HIS101 eLearning Pilot Evaluation

CDC Grant 15-1535: Building Effective Health Information Systems under the President's Emergency Plan for AIDS Relief (PEPFAR)

Final Draft Report
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INTRODUCTION

Since PEPFAR's inception in 2003, the use of electronic health information systems (HIS) has been a critical component of PEPFAR implementation. High-quality data are essential to HIV prevention, care and treatment, policy development, resource planning, and accountability. Understanding the burden of disease requires functioning surveillance and aggregate indicator monitoring systems. Providing effective patient treatment requires consistent and available longitudinal patient, laboratory and pharmacy data and a skilled workforce to deliver that care. However, all of the PEPFAR focus countries have major gaps in their national health information systems.

National health information systems impact how healthcare workers carry out their day-to-day work. Systems include paper-only, paper and electronic, and electronic-only models. Increasing dependence on health information systems for data-driven decision making necessitates a workforce that values and understands the systems, their strengths and benefits, as well as their limits and weaknesses. Most often healthcare workers are trained on the use of specific tools, but are not trained on the big picture of health information systems and their role in supporting successful health care programs. Data that enter health information systems start with healthcare workers at the site level, which means the quality of the data is in their hands. Healthcare workers need to understand health informatics concepts and their role in health information systems implemented from the site level to the national level. Novel approaches are needed to effectively and efficiently increase knowledge, skills and motivation among healthcare workers at all levels of the health system. One such novel approach is blended eLearning, which integrates face-to-face and digital learning activities to match participants' varied learning styles.

Systematic reviews (George PP, 2014) and meta-analysis (Cook DA, 2008) show eLearning outcomes being equivalent to traditional learning for continuing education of health professionals. Furthermore eLearning and mobile learning models have been used effectively to train healthcare workers in resource-limited settings (Chang, 2012; Frehywot, 2013; Kebaetse, 2013). Cost evaluation models of eLearning, specifically blended eLearning, indicate that blended eLearning results in cost savings, compared to traditional training, for large scale initiatives (Sissine M, 2014).

Justification

Over the past eight years, with investments from PEPFAR and other sources, HIV counseling and testing has identified millions of people with HIV/AIDS, and antiretroviral treatment (ART) has extended the lifespan of people living with HIV. Due to this impact, electronic systems are essential to manage the volume of patient data. For example, in addition to the paper tools and reports currently in use, the implementation of the District Health Information System 2 (DHIS2, see https://www.dhis2.org/) is

being scaled up in many countries. This growth creates a greater need to standardize functional and technical requirements for health information systems, design systems that facilitate and enable interoperability between different health and health-related information systems (e.g., electronic medical records (EMR), laboratory information systems (LIS), human resource information systems (HRIS), pharmacy, and others), facilitate linkage and de-duplication of records, strengthen data quality and completeness, and reinforce data security, privacy, and confidentiality measures. It also creates the need to scale up informatics capacity where gaps exist to enable innovative technical solutions to advance this agenda through increased access to informatics learning resources. The overall advancement of health information systems in PEPFAR-supported countries will depend upon robust strategic planning and governance, improved in-country human capacity, and on-going evaluation of health information system implementations to identify effective practices, efficiencies gained, and health impacts and to increase sustainability and country ownership.

I-TECH has a five-year cooperative agreement with The U.S. Centers for Disease Control and Prevention (CDC) to support the development of human resources for health that support PEPFAR countries' health information systems. Year one activities focused on developing HIS-focused eLearning resources delivered through novel methodologies. These resources will be publicly-available for adaptation and use across a wide variety of PEPFAR-supported countries which are interested in strengthening their health information systems. Conducting an initial evaluation of a pilot implementation helps ensure that the resources are well matched to needs, understandable, usable, and useful. Pilot evaluation also contributes to quality improvement of future learning resources in project years two to five.

In-person HIS101 Course

In 2009, CDC South Africa identified the need for a competent HIS workforce to apply informatics-related concepts in the implementation of information systems at all levels of their health system. To address this need, a four and a half day competency-based course, titled *Introduction to Health Information Systems (HIS 101)*, was developed by the CDC-Atlanta HIS Team for personnel from PEPFAR partner countries who are involved in HIS-related activities at the national, provincial, district, and sub-district/facility level. Between 2009 and 2012, this course was delivered in a workshop format in South Africa, Namibia, Nigeria, Swaziland, and Atlanta.

eLearning Modules

In order to increase access to the *HIS101* course, I-TECH converted two sessions, *Information Use, Technology, and Terminology* and *Data Management Concepts*, from the face-to-face introductory course into a blended eLearning format comprising of a half day, face-to-face HIS eLearning Orientation and three separate, self-paced eLearning modules with the following learning objectives:

Module 1: Introduction to HIS: Information Use, Technology, and Terminology

- Explain the difference between information literacy, computer literacy, and information system literacy
- Define key information system terms
- Identify the components of a health information system

Module 2: Health Information Systems: Classification and Architecture

- Describe the logic underlying health information systems
- Describe information system classifications and architectures

Module 3: Data Management Concepts

- Define data management concepts
- Describe components of the data management process

The eLearning modules retained the same learning objectives, core content, and pre/post-test questions as the two workshop sessions. Since course facilitators typically provide examples and clarification in response to student questions during face-to-face sessions, I-TECH included such content in the eLearning modules.

The face-to-face HIS eLearning Orientation was held with the training participants to distribute tablets, orient users to the tablet and eLearning application, review the timeline for completion of the modules, and confirm the process of returning the tablets to I-TECH. The modules were also made available via an online portal (http://globalhealthworkforce.org/), for participants who preferred not to use the tablets. Participants returned to their place of work and were given up to four weeks to complete the eLearning modules in a self-paced manner.

METHODS

Pilot Process

Engagement with Ministries of Health

In collaboration with CDC Program and Technical Officers, I-TECH selected Namibia and Tanzania as countries to pilot the eLearning materials. Both countries use a range of HIS, including DHIS2, HRIS, and pharmacy systems, to name a few, meaning that their respective health workforce were familiar with the growing adoption and continued expansion of HIS in their day to day work. I-TECH sought and gained approval for the pilot activities from the Namibia Ministry of Health and Social Services (MOHSS) and the Tanzania Ministry of Health, Community Development, Gender, Elderly and Children (MOHCDGEC) before proceeding.

In March 2016, I-TECH jointly met with the MOHSS and CDC in Namibia and the MOHCDGEC and CDC in Tanzania to introduce the project. The discussion focused on defining the target audience, identifying possible implementation mechanisms, and geographical distribution. In Tanzania, these discussions resulted in the creation of a Technical Working Group consisting of the Ministry agencies represented in the discussions (Monitoring and Evaluation [M&E] Unit, Human Resources Department). In Namibia, following the initial meeting with MOHSS and CDC, I-TECH presented the HIS project to the Namibia HIS Technical Working Group Meeting, where the project was well received.

Selection of participants

In this pilot of the eLearning modules, I-TECH worked in specific geographic areas in Namibia and Tanzania, registering participants from different sites within the area. I-TECH targeted 75 participants in each country, understanding that some participants might not complete all three eLearning modules by the end of the pilot. Because the modules are self-paced and asynchronous, participants could selectively use individual eLearning modules based on their professional role or interests. This means that the target audience includes a wide range of cadres. Target participants include clinical staff, data clerks, data managers, pharmacy staff, and laboratory staff from regions, districts, and facilities.

Facilities were selected from among those where activities related to HIS or M&E strengthening are currently being implemented by each country's Ministry of Health and implementing partners. Examples of these activities include I-TECH's HIV Clinical Strengthening Program and the University of California San Francisco's Data Action and Review Forums.

Balancing budget constraints with covering a broader geographic sample for the pilot, I-TECH selected participants in the Otjozondjupa, Erongo, and Khomas regions of Namibia and the Kinondoni, Ilala, and Temeke districts of Tanzania's Dar es Salaam region. The pilot project invited participants (clinical staff, data clerks, data managers, pharmacy staff, and laboratory staff) from those regions, including regional, districts, and facility-level staff to use the eLearning modules.

