4	17.7	6.5	8.1	18.2	21.9	7.2	8.2
40 - 49	14.7	18.2	5.5	8.4	16.3	19.4	7.1	8.8	16.5	19.1	5.6	8.0	16.9	20.1	6.8	7.7
50+	11.5	14.8	5.2	8.6	13.3	19.3	5.8	8.6	10.9	13.6	4.7	7.1	15.4	18.9	6.2	7.2
Cadre																
Nurse	13.9	17.7	5.2	8.6	16.8	18.8	7.0	8.3	14.8	17.2	5.7	8.0	18.5	21.9	7.3	8.2
CO/Physician	15.2	18.5	6.8	8.7	17.7	18.2	8.0	8.8	15.9	19.3	6.6	8.0	19.8	22.8	7.7	8.5
HRIO/Data Clerk	14.3	18.8	8.6	8.9	16.9	17.6	8.5	8.8	15.0	17.8	7.8	8.6	18.3	21.3	6.9	7.9
Counselor/SW	0.0	0.0	-	-	17.0	20.0	8.2	9.0	16.0	14.5	8.0	8.5	15.0	18.9	6.3	7.2
Lab/Pharm	15.5	18.5	7.3	9.0	18.0	17.3	8.2	7.5	6.0	9.0	1.5	3.5	18.0	21.9	7.1	8.2
Region																
Nyanza	14.1	18.5	5.7	8.7	16.9	17.8	7.7	8.5	13.8	16.7	6.2	8.0	17.9	21.4	7.0	8.1
Western	14.7	18.5	7.6	8.8	16.9	19.0	7.7	8.8	15.9	19.2	6.7	8.1	17.4	21.5	7.0	8.1
Rift Valley	14.6	17.8	5.8	8.6	-	-	-	-	17.4	19.4	7.3	8.1	17.7	20.7	7.1	7.7
Central	-	-	-	-	17.6	17.9	8.6	8.6	-	-	-	-	19.1	22.3	7.3	8.1