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Development and Implementation of an mHealth-based Mentoring Application for Use in Resource-Constrained Settings

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Background and Purpose: Clinical mentoring remains important in improving the quantity and quality of human resources for health (HRH) within low- and middle-income countries (LMIC). Few digital health solutions exist to support in-field mentoring. We herein describe the development and implementation of a robust HRH mentoring application for use within LMIC care settings. Our objective was to improve the quality of health care services through the collection of high-quality mentoring information that could be utilized expeditiously to improve programming.
Methods: We adopted a user-centered approach to gather key features needed for the mHealth mentoring application, and internally developed the system leveraging agile approaches. Usability testing was conducted, and system improvements were made prior to wider-scale implementation of the mentoring application.
Results: The developed mentoring application had three key components: (1) an android-based mHealth application for mentors, (2) a server-side application, and (3) a web-based front-end for platform administration. The mHealth application was used during routine mentoring sessions through smartphone devices capacitating users to collect mentoring session data, synchronize collected data to a secure server, and view individualized summary mentoring reports. The application was successfully implemented at health facilities supported by Friends in Global Health in Zambézia Province, Mozambique. By June 2019, 172 mentors were using the application and over 5,500 mentoring sessions were recorded into the system.
Conclusions: An HRH mentoring mHealth application extends the reach of conventional solutions to support the provision of continuous provider education by placing digital technology in the hands of mentors performing on-site mentoring activities.

Keywords: Mentoring, mHealth, Capacity building, Point-of-care, Mozambique

1 Introduction

In 2014, UNAIDS released the 90-90-90 targets. These targets state that by 2020, 90% of all people living with HIV will know their HIV status, 90% of all HIV-positive people will receive sustained combination antiretroviral therapy (ART), and that 90% of all people receiving ART will be virally suppressed[1]. Achieving these ambitious 90-90-90 goals requires well-trained and sufficient numbers of health care personnel at multiple levels, and well-functioning care systems. Unfortunately, for low and middle-income countries (LMICs), where most persons living with HIV reside, the numbers and qualifications of healthcare providers remain inadequate to meet the population's care needs [2]. In fact, human resources

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for health (HRH) has been identified by the World Health Organization (WHO) as being essential to the scale-up and sustainability of comprehensive HIV care [3], and approaches are urgently needed to address this constraint within LMICs [4].

One of the approaches recommended to improve HRH in LMICs is the utilization of clinical mentoring approaches for existing personnel. The WHO recommends clinical mentoring to assist in the scale-up of comprehensive HIV services, and to address "ongoing professional development to yield sustainable high-quality clinical care outcomes" [5]. Clinical mentoring is "a system of practical training and consultation that fosters ongoing professional development to yield sustainable high-quality clinical care outcomes" [5]. There is robust evidence that widely adopted clinical mentoring approaches can improve patient care, and address professional development needs for providers to ensure the provision of high quality care [6]. In addition, clinical mentoring has been demonstrated to improve the knowledge, confidence, satisfaction and retention of health providers [7].

As in any health system strengthening initiative, the performance of clinical mentoring programs needs to be monitored closely and improvements made in a timely fashion. It is important to track the number of sessions provided by mentors and determine whether these achieve set quantitative as well as qualitative targets. There is also a pressing need to examine whether mentees are being adequately mentored, and whether they are able to demonstrate the requisite level of competence required as part of their professional development. Over the longer-term, it is important to systematically quantify the health outcome impacts of clinical mentoring, by linking the provision of clinical mentoring sessions to select patient outcomes.

In most HIV-care programs in LMICs, clinical mentoring sessions are either not rigorously and systematically tracked, or they are manually captured but only on paper-based forms. This presents a challenge to easily aggregating and the collected data and using the mentoring data to inform decision-making for quality improvement of mentoring programs in real-time. The timely collection of high-quality health information forms an integral component of the WHO framework [8, 9], and innovative approaches that improve the use of clinical mentoring data are essential to ensure continued quality improvement within existing national programs. A core role of health information technology (HIT) is to strengthen the health system and HIT offers an opportunity to enhance the collection and utilization of mentoring data for decision-making. In fact, the increasing adoption of mobile technology within LMICs make it an ideal technology in settings where clinical mentoring sessions are offered in geographically dispersed settings, many of which are very rural and have limited internet connectivity.

We herein describe the development and implementation of a robust mobile point-of-care (POC) HRH mentoring application for use within an HIV care and treatment program, as a proof of concept of the potential of HIT to strengthen systems focused on clinical mentoring and to improve the overall quality of patient care and associated outcomes.

2 Materials and methods

2.1 Setting

The HRH mentoring mobile application was developed by the Friends in Global Health (FGH) program [23], Mozambique, in collaboration with colleagues at Vanderbilt University Medical Center (VUMC). VUMC/FGH, with U.S. government funding support from CDC/PEPFAR, presently supports the provision of comprehensive HIV services at 195 health facilities in 17 districts within Zambézia province in Mozambique. As of June 2019, greater than 190,000 patients were receiving potentially life-saving ART at FGH-supported health facilities, where in addition to the provision of ART services ranging from adult HIV care and treatment, pediatric HIV care and treatment, HIV prevention (including the prevention of mother-to-child HIV transmission (PMTCT)), HIV testing and counseling (HTC), family planning services, care for HIV/tuberculosis (TB) co-infected persons, care and treatment of additional opportunistic infections (i.e. Kaposi's sarcoma, cervical cancer, etc.), amongst others. VUMC/FGH currently employs more than 200 trained mentors to support health facilities across several key HIV care domains including adult and pediatric care and treatment (including early infant diagnosis), adult care & treatment (including 2nd line ART, etc.), pediatric care & treatment (including early infant diagnosis (EID), child-at-risk (CCR) services, etc.), laboratory, pharmacy, monitoring and evaluation (M&E), HIV testing and counseling (HTC), HIV/TB co-infection, TB screening and treatment (including multi-drug

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resistant (MDR) TB), HIV prevention (including PMTCT, Pre-exposure prophylaxis (PrEP), etc.), other opportunistic infections (i.e. Kaposi's sarcoma, cervical cancer screening, etc.) and nutritional counseling/services.

Existing Mentoring Workflow & Tools: Consistent with the vast majority of other clinical implementing partners within Mozambique providing comprehensive HIV care services, FGH originally employed a traditional paper-based approach to track clinical mentoring activities. At the beginning of every week, each mentor was given a schedule of mentoring sessions they needed to conduct. The mentor would then travel to a health facility, equipped with Ministry of Health (MoH)-mandated clinical mentoring data capture forms to complete. During each clinical mentoring session, the mentor would manually complete the relevant sections on the paper-based form, and at the time of return to FGH headquarters, they would share these forms with their supervisors. In subsequent years, the mentors manually entered completed forms into a REDCap™ [10] database developed by the VUMC/FGH team. This paper-based system, however, had multiple challenges including: (1) an inability to easily track completed mentoring sessions, (2) time consuming data entry (done retrospectively), (3) data quality issues for the retrospectively entered data that often had associated data entry errors, (4) the inability for mentors to access their historical data real-time during mentoring sessions, and (5) the lack of the mentoring data availability in timely fashion for managers and decision-makers.

2.2 Application Development

Preliminary data collection/needs assessment: We began by engaging an interdisciplinary team to identify the key attributes, optimal flow, essential data elements and reporting functionality that the majority of key stakeholders desired for the HRH mentoring application to possess. This team included clinical mentors from multiple departments, managers, monitoring and evaluation (M&E) personnel, strategic information (SI) and quality improvement (QI) team personnel, and they were all overseen by a project steering committee. Once the essential functional requirements had been identified, the team also helped to prioritize the order of attributes including the creation of a timeline for mobile mentoring application development, field testing, and eventual implementation.

Application Development & Testing: A team of VUMC/FGH strategic information personnel with experience in mobile health and server-side application development was selected to develop and implement the application, with project workflow being coordinated by a technical project manager. This team adopted an agile practical methodology including daily scrums and weekly sprints. During the development phase, the team involved end-users to help identify bugs, ensure that the system requirements were being met, and to evaluate the adequacy of the interface, user experience and workflow. Once the first version of the system was adequately developed and refined, we deployed it in a real-world setting with a new set of users on three devices over a two-month period. During this period, the development team got a chance to get direct feedback from the end-users, to fix bugs, and to implement suggested relevant improvements.

2.3 Implementation

The developed application was implemented within clinics at VUMC/FGH-supported health facilities, with various clinical mentoring domains and health facilities sequentially enrolled.

3 Results

3.1 Systems Architecture

The developed clinical mentoring application platform had three main components, namely: (1) mobile, (2) server-side, and (3) web-based manager front-end (Figure 1).