Group-based orientation

Half-day, face-to-face orientations were conducted in both countries. Each participant in the eLearning pilot attended a single orientation, and there were four orientation sessions held in Namibia and three in Tanzania (**Table 1**). The aim of the orientation was to enable participants to successfully access and complete self-paced eLearning modules on Health Information Systems. All orientations began with background information on the purpose of the Building Effective HIS eLearning Project, eLearning technologies, and the learning objectives of the three eLearning modules being piloted. The second half of the orientation focused on strategies for effective self-study, review of the informed consent form and tablet user agreement, and accessing the eLearning modules and pre/post-tests on the tablet and/or website. Participants were provided with an opportunity to practice using the tablets and the eLearning materials using the Navigation module available in the Overview. Participants also participated in discussions on how to access help in the event that they encountered problems or had questions as they went through the eLearning modules.

Table 1: Orientation Training Sites by date and location

Date	Country	Region - City/District	Total Participants
14 June 2016	Namibia	Erongo – Walvis Bay	23
15 June 2016	Namibia	Otjozondjupa - Okahandja	12
16 June 2016	Namibia	Otjozondjupa - Otjiwarongo	11
17 June 2016	Namibia	Khomas - Windhoek	26
21 June 2016	Tanzania	Dar es Salaam - Kinondoni	19
22 June 2016	Tanzania	Dar es Salaam - Ilala	20
23 June 2016	Tanzania	Dar es Salaam - Temeke	20

In addition to participants from the districts, one trainer attended three of the four orientations in Namibia. This trainer is associated with the National Health Training Center (NHTC). Over the course of the three orientations, she led the session on *Effective Self-Study* as well as introductions to the course and confirmation of the courses sanctioning by the Namibia MOHSS. Similarly, in Tanzania, three tutors associated with the Center for Distance Education's *Clinical Assistants to Clinical Officers Upgrading Distance Education* program played a similar role. Over the course of the three orientations, each tutor

led the sessions on *Effective Self-Study, Accessing the HIS eLearning Modules*, and *What to do When Something Goes Wrong*. During the orientation sessions in Tanzania, participants decided to create a WhatsApp group in order to address challenges identified during the *What to do When Something Goes Wrong* session. Challenges included language barriers, technology problems, or motivation.

Pilot Implementation

In Namibia, the deadline for completing all components of the modules, including pre-tests, post-tests, participant evaluations of each module, and a final course evaluation was July 14, 2016. This gave the Namibian participants four weeks to complete the modules. In Tanzania, a limited number of tablets and unreliable internet connection led the team to disseminate the tablets to half of the participants from June 21 through July 8, then collect and distribute tablets to the second half of participants to use from July 5 through July 22. Only one participant expressed interest in taking the modules online. As participants in the first pool completed the modules, they notified the WhatsApp group or the I-TECH focal point to arrange collection of the tablet. For both groups, an I-TECH focal person made several reminder calls to participants over the course of the pilot to encourage participants to complete the modules.

Pilot Evaluation and Conclusion

Participant evaluations were available for each module and for the eLearning course overall. The instruments used Likert scales, and also included open-ended questions about recommendations for improving the eLearning modules. To conclude the pilot, I-TECH collected all of the tablets signed out to users.

Data Collection Methods and Sources

The following data collection methods and sources were used:

1. At the orientation, each participant was assigned a unique numeric identifier for the purposes of the pilot.
2. Participant demographic data was collected through routine processes. Specifically, participants at the orientation sessions completed participant registration forms and the data were entered to the TrainSMART training data system.
3. Individual participant pre-test and post-test results were collected from tests taken online or via tablets. Participants were instructed that pre-tests should take place prior to viewing the module and post-tests should take place at the conclusion of the module with the scores recorded on the tablet. Identical, multiple choice questions were used, however the order in which they were presented differed between pre-test and post-test. Tablets were brought back to Windhoek (Namibia) or Dar es Salaam (Tanzania) and program assistants unlocked the tablets to upload the pre-test, post-test, and participant evaluation data to the server. Data for participants that accessed the modules via the web portal were extracted from that online database into an Excel file. Data from the two sources were then compiled in a single data set. When participants uploaded multiple tests of one type, only the first test was used.
4. Participants completed a course evaluation form for each module to collect quality improvement feedback on the eLearning module content usefulness, clarity, and perceived knowledge transfer. They also completed a single overall course evaluation, which was available to all participants, even if they did not complete all modules. Evaluations were provided to participants using the same digital format as the pre- and post-tests. Participants were instructed to complete the evaluations (3 individual module evaluations and 1 final course evaluation) after the module and post-test had been finished.

5. I-TECH's programmatic costs for carrying out the eLearning pilot were collected using I-TECH's routine financial management systems.

Analysis

We analyzed the anonymized participant demographic data using descriptive statistics (simple frequencies) to characterize all pilot participants. Using the pre- and post-test data, we analyzed module completion levels using descriptive statistics (simple frequencies). Next we used descriptive statistics (means, frequencies) to analyzed pre- and post-test scores as well as change scores for those who completed both pre- and post-tests. We used paired t-tests to test for statistically significant changes in knowledge by module and for the 3 modules combined. We characterized results by country (Namibia vs. Tanzania), by cadre (nurse vs. physician vs. all other), by sex (female vs. male), and by medium of eLearning module use (tablet vs. online). We used the Pearson's Chi-2 test statistic to test for statistically significant differences in passing, and used t-tests to test for statistically significant differences in pre-test, post-test and change scores by these variables. Last, we carried out multivariable analyses using generalized estimating equations (GEE) on passing and on post-test scores, with robust variance and exchangeable correlation assumed for results of individual participants across the modules. We included only cases with both pre- and post-test scores. Our models treated passing as a binary variable and change score as a continuous variable, and the models adjusted for pre-test score, module, country, cadre, sex, and eLearning medium, to identify associations of interest.

To better understand mastery of specific topics, we compared individual question results for pre- and post-tests of participants to measure the change in the proportion of participants with correct scores. Individual question results were analyzed as being 'correct' or 'incorrect' and the percentage figures represent the aggregate of all participants answering a question correctly. The analysis considered only participants with pre-test and post-test scores for an individual module.

We were able to compare the results of the eLearning pilot with results of the in-person course for a sub-set of the learning objectives and post-test questions. Specifically, the 10 post-test questions used in the *Information Use, Technology, and Terminology* module of the in-person course matched questions used in eLearning Modules 1 and 2. We used a t-test to compare mean post-test results among in-person course participants with eLearning course participants, testing the null hypothesis of no difference in the distribution of scores between the in-person and eLearning modalities. We carried out a secondary analysis which examined this same question among only the participants from Namibia (the only country where both in-person training and eLearning were carried out).

Next, we analyzed the course evaluation form data using qualitative and quantitative methods. For feedback provided in response to open-ended questions, we coded responses by theme and by favorability of the comment (i.e. whether the comment was positive or negative). We also carried out simple descriptive analysis of median values for the Likert scale data and summarized results.

Finally, we analyzed I-TECH's financial data and grouped costs into the following categories: 1) programmatic management costs; 2) costs for designing and creating the modules; and 3) costs for implementation of the pilot. This enabled us to estimate approximate costs for each step as well as a rough unit cost per participant.

Analysis was conducted using STATA 13 data analysis and statistical software as well as Microsoft Excel 2013 pivot table functions.

Results

Participant Profile

A total of 131 participants completed TrainSMART registration forms, with 55% from Namibia and 45% from Tanzania (**Table 2**). Out of all participants, 67% were female and 33% male. Participants in Namibia consisted primarily of nurses (48 in Namibia versus 18 in Tanzania) while in Tanzania the largest group of participants were physicians (26 in Tanzania and 3 in Namibia). Twenty-eight participants (16 in Namibia and 12 in Tanzania) indicated their qualification as "Other." While the TrainSMART data system allows participants to specify their professional role, this data element is not mandatory and it was not possible to understand more specifically the range of cadres and roles covered in the "Other" category.

Table 2: Participant Qualification and Gender by Country

Participant characteristic	Namibia, n (%)	Tanzania, n (%)	Total, n (%)
Qualification			
Nurse	48 (66.7%)	18 (30.5%)	66 (50.4%)
Physician	3 (4.2%)	26 (44.1%)	29 (22.1%)
Pharmacy	4 (5.6%)	0 (0%)	4 (3.1%)
Social Services	0 (0%)	1 (1.7%)	1 (0.8%)
Community Health Worker	1 (1.4%)	0 (0%)	1 (0.8%)
Dental Services	0 (0%)	1 (1.7%)	1 (0.8%)
Mid-Level Clinician	0 (0%)	1 (1.7%)	1 (0.8%)
Other	16 (22.2%)	12 (20.3%)	28 (21.4%)
Gender		**n (%)**	
Male	14 (19.4%)	29 (49.2%)	43 (32.8%)
Female	58 (80.6%)	30 (50.8%)	88 (67.2%)
Total	**72 (55.0%)**	**59 (45.0%)**	**131 (100%)**

Participation in eLearning Pilot

Out of the 131 people oriented, a total of 95 persons completed at least one pre-test across the 3 eLearning modules (55 in Namibia and 40 in Tanzania) (**Table 3**). The proportion of orientation participants who engaged with eLearning was not statistically significantly different by country (p=0.27).

Among those who engaged in eLearning, 87 persons completed at least one post-test (48 in Namibia and 39 in Tanzania). Among eLearning participants, 11 failed to complete both pre- and post-tests for all three modules. Twelve people completed them for one module, 22 completed them for two modules, and 50 completed them for all three modules. **Table 3** presents the proportion of oriented persons who completed pre- and post-tests for each module, overall and by country. Among those who engaged in some way with eLearning, completion of at least one module similar in Namibia and in Tanzania (63% vs. 66%, p=0.67).

Table 3: Participation and Completion of Modules

	Total		Namibia		Tanzania	
	Number	Percent	Number	Percent	Number	Percent
Oriented	131		72		59	

Participated in eLearning	95	73%	55	76%	40	68%
Completed post-test for at least 1 module	84	64%	45	63%	39	66%
Module 1						
Completed pre-test	86	66%	52	72%	34	58%
Completed post-test	78	60%	45	63%	33	56%
Completed pre-test and post-test	73	56%	42	58%	31	53%
Module 2						
Completed pre-test	78	60%	44	61%	34	58%
Completed post-test	76	58%	43	60%	33	56%
Completed pre-test and post-test	68	52%	38	53%	30	51%
Module 3						
Completed pre-test	71	54%	36	50%	35	59%
Completed post-test	71	54%	39	54%	32	54%
Completed pre-test and post-test	65	50%	33	46%	32	54%
All 3 Modules						
Completed pre-test	59	45%	32	44%	27	46%
Completed post-test	60	46%	36	50%	24	41%
Completed pre-test and post-test	50	38%	28	39%	22	37%

Among those who engaged with the eLearning modules, 77 out of 95 did so using a tablet (81%) while 18 do so via online access to the modules (19%). All online users were participants in Namibia.

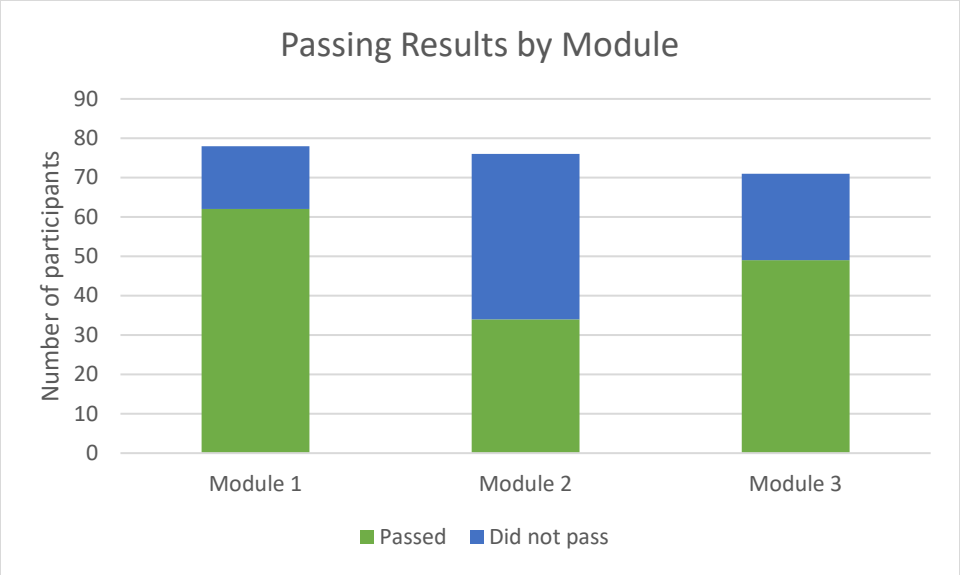
Among those exposed to the eLearning orientation, there was no meaningful difference by cadre or sex among those who completed at least one pre- or post-test compared with those who only attended the orientation. By cadre, 23% of nurses, 31% of physicians, and 32% of other professionals only attended the orientation but did not complete a pre- or post-test (p=0.53). By sex, 25% of females and 33% of males only attended orientation but did not complete a pre- or post-test (p=0.36).

Change in Knowledge with eLearning Pilot

Results by Module

The threshold for passing each eLearning module was 70% on the post-test. For Module 1, 79% of participants passed, while for Module 2 and 3 the passing rates were lower (45% and 69% respectively). The proportion of participants who passed was statistically significantly different by module (p<0.001) (**Graph 1**).

Graph 1: Passing Results by Module



For Module 1, among the 73 participants who completed both a pre-test and a post-test, 70% saw a positive change in their scores. The mean increase in Module 1 scores was 1.7 points or 17% (**Graph 3**). For Module 2, among the 68 participants completing both a pre-test and a post-test, 63% saw an increase in their score. The mean increase in Module 2 scores was 1.4 points or 14%. For Module 3, among the 65 participants who completed both a pre-test and a post-test, 77% increased their score by an average of 1.8 points or 18%.

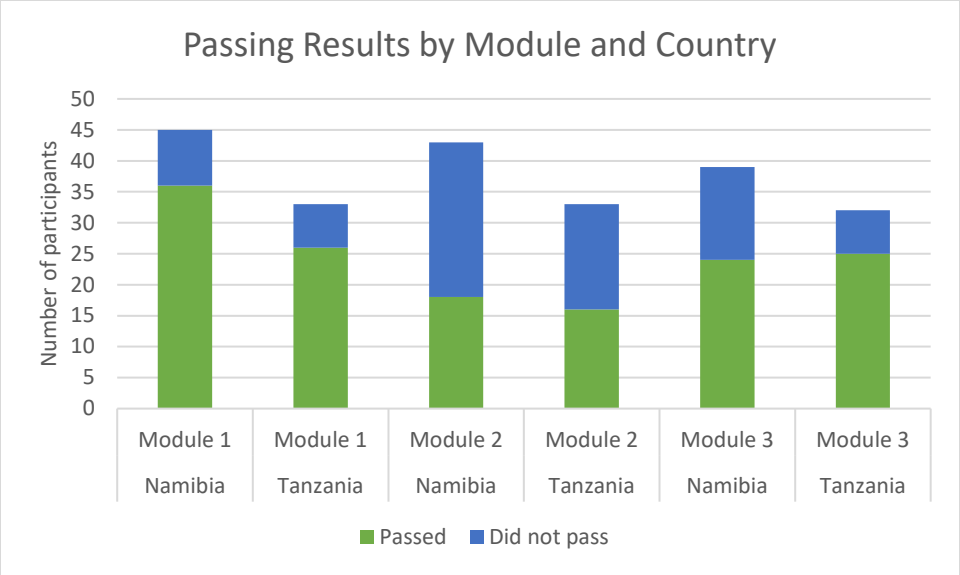
On average, across all modules, mean scores increased by 1.6 (16%) on post-test compared to pre-test ($p<0.001$). Compared to the change scores for Module 1, change scores on average were slightly lower for Module 2 (by 0.4 points), and slightly higher for Module 3 (by 0.1 points), but the difference in change scores across modules was not statistically significant ($p=0.28$).

Results by Country

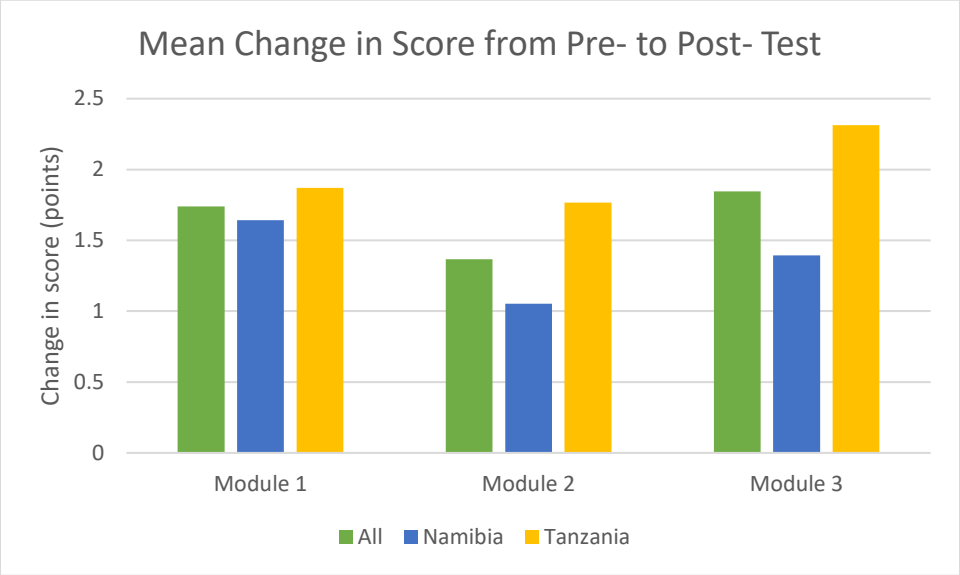
Passing rates by module and country are shown in **Graph 2**. Passing rates did not significantly differ by country both overall and for specific modules, although the difference by country for Module 3 approached statistical significance (62% vs. 78%, $p=0.13$).

Overall all three modules, the proportion of participants who increased their test scores was higher in Tanzania than in Namibia (75% vs. 65%), and change scores were higher in Tanzania than in Namibia (2.0 vs. 1.4, $p=0.03$). By module, mean increases in Tanzania were 1.9 (19%) for Module 1, 1.8 (18%) for Module 2, and 2.3 (23%) for Module 3 (**Graph 3**). In Namibia, the corresponding mean increases were 1.6 (16%) for Module 1, 1.1 (11%) for Module 2, and 1.4 (14%) for Module 3.

Graph 2: Passing Results by Module and by Country



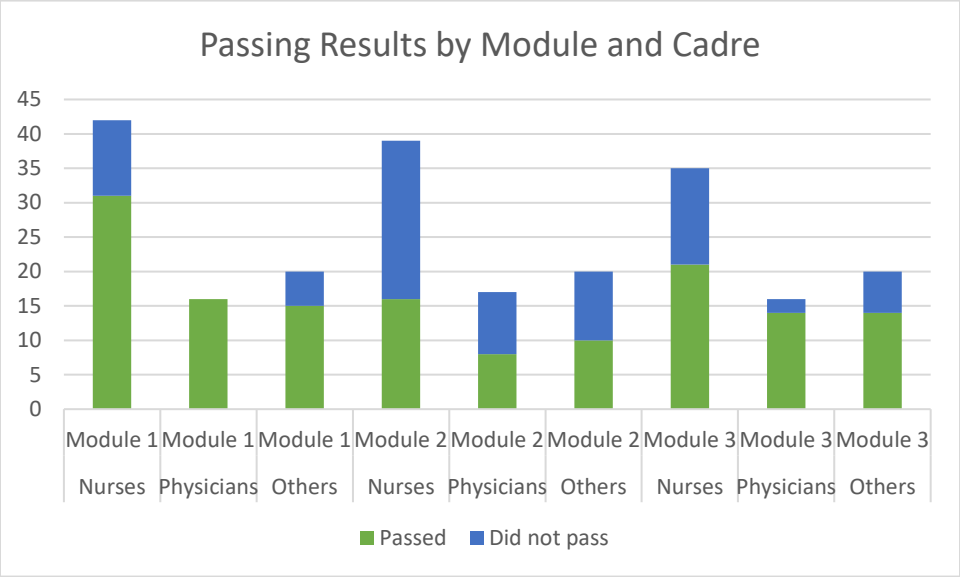
Graph 3: Change Scores by Module and by Country



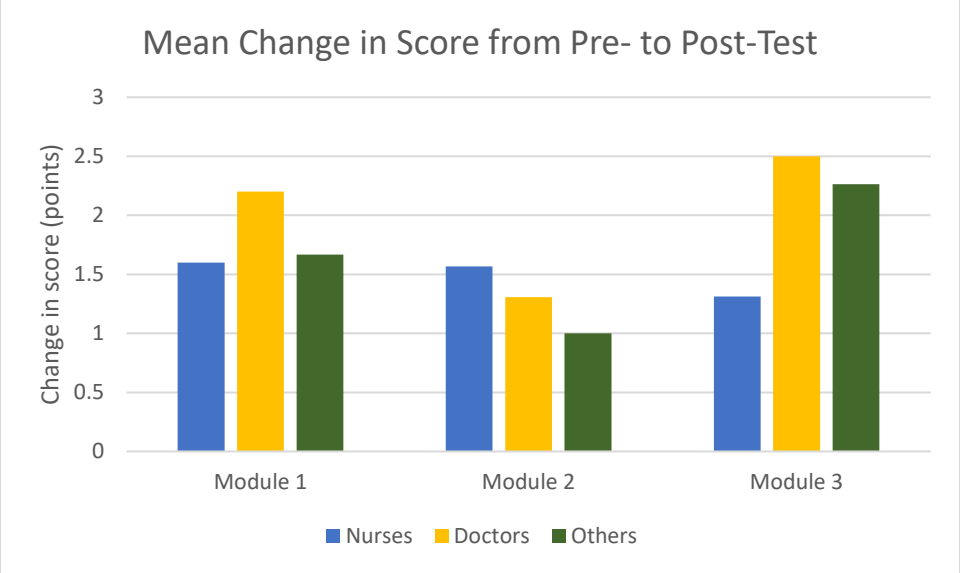
Results by Cadre

There were modest differences in passing rates by cadre for each module, but only for Module 1 was the rate of passing marginally statistically significantly different by cadre (p=0.07) (**Graph 4**). Change scores were highest for physicians for Modules 1 and 3 (**Graph 5**), but across the three modules results were not statistically significantly different by cadre (p=0.37).

Graph 4: Passing Results by Module and by Country



Graph 5: Change Scores by Module and by Cadre

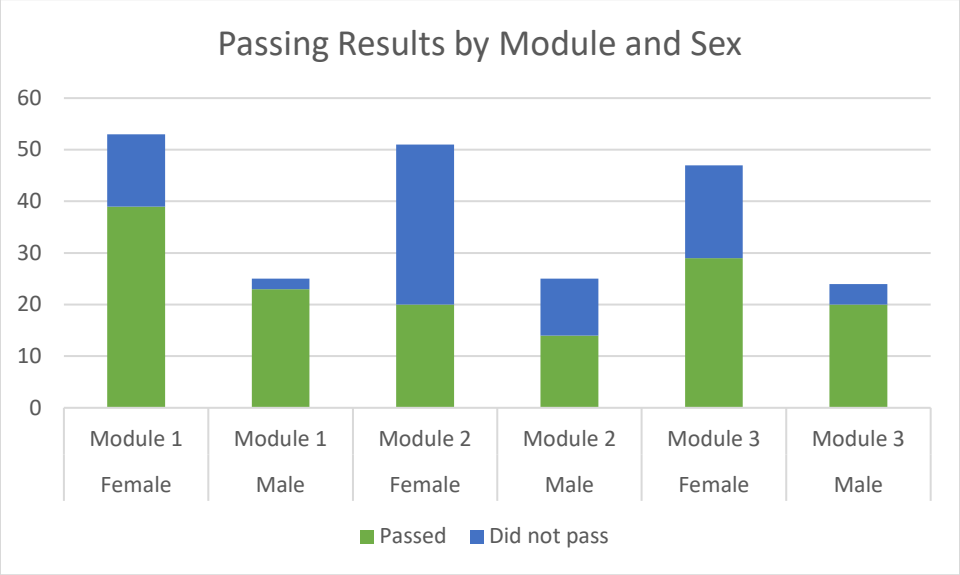


Results by Sex

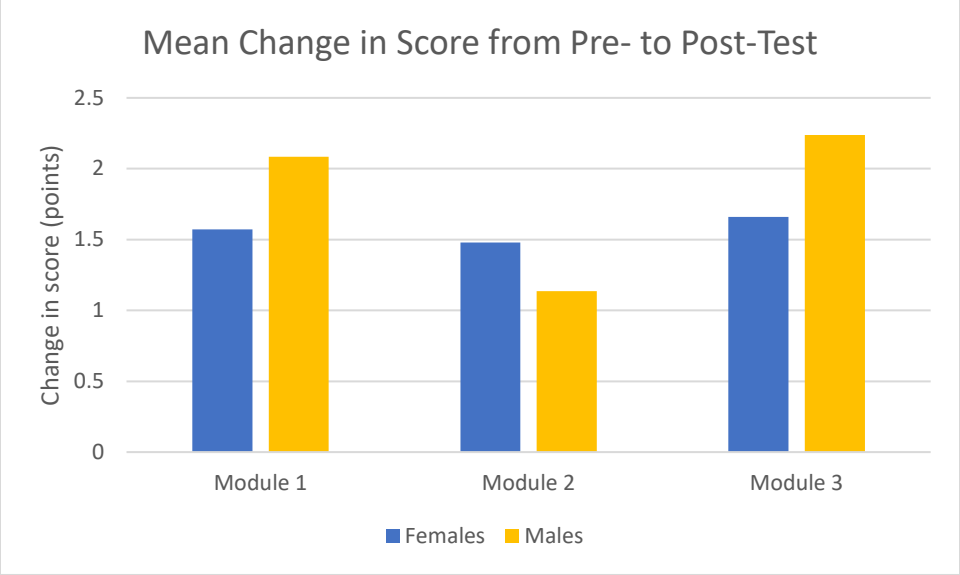
There were modest differences in passing rates by sex for each module, and for both Modules 1 and 3, the rates of passing were marginally statistically significantly different by sex (p=0.06 for both) (**Graph 6**). Average change scores were higher among males compared with females for Modules 1 and 3

(**Graph 7**), but across the three modules results were not statistically significantly different by sex (p=0.40).

Graph 6: Passing Results by Module and by Sex



Graph 7: Change Scores by Module and by Sex

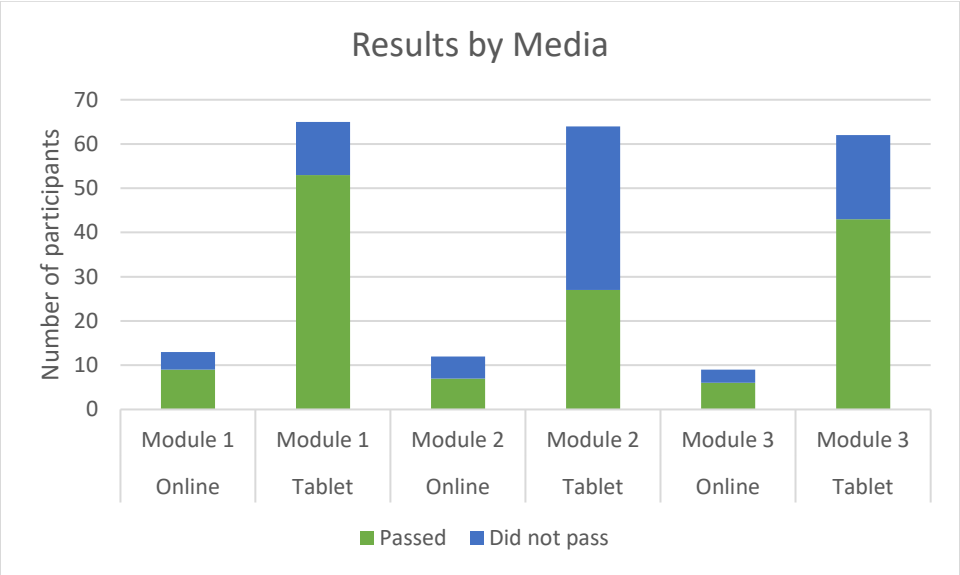


Results by Media

Pass rates by media are shown in **Graph 8**. The pass rates by media across all modules were not significantly different (65% for online vs. 64% for tablet, p=0.97). Similarly, the average increase in scores across all modules was not meaningfully different by media, with online users increasing on average by 1.7 or 17% and tablet users increasing on average by 1.6 or 16% (p=0.91). The proportion of

participants who experienced an increase in score from pre-test to post test was also not meaningfully different by media (72% for online vs. 69% for tablet).

Graph 8: Passing Results by Media

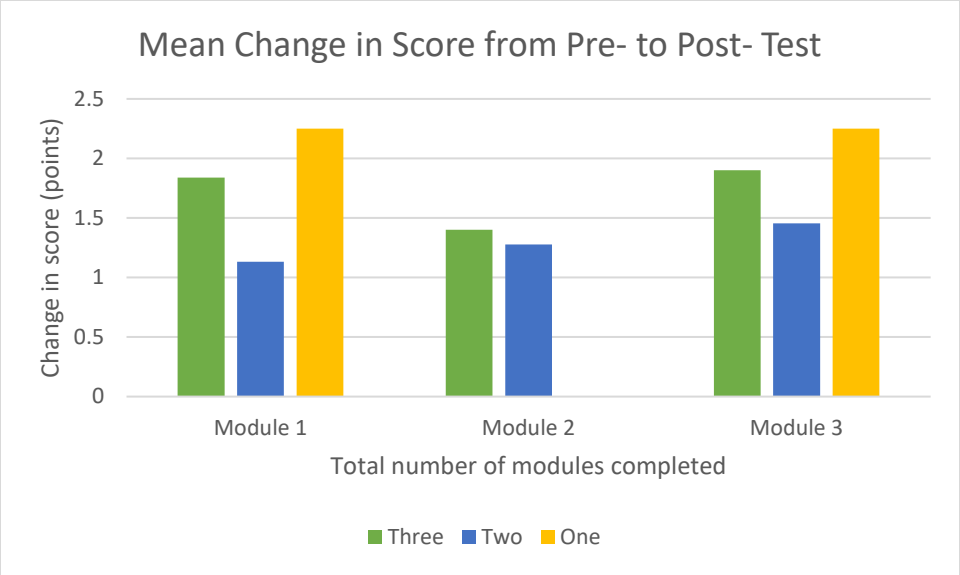


Results by Number of Modules Completed

The results by number of modules completed are shown in **Graph 9**. Among the 50 participants who completed pre- and post-tests for all three modules, 68% of participants saw their mean scores increase, with average increases of 1.8 points, 1.4 points, and 1.9 points by each module respectively. One third (33%) of participants completing all three modules scored 70% or higher on all 3 post tests. Average change scores were not significantly different based upon the number of modules completed (p=0.26).

In Namibia, 61% saw a positive change in all three of their scores with 31% achieving a score of 70% or higher on all three post-tests. Tanzania saw 77% of participants experience an increase in their scores with 38% scoring 70% or higher on all three post-tests.

Graph 9: Mean Change Scores by Number of Modules Completed



Multivariable Analysis Results

In an adjusted model where passing at the 70% level was considered as the outcome of interest, we found that higher pre-test score and module were factors associated with passing, and that country, sex, cadre, and media were not associated with passing (**Table 4**). The relative risk (RR) can be interpreted as the relative risk of passing, with RR=1.0 representing no association between the factor and passing, RR<1.0 representing lower likelihood of passing, and RR>1.0 representing higher likelihood of passing, for each factor. Specifically, for each 1 unit increase in pre-test score, participants had an 8% increased opportunity of passing the module (p=0.01). Compared to Module 1, passing was 41% lower for Module 2 in the adjusted analysis (p<0.001).

Table 4: Relative Risk (RR) of Passing[1]

Factor	RR	p- value	95% CI	
Pre-test score (1 point increase)	1.08	0.01	1.02	1.15
Module 2 (reference = Module 1)	0.59	<0.001	0.45	0.79
Module 3 (reference = Module 1)	0.94	0.47	0.79	1.12
Tanzania (reference = Namibia)	1.02	0.86	0.79	1.33
Sex (reference = Female)	1.19	0.17	0.93	1.53
Physician (reference = Nurse)	1.20	0.27	0.87	1.65
Other cadre (reference = Nurse)	1.13	0.42	0.84	1.51
Online (reference = Tablet)	1.03	0.89	0.69	1.53
Constant	0.42	<0.001	0.26	0.69

[1]Generalized estimating equations model with participant identifier as panel variable, using Poisson family, log link and robust standard errors.

In an adjusted model where post-test score was considered as the outcome of interest, we again found that pre-test score and module were factors associated with post-test scores, and that country, sex, cadre, and media were not significantly associated with post-test score (**Table 5**). The β-coefficient for this model can be interpreted as the average change in the post-test score for each factor after adjustment for all other factors in the model. Specifically, for each 1 unit increase in pre-test score, participants had a change score which was 0.66 points less (p<0.001). Compared to Module 1, post-test scores were 1.33 points lower for Module 2 and 0.60 points lower in the adjusted analysis.

Table 5: Association between Change Score and Factor[2]

Factor	**β**	**p- value**	**95% CI**	
Pre-test score (1 point increase)	-0.66	<0.001	-0.79	-0.52
Module 2 (reference = Module 1)	-1.33	<0.001	-1.90	-0.75
Module 3 (reference = Module 1)	-0.60	0.02	-1.09	-0.12
Tanzania (reference = Namibia)	0.51	0.11	-0.12	1.13
Sex (reference = Female)	0.31	0.50	-0.58	1.19
Physician (reference = Nurse)	0.11	0.84	-0.95	1.17
Other cadre (reference = Nurse)	0.34	0.43	-0.50	1.18
Online (reference = Tablet)	0.44	0.47	-0.75	1.63
Constant	5.34	<0.001	4.23	6.44

[2]Generalized estimating equations model with participant identifier as panel variable, using Gaussian family, identity link and robust standard errors.

Results by Question

Analysis of pre- vs. post-test scores in aggregate for each question revealed a range of absolute changes in the proportion of participants with correct responses. The range extended from very positive improvements from pre- to post-test to no improvement, to even a decline for five questions. **Table 6** shows the number of test questions by the level of change in proportion of participants with correct scores (with positive values indicating improvements from pre-test to post-test).

Table 6: Change in proportion of participants with correct scores

Improvement in individual question results between pre-test and post-test (n=30)						
	40% or greater	30-39%	20-29%	10-19%	0-9%	Declined
# of Questions	3	3	5	8	6	5

Table 7 shows examples of questions where participants showed the most improvement. Such "high improvement" questions were present in all three modules.

Table 7: Examples of questions with strong gains

Questions with highest gains from pre-test to post-test: Correct answer **highlighted**	Absolute change in proportion of participants with correct responses

Module 1: Q4. When trying to locate the information you need in an electronic information source, you would use a strategy called: A. Narrow domain searches **B. Boolean searches** C. Universal searches D. Wide domain searches	47% (25% to 72%)
Module 1: Q6. Data is usually defined as: A. The beginning of a database **B. A thing without meaningful relation to anything else** C. The things within a database D. A beginning to understanding a problem	45% (44% to 88%)
Module 2: Q1. In creating a logic model you would include: A. Data, information, technology, and timelines B. Models, systems, technologies, and architectures **C. Inputs, activities, outputs, and outcomes** D. Sources, costs, milestones, and determinates	40% (51% to 91%)
Module 3: Q10. The three phases of data management are: A. Save, secure, archive **B. Capture, Store, Retrieve** C. Collect, Save, Analyze D. Record, Store, Retrieve	38% (43% to 82%)

Of the five questions with declining scores, three questions saw less than 50% of participants provide the correct answer on both the pre-test and post-test. Question 4 in module 2 saw the number of participant answer correctly decline by 15%, from 62% to 47%. Three of the five questions that saw a decline were from Module 2, with one each in Module 1 and 3. The question with a decline in Module 1 saw 89% of participants answer correctly on the pre-test with 85% correct on the post-test.

Table 8: Examples of questions with declines

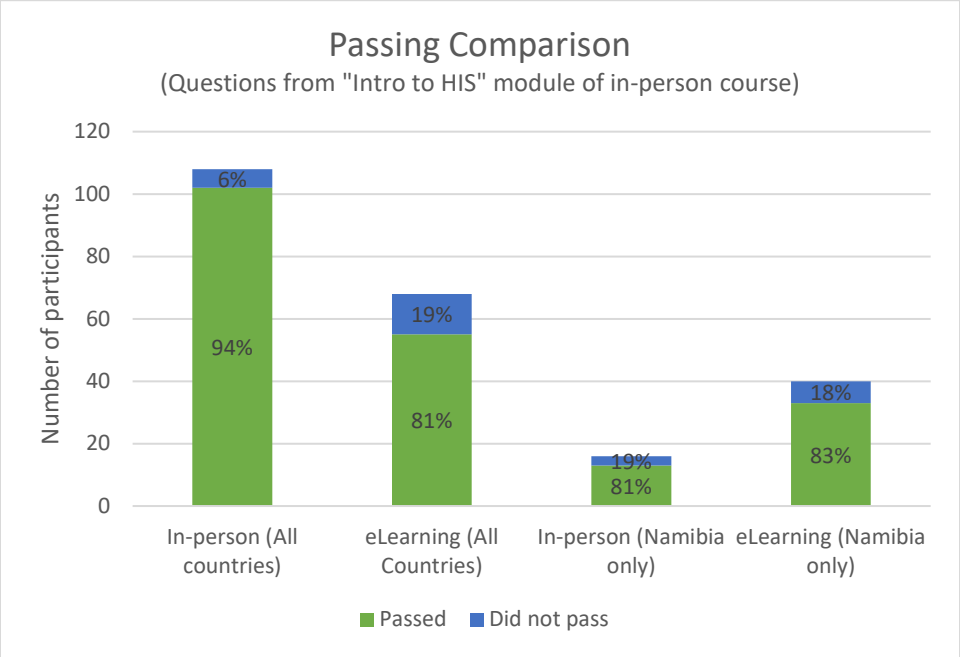
Questions with declines from pre-test to post-test: Correct answer **highlighted**	Absolute change in proportion of participants with correct responses
Module 2: Q4. Well-designed health information system architecture can result in a health information system that is **A. Flexible, reduces duplication, and works within a country's context** B. Stable, stand-alone, and flexible C. Centralized, permanent, and open source D. Complex, reduces duplication, and free	-15% (62% to 47%)
Module 2: Q3. Choose the system architecture that completes the following sentence: A _____ contains all the entered data, no matter where it is entered. A. Federated system	-4% (42% to 38%)

B. De-centralized system **C. Centralized system** D. Stand-alone system	
Module 3: Q8. Data quality during data capture can be managed by: A. Single point of entry **B. Fields that accept certain values** C. Statisticians D. Strategic Plans	-2% (48% to 46%)
Module 2: Which of the following statements about open source software is false? A. Open source is a process for developing any kind of software B. Cannot restrict distribution of modified code C. Software code and modules are contributed to a software project from many developers **D. Software undergoes peer review through a closed process**	-1% (44% to 43%)

Results in Comparison with In-Person Course

For the 10 test questions associated with the "Intro to HIS" module of the in-person course, the level of passing was higher in the in person course (94.4%) vs. in the eLearning course (81.0%) for participants from all countries (**Graph 10**). When restricting to participants from Namibia, the pass rates were similar (81.3% in-person vs. 82.5% eLearning).

