mHEALTH FOR HIV LANDSCAPE ANALYSIS

UNIVERSITY OF WASHINGTON GLOBAL HEALTH START PROGRAM
REPORT TO THE BILL AND MELINDA GATES FOUNDATION

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PRODUCED BY: PINTYE J, COLLIER K, WESTLEY E, AGRAWAL N, MANHART L

EXECUTIVE SUMMARY

In November 2012, the HIV team at the Bill and Melinda Gates Foundation (the Foundation) submitted a work order to the Global Health Strategic Analysis and Research Training (START) Program team at the University of Washington, titled *mHealth for HIV Landscape Analysis*. The objectives for this work order include:

- Objective 1: Conduct a landscape analysis of mHealth for HIV projects. At the request of the Foundation, we focused on projects with applications specifically relevant to the HIV/AIDS cascade of prevention, care and treatment.

- Objective 2: Rank projects in the inventory based on a target product profile (TPP) developed by the HIV team, which outlines desired functionality of an mHealth application for HIV.

The START team conducted a literature review to identify mHealth tools and projects including both peer-reviewed literature and grey literature as source material. The START team then identified projects of particular relevance in resource limited settings and compiled projects into a useable inventory. Finally, the START team identified gaps in the mHealth literature with attention to the quality of quantitative and qualitative research and evaluation reports. Data on identified mHealth projects were compiled in an inventory including elements on project background, information technology (IT), and health components. The final inventory includes 70 projects.

A target product profile (TPP) was developed by the HIV team to describe an ideal mHealth tool that could be applied in low-resource, high disease burden countries in Africa, and an algorithm was developed to score projects against the TPP. Upon request from the Foundation, the START team also used a weighted scoring approach to calculate weighted scores of all mHealth projects included in the inventory to better reflect the elements of the TPP that are of highest priority to the Foundation ("Impact Measurement" and "Cascade of Care").

The TPP scoring algorithm and weighting scheme was used to develop a ranked list of mHealth tools and returned ten top performing projects for further information technology (IT) analysis. Each of the ten projects are described and compared to others by element and overall performance.

The main deliverable of this project is the compiled inventory which is included as a separate document. A PowerPoint presentation is also included as a separate document which presents the results of the systematic search and TPP scoring. This report serves to complement the inventory by outlining and describing the work of the START team to complete the *mHealth for HIV Landscape Analysis* work order. This report concludes with general recommendations and considerations for a next stage of analysis focused on IT platforms.

TABLE OF CONTENTS

INTRODUCTION

As outlined in the *mHealth for HIV Landscape Analysis* work order provided by the HIV team (Appendix 1), the Foundation's HIV Treatment Optimization strategy is focused on reducing the cost of antiretroviral drug therapy (ART), bringing HIV diagnostics to the point of care, and improving the delivery of prevention and treatment services, with the objective of improving access for people living with HIV/AIDS (PLWHA) in the countries with highest disease burden. The core of the service delivery strategy is the prevention, care and treatment cascade, a model which describes the steps through which people with HIV pass from diagnosis to active linkage into care, to initiation of ART, retention in care, and eventual viral suppression. For those diagnosed HIV-negative, the goal is linkage to combination prevention interventions and re-testing.

Strengthening service delivery across the HIV cascade of prevention, care and treatment is critically important not only in improving health outcomes of PLWHA, but also in primary and secondary prevention activities. Attrition at each step of the cascade results in overall low levels of viral load suppression among PLWHA (Kilmarx and Mutasa-Apollo 2013). Achieving and maintaining viral load suppression among PLWHA is a crucial step in maximizing treatment as prevention strategies, underscoring the importance of strengthening service delivery across the cascade (Hull, Wu et al. 2012).