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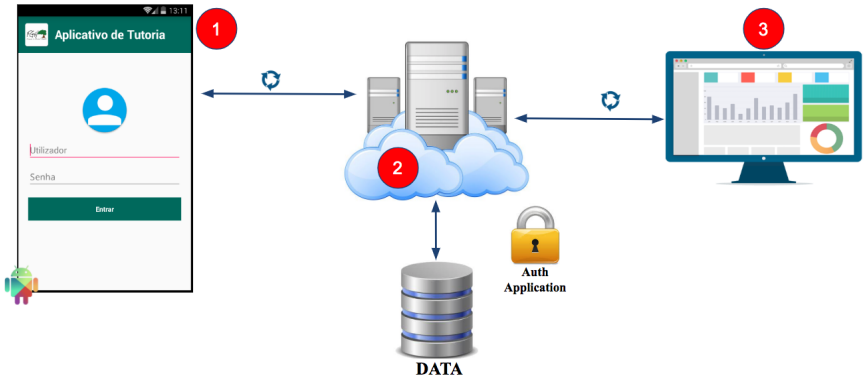

Figure 1. Mentoring Application Architecture

(1) *Mobile*: The mobile application was the one used by mentors to collect data during routine clinical mentoring sessions and worked in both online and offline modalities. Some of the features within the mobile application included: (a) the ability to add and delete mentees; (b) the ability to collect data in pre-populated forms for mentoring activities; (c) ability to synchronize data from completed forms to a secure server, and (d) ready viewable access to individualized mentoring activity summaries for the provider. The mobile mentoring application also had several security features, ensuring protection of the collected data. The application did not collect any protected health information.

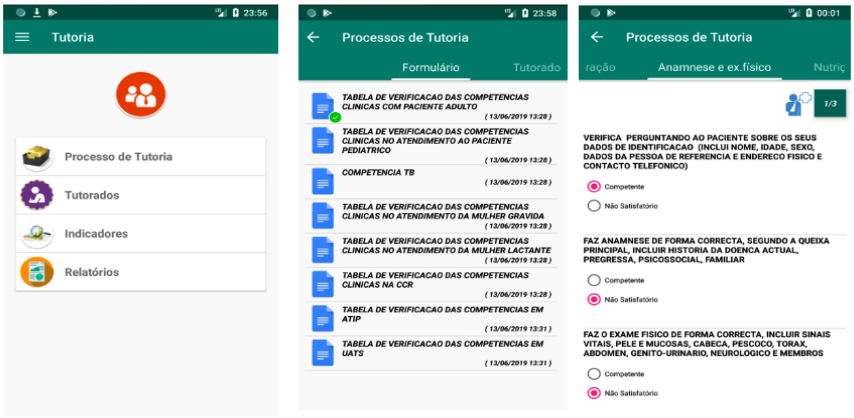

Figure 2. Mentoring mHealth application screenshots

(2) *Server-side*

The server-side application was responsible for handling the whole business logic defined in the requirements gathering and expose the data to the other clients (front-end and mobile). This server-side application was developed in Java and the data was stored in a MySQL™ database. Features supported on the server-side included the ability to: (a) add and update programmatic areas for mentoring; (b) add and update mentors and mentees; (c) map mentors according to their programmatic area to enable mentoring forms relevant to their specific area to be pushed to the mobile application; (d) add and update forms; (e) add and update questions within forms; and (f) generate mentoring reports.

(3) *Web application*

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A web-based front-end was developed for use by system administrators and managers to help access and perform the functions supported by the server-side application. The front-end was written in JavaScript™ using the AngularJs™ framework.