Graph 10: Passing Comparison for In-Person vs. eLearning Course Participants

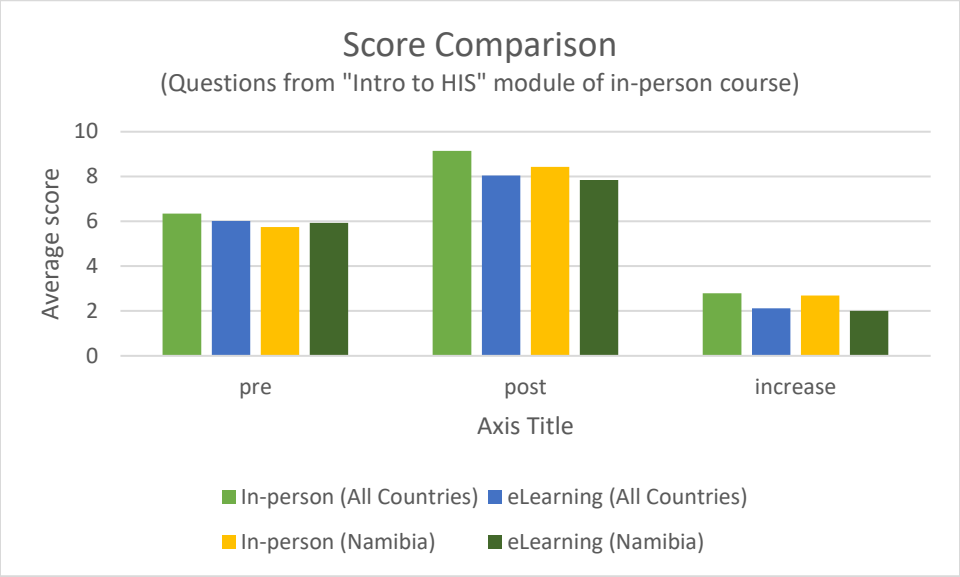


For the 10 test questions associated with the "Intro to HIS" module of the in-person course, in-person training participants scored slightly higher at pre-test compared to eLearning participants (mean in-person score = 6.34 vs. mean eLearning score = 6.01), but the difference was not statistically significant (p=0.22). At post-test, there was a meaningful difference; the mean scores were 9.14 for in-person vs.

8.04 for eLearning (p<0.001). As expected, the average change scores from pre- to post-test was higher among the in-person participants (2.80 vs. 2.11; p=0.03) (**Graph 11**).

When restricted to participants from Namibia, the difference between post-test scores by training modality was less marked and was no longer statistically significant (mean in-person score = 8.44 vs. mean eLearning score = 7.85; p=0.33).

Graph 11: Score Comparison for In-Person vs. eLearning Course Participants



Participant Evaluation with eLearning Pilot

Ninety-six participants completed at least one module evaluation, with only 22 participants evaluating all 3 modules. Evaluations for individual modules were received from both Namibia (n=62) and Tanzania (n=33), and were provided by both tablet (n=65) and online (n=31) users. Two things to note while reviewing the results of the participant evaluations: 1) no Tanzanian participants elected to use the website version of the eLearning modules; and 2) one user's unique ID failed to upload, leading to one participant providing no country of origin.

The average satisfaction ratings across different dimensions of satisfaction was at least 4 (Agree) for all modules, with the exception of Module 2, where the average satisfaction rating fell below 4.0 for relevance and ability to relate to scenarios (**Table 9**). For Module 2, many participants from both pilot countries felt that the content was very difficult to understand. Sample quotes included:

- *"[P]lease try to simplify this module. It was very much defficult[sic] for me to follow. It is not what I am doing every day. Much complicated and I don't know how HIS is going to benefit from this kind of information."*
- *"The module is too complex and confusing"*
- *"To limit the contents, it too much."*
- *"the course was crucial but too many material was placed in one module. I suggest to divide the course into two courses. And use a bit light technical words"*

Regarding Module 2, participants suggested the incorporation of an easy to access glossary of terms, more time to complete the module, and dividing up the content into manageable chunks would have benefited the course.

Table 9: Mean Satisfaction Score by Module

	Module 1 N=56	**Module 2** N=55	**Module 3** N=52
The program presented me with new and useful information[1]	4.4	4.0	4.1
The program was relevant to me[1]	4.2	3.9	4.2
I could relate to the scenarios presented[1]	4.3	3.7	4.1
The program motivated me to take action[1]	4.3	4.1	4.2
I will be able to apply what I learned to my job. [1]	4.4	4.1	4.2
I would recommend this program to others[1]	4.5	4.3	4.2
Clarity of content[2]	4.3	4.0	4.1
Organization of information[2]	4.3	4.1	4.1
The navigation of the module[2]	4.2	4.0	4.2
The amount of information[3]	1.9	2.0	2.0

[1] Rating scale: 1 – Strongly Disagree, 2 – Disagree, 3 – Neither Agree nor Disagree, 4 – Agree, and 5 - Strongly Agree.
[2] Rating scale: 1 – Very Poor, 2 – Poor, 3 – Fair, 4 – Good, and 5 – Very Good.
[3] Rating scale: 1 - Did not Achieve, 2 - Somewhat Achieved and 3 - Fully Achieved.

In the participant evaluations for each module, participants were asked to rate their confidence on the objectives; ratings were relatively positive with the majority of objectives above a confidence rating of 3 (Confidence Unchanged). The objective with the lowest mean score was the second objective in Module 2 with 9 participants indicating low confidence and 40 participants indicating higher confidence (**Table 10**).

Table 10: Confidence in Achievement of Module's Learning Objective

	Objective	Average (mean) score on confidence of achieving objective[1]	N (%) indicating low confidence towards objective	N (%) indicating confidence towards objective
Module 1 N=56	I can explain the difference between information literacy, computer literacy, and information system literacy	4.2	0 (0%)	50 (89.2%)
	I can define key information system terms	4.0	3 (3.5%)	49 (87.5%)
	I can identify the components of a health information system	3.9	2 (3.6%)	40 (71.4%)
Module 2	Describe the logic underlying health	3.8	6 (10.9%)	46 (83.6%)

N=55	information systems			
	Describe information system classifications and architectures	3.6	9 (16.4%)	40 (72.7%)
Module 3 N=52	Define data management concepts	4.0	2 (3.8%)	43 (82.7%)
	Describe components of the data management process	3.9	4 (7.7%)	39 (75%)

[1] Ranking: 1 – Much Less Confident, 2 – Less Confident, 3 – Confidence Unchanged, 4 – More Confident, and 5 – Much More Confident.

Satisfaction on the teaching methods was positive with some participants stating *"this is a very good way of leaning [sic], hope trainers will train us more. I am very pleased and interesting in this leaning [sic]."* Out of the 52 respondents of the evaluation, 23 rated the content *Very Good* or *Excellent* with 2 participants rating the content as *Fair* (**Table 11**). However, some participants commented that having more hardcopy materials would help as well, *"the powerpoint should be accompanied by detailed published document, to refer to for more clarity where its needed. e.g some topics arent[sic] that elaborated enough, and for more simolar[sic] examples"* or *"we must given manuals with explanation of everything."*

The lowest average satisfaction rating of a blended learning method used by all participants (excluding the website and tablet) was the in-person orientation with an average score of 3.36 out of 5 (between *Good* and *Very Good)*. Participants provided context for rating the orientation with many mentioning the length of time and practicing of skills beforehand. Sample comments from participants included:

- *"Basic practical skills supervision on how to operate the tablet prior taking the [course] could have helped me better instead of submitting several pretest several times due to the challenge with operation"*
- *"I suggest next program duration to be increased instead [of] one day."*
- *"Time extensions on orientation sessions" (tablet user)*
- *"One week training needed to get more clarity" (tablet user)*

Table 11: Count of Satisfaction in Methods used during Blended Learning Course

	Rate Your Satisfaction with the following:				
	Overall Content of the Course	In Person Orientation	eLearning Modules	Website*	Tablet
Poor	0	0	0	1	0
Fair	2	5	2	6	2
Good	27	28	23	12	13
Very Good	16	14	17	11	14
Excellent	7	5	6	4	14
Not Applicable				10	1
Total	52	52	48	44	44
Mean Rating	3.53	3.36	3.56	3.32**	3.93**

Ranking: 1 –Poor, 2 – Fair, 3 – Good, 4 – Very Good, 5 – Excellent, and 6 – Not Applicable

*No website module users were provided with this evaluation
**Not Applicable removed from average

Costing of the Pilot Program

The main difference in costs between the in-person course and the eLearning course is based upon the number of training days needed. The model we used incorporated one day of participant per diem, for the orientation session, while the in-person courses required covering participation costs over five days.

Table 12 shows sample costs for several scenarios for in-person vs. eLearning formats, based upon observed project costs at the time of the eLearning pilot in Namibia (May-June 2016). All scenarios assume that an international trainer travels to Namibia. For eLearning training, we present scenarios with 20 and 40 participants in the orientation session. The results demonstrate a per participant cost which is 2.2 – 4.8 times greater for the in-person course. When we apply an assumption about the proportion of participants who earn a passing score on course modules, we see that the cost per participant passed 1.5 – 3.3 times greater for the in-person course.