Mobile technology applications for health (mHealth) have the potential to strengthen the HIV cascade of prevention, care and treatment in resource-limited settings. Mobile technology is increasingly used to improve health outcomes in the delivery of services and mobile phone saturation in Africa is on the rise (Krishna, Boren et al. 2009, Free, Phillips et al. 2010). mHealth can benefit both patients and providers by helping to overcome resource limitations on the supply side of healthcare in addition to structural and behavioral factors on the demand side (Thirumurthy and Lester 2012). mHealth includes a wide range of applications such as tracking patients who are lost to follow-up, reducing stockouts of drugs and diagnostics, reminding people to take their medication, and ensuring that test results are returned from the laboratory to the clinic (Barrington, Wereko-Brobby et al. 2010, Lemay, Sullivan et al. 2012). Despite the fact that the mHealth landscape is very active, the large number of pilot studies have provided little clarity on which approaches are scalable and have the capacity to produce impact at a national level (Tomlinson, Rotheram-Borus et al. 2013). A structured compilation of key facts does not exist, aside from sporadic systematic reviews that focus only on peer-reviewed literature, and fail to capture the entire mHealth universe. Some systematic reviews are available in the mHealth literature for discrete aspects of the prevention, care and treatment cascade, yet currently there is no evaluation in the literature assessing mHealth effectiveness across the cascade in its entirety as a continuum. In addition, although mHealth is commonly perceived as a promising tool with the ability to encourage aspects of the cascade such as behavior change, most systematic reviews conclude that more evaluations of current interventions need to be conducted to establish stronger evidence (Gurman, Rubin et al. 2012).

The primary purpose of this report is to outline and describe the work undertaken by the START team to achieve the objective of the *mHealth for HIV Landscape Analysis* work order. The purpose of the *mHealth for HIV Landscape Analysis* project was to identify projects engaging mHealth applications relevant to the HIV prevention, care and treatment cascade and evaluate their demonstrated potential for scalability and impact. The objectives of the *mHealth for HIV Landscape Analysis* project were to 1) identify and compile an inventory of mHealth projects that have demonstrated utility in the HIV cascade

of prevention, care and treatment or could be adapted for use in the cascade, and, 2) evaluate and quantify the potential of the identified mHealth projects to expand functionality across multiple phases of the cascade and to be scaled-up into a national-level program.

For the purposes of this report, we refer to a "project" as a planned enterprise designed to achieve a health output or outcome while utilizing an mHealth application. We refer to an "mHealth application" as the actual software tool, which is utilized by its end-user. The phrase "cascade of care" refers to the full HIV/AIDS prevention, care and treatment cascade. The term "platform" is used in the global sense as describing a mode of delivery. We use the term "software platform" as an IT reference to describe the underlying software of a system utilized in a project.

OBJECTIVE 1

The first objective of the current project was to conduct a landscape analysis of mHealth for HIV projects. The search focused on projects with applications specifically relevant to the HIV/AIDS cascade of care but included other high performing mHealth applications that could be adapted. The START team identified projects of particular relevance in resource-limited settings and compiled projects into a useable inventory.

The initial scoping meeting (November 14, 2012) positioned the landscape analysis to identify trends in mHealth projects including funding gaps, key players and opportunities for collaboration with other Foundation teams. Four priority opportunities were identified at the outset of the project: testing and linkage to care; adherence and retention; demand generation for male circumcision; self-testing support; and incentive payments to individuals and providers. Based on subsequent discussions with the HIV team, the project scope was narrowed to focus specifically on mHealth projects for the HIV/AIDS cascade of prevention, care and treatment. An iterative process of discussions with the HIV Team was used to finalize the data elements contained in the inventory and focus the types of mHealth projects included in the inventory (Table 1).