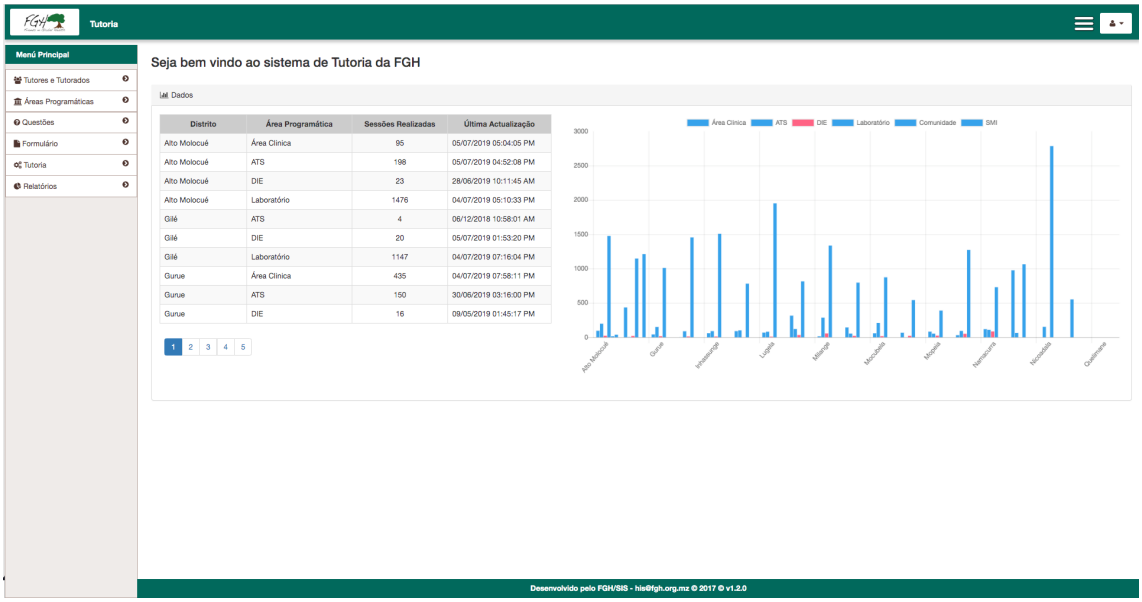

Figure 3. Mentoring web application screenshots

3.2 Implementation Data

The initial implementation of the mentoring application was with the monitoring and evaluation (M&E) team in June 2017. To date, 35 mentors from the M&E team provided their clinical mentoring sessions using the mobile app. Subsequently, two additional mentoring domains were added including laboratory and clinical mentoring domains (MCH, Pharmacy, HTC and Community). Currently, 40 laboratory mentors and 97 clinical mentors use the application to record their mentoring sessions, for a total of 172 active users of the application.

There is active use of the application as demonstrated in Table 1. In three months between April and June 2019, a total of 5,561 mentoring sessions have been performed using the application.

	Mentoring Domain	April	May	June	Total
1	Monitoring & Evaluation	25	47	98	170
2	Laboratory	1506	1507	1351	4364
3	Clinical Area	271	312	444	1027
Totals		**1,802**	**1,866**	**1,893**	**5,561**

Table 1. Number of mentoring sessions performed in the last 3 months

4 Discussion

One of the key impacts of health information technology is in health systems strengthening. In LMICs, there has been little use of digital technologies to track the performance of field-based clinical mentors and their mentees, to evaluate the quality of field-based mentoring sessions, and to inform decisions around approaches to optimize the impact of mentoring sessions. Use of digital technologies for HRH in

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these settings have largely been focused on developing and implementing interoperable health worker registries, with systems like iHRIS being widely utilized [11]. Existing mechanisms to track continued provider education have also largely relied on traditional tracking approaches with class-based courses registered within the digital system and trainee participation recorded following delivery of the course. Examples of such systems include the Training System Monitoring and Reporting Tool (TrainSMART™) [12]. To our knowledge, our group is the first to describe the development and real-world implementation of a system to track field-based clinical mentoring activities to support HIV care and treatment within an LMIC setting. The development and implementation of our mobile application significantly extends the reach of digital health technologies to support HRH development outside the classroom.

We adopted a user-centered approach to inform the development of the HRH mentoring system, taking into account key considerations within resource-constrained settings. As such, the system functions fully offline, is highly customizable to support different types of clinical mentoring domains and possesses the necessary security features while avoiding the use of protected health information. With implementation of this clinical mentoring system, mentors no longer have to retrospectively enter paper-based data into electronic systems, saving time and reducing data entry errors. With this system, it is also easy to track when clinical mentoring sessions are actually being conducted so managers/decision makers have the ability to monitor performance of individual mentors (i.e. tracking how many sessions they performed) and to identify gaps in the quality and timeliness of mentoring activities.

In addition to extending the HRH system to cover more HIV care and treatment-specific domains, our future plans also include enabling our system to be compatible with other HRH and data aggregation systems used within LMIC settings. We also plan to incorporate gamification into the app by incorporating rewards, specifically leaderboards, points and badges, etc. for various clinical mentoring milestones and achievements. Beyond evaluating performance of individual clinical mentors and their mentees, we eventually plan to evaluate the impact of digitally-facilitated clinical mentoring sessions on select patient outcomes and program indicators. Our current system is only being implemented in one care system in one setting and it is our hope that it can be scaled-up to cover more care programs across multiple countries, especially after enhancements to its functionality have been made.

Acknowledgments

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Statement on conflicts of interest

There are no conflicts of interests associated with this work.

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