Table 12: Sample Costs of Training for In-person vs. eLearning Course

Parameter	In person course	Online course	Tablet based course	Online course	Tablet based course
Number of participants	20	20	20	40	40
International trainer airfare	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500
International trainer per diem	$ 1,694	$ 726	$ 726	$ 726	$ 726
Transportation to training facility	$ 300	$ 300	$ 300	$ 300	$ 300
Facility cost	$ 4,000	$ 800	$ 800	$ 800	$ 800
Participant per diem	$ 12,100	$ 2,420	$ 2,420	$ 4,840	$ 4,840
Tablets			$ 3,000		$ 6,000
Total	$ 19,594	$ 5,746	$ 8,746	$ 8,166	$ 14,166
Cost per participant	$ 980	$ 287	$ 437	$ 204	$ 354
Pass rate	94%	65%	64%	65%	64%
Cost per participant passed	$ 1,042	$ 442	$ 683	$ 314	$ 553

Discussion

During the eLearning pilot, we observed strong uptake of the modules among health care workers of diverse cadres. The passing rate was particularly strong for Module 1 (79%), followed by Modules 3 and 2. There were no meaningful differences in passing rates or change scores by media (tablet vs. online), or in passing rates by country. However, in Tanzania, change scores were somewhat lower than those observed in Namibia. In general, participants expressed a high level of satisfaction with the materials. The technology proved to work very well, with no users reporting any major obstacles preventing them from accessing the course materials via either the online or tablet format.

Still, there were several areas for improvement which emerged. Module 2 focuses on challenging technical content around system classification and eHealth architecture, and participants were least satisfied with this part of the course. The lower passing rates and change scores for Module 2, which

was consistent across the 2 countries, across cadres, and across the media, reflect the challenges of the technical content. Participants, who were primarily front-line health care workers, found the content less relevant to their daily responsibilities than the content from the other modules. While our sample size was relatively small and associations not necessarily statistically significant, our findings suggest that nurses tended to find the material most challenging and that "Other" health care workers scored most strongly on Module 2. This feedback points to the desirability of a strategy of dissemination where health-sector personnel can pick and choose which modules to complete, prompted by a description of the types of personnel for whom the material is most relevant.

Another area for possible improvement is in the orientation as part of a blended learning strategy. Participants expressed concerns about the length of orientation, and expressed lower satisfaction with the in-person orientation compared to the eLearning portion of the blended learning approach.

Certain questions on the pre- and post-tests had consistently low scores, little change between pre- and post-test scores, or even negative changes between pre- and post-test scores. These results provide valuable information on possible areas to improve the existing modules to better convey the information. A first step will be more analysis on whether the low improvement reflects poorly worded test questions or lack of clarity in the teaching material.

When comparing the results between the in-person course and the eLearning course, we observed that the in-person course showed moderately more favorable outcomes in terms of increased scores at post-test and passing rates. This could be explained by the ability of in-person trainers to customize the content to answer questions from participants, a higher level of learner engagement during an in-person training, or a more favorably selected group of participants. Indeed, we believe that participants at the in-person courses tended to be higher level health officials working at regional and national levels in their countries, while participants in the eLearning pilot tended to be front-line health care workers or district personnel. The higher level participants may have had a greater capability of absorbing the course content.

In terms of the technology, a small number of users reported that an incorrect post-test was associated with the modules when used in the online format; however, we were not able to replicate the problem in our testing. We recommend further testing before additional online dissemination.

Prior to conducting the pilot, we had not anticipated the strong interest in use of the eLearning course in an online format, and had expected that most participants would use the tablets. In Namibia, where internet connectivity is strong and there is not a high cost for unlimited data access via smartphones, a sizable proportion of participants preferred to view the online modules using smartphones. These participants indicated a discomfort with accepting responsibility (and potential liability) for the tablets, given that they could break or be lost.

The strategy of distributing the course via tablets depends upon presence of an existing coordination mechanism capable of managing the loaning and collection of tablets. In Tanzania, the National Center for Distance Education has been pursuing an ambitious strategy of using distance learning modalities for pre-service training. As part of our technical assistance to this Center, I-TECH had previously provided tablets; however, in the future the Center plans to have students purchase their own tablets, just as they would purchase text books for in-person learning. Thus, it is not clear that this Center could serve as a "hub" for coordinating loans, collection and handover of tablets in the future. Decisions about what

media to use must become part of each country's implementation strategy, with careful consideration about what the organizational and IT infrastructure in the country can support.

This pilot demonstrated that eLearning supports efficient coverage of larger groups of participants in a shorter period of time. Our trainers were able to visit multiple training sites, reaching 7 sites in 2 countries during a 2-week period. Using the blended approach to learning also has the advantage of only pulling participants away from their health facilities for the half-day orientation instead of the entire training course. This allows participant health providers to stay in their sites where they are needed most. Our cost estimates demonstrate the efficiency of this approach, with costs of approximately 3 times less for the eLearning course. We recommend that more formal cost analyses occur to examine the true costs and benefits to health systems of the HIS101 eLearning course.

Conclusions and Recommendations

Overall, the pilot demonstrated the feasibility of large-scale dissemination of the HIS101 course in eLearning format. The results highlight several suggestions and improvements for implementing HIS eLearning that can be used to increase uptake of the modules and ultimately expand participants' competency in HIS systems. I-TECH will use the individual question results data to revisit and improve topics in the piloted modules when scores remained low on posttests. Test questions will also be reviewed to make sure they align with the content as presented in the eLearning modules.

Given the demonstrated feasibility of the HIS101 eLearning course, there are multiple strategies for further dissemination. These strategies contain trade-offs in quality, efficiency, and scale of dissemination. For example, a stronger blended learning approach could be used to address some challenges faced by participants, such as the low completion rates, lower satisfaction with the more challenging content seen with Module 2, and the lower overall passing rates compared with the in-person training. Several actions could be taken to improve completion of pre-tests and post-tests. For instance, expanding the orientation to include real-time completion of the pre-tests (thereby ensuring full completion of pre-tests), or instituting a face-to-face administration of the post-test would improve test completion rates. Face-to-face meetings on-site or via teleconference or webinar could enhance learning by providing participants with an opportunity to discuss content that is more challenging with their colleagues, a facilitator/content expert, or tutor.

Implementers have numerous options for fitting the modules into their own continuous education programs. Participants discussed the possibility of using these modules packaged in the eLearning format as refresher trainings for HIS users or HIS Officers. Since each module stands on its own, course implementers could pick and choose modules based on their target audience and educational program. The modules can also be offered within a facility as part of facility-organized CME sessions, as part of mentorship or on-the-job training on facilities' information systems, or national-level CME programs offered by universities or professional boards or councils.

An advantage of self-paced, eLearning modules is that individuals can take those that are most relevant to their position and the competencies that they need to develop. The finding that participants found Module 2: *System Classification and Architectures* challenging and that they raised questions about its applicability to their daily work, indicates that further "segmentation" of the HIS101 content to different audiences and cadres of healthcare workers could be desirable as part of a scale-up strategy. Further guidance to implementers on which modules are best suited to which cadres and competency levels will

be helpful to ensure relevance to learners. For example, Module 2 may be best suited to HIS officers rather than nurses and doctors.

Further work to leverage flexible technology for the eLearning course could be helpful. In areas where internet infrastructure is appropriate and smartphone adoption is high, providing participants with a web address or a downloadable app for offline viewing could provide a cost effective method for delivering HIS101 concepts to health providers. With an eye on improving response rates, while reducing complexity, the modules could be engineered to require participants to follow the sequence of pretest, viewing the module, posttest, and participant evaluation. Participants would not be permitted move to the modules having not completed pretest and so on, with the system not recording the module as complete until all components done. An administrative section could be added allowing course managers in different settings to turn on and off the tests and evaluations depending on their implementation strategy, without direct I-TECH support.

In the future, pending funding availability, I-TECH plans to develop up to an additional twelve modules in year's two-to-five of the project, such that the entire HIS101 course will become available in eLearning format. We believe this pilot evaluation demonstrated the strong feasibility and acceptability of the eLearning approach. I-TECH will coordinate future deployment of eLearning modules with the Center for Disease Control and Prevention and the various Ministries of Health.

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