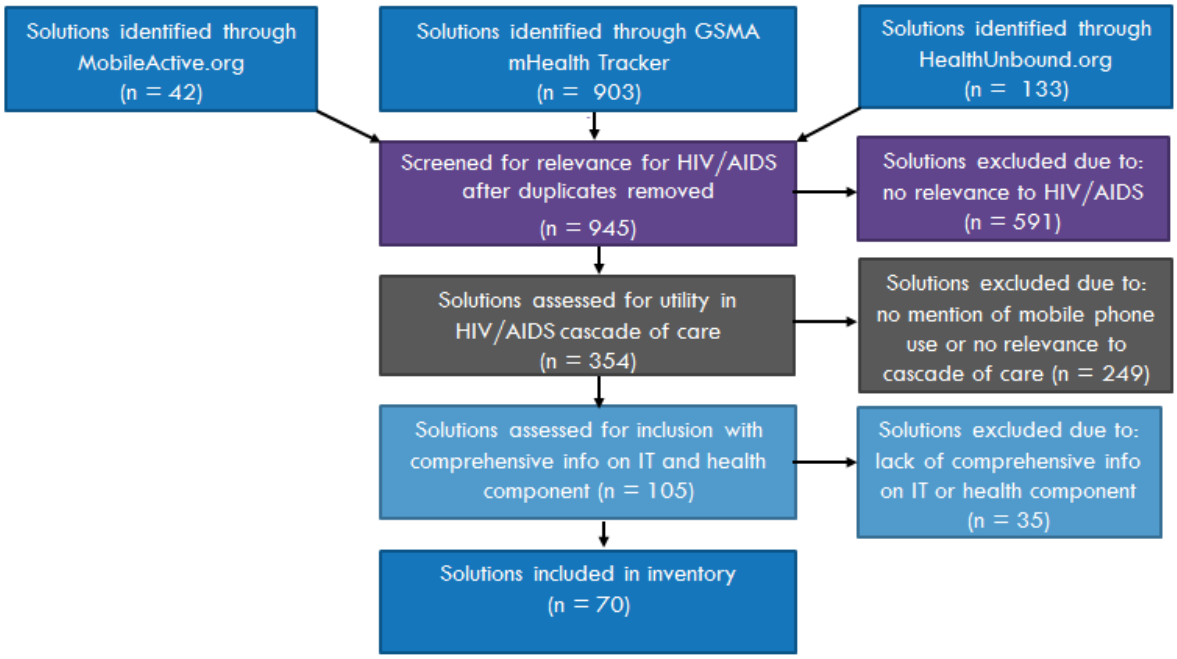
TABLE 1: DATA ELEMENTS ABSTRACTED

Project title	Type/source of software
Sponsor/funder	Type/source of hardware
Geography	Open source or not
Implementing partner (MSF, PEPFAR)	Health area addressed (HIV, MCH)
IT partner	Problem addressed
Academic partner	Started when
Other partners (e.g. Pharma)	Results of pilots
Government involvement/buy-in	Any scale-up
Multi country involvement	Impact evaluation and published literature

METHODS FOR OBJECTIVE 1

Our search strategy consisted of a modified Cochrane approach to identify mHealth projects in the peer reviewed literature, followed by a snowball technique where we leveraged the identified projects to locate others. The latter was essential to capture the grey literature and internet search engines were used to gather comprehensive information on the data elements included in the inventory. Several mHealth databases or repositories emerged as sources for HIV/AIDS related mHealth projects (MobileActive.org, HealthUnbound.org, and GSMA-Tracker – see Appendix 2). mHealth projects were included in the inventory if they utilized mobile technologies and had actual or potential function to improve some aspect of the HIV/AIDS cascade of care, including supply chain management and health systems strengthening. mHealth projects that did not have a webpage, report or other documentation beyond the minimal information provided in databases or repositories were excluded. The excluded mHealth projects are captured in a list in Appendix 3. Figure 1 illustrates the systematic search results.

FIGURE 1: SYSTEMATIC SEARCH RESULTS



RESULTS FOR OBJECTIVE 1

The inventory's Excel file contains nine tabs corresponding to the objectives of *mHealth for HIV Landscape Analysis* work order (see Table 2). The tabs corresponding to Objective 1 are described in detail in this section of results. Tabs corresponding to Objective 2 are described in that section.

TABLE 2: TABS INCLUDED IN EXCEL INVENTORY & CORRESPONDING OBJECTIVE

Tab Name	Corresponding Objective
Definitions	1
Background Info	1
IT Component	1
Health Component	1
TPP Scoring Results	2
TPP Scoring No Weights	2
TPP Scoring Weighting Cascade & Impact	2
TPP Scoring Cascade only	2

The inventory compiles mHealth projects that have comprehensive and accessible information available for most of the desired data elements outlined by the HIV team; few projects had all data elements available. Background information, IT components and health components are categorized in three separate tabs in the Excel file to simplify review across content areas:

- Background Information Tab: Summary of the mHealth project and its objectives, including timeframe, project status and funding information. IT partners, non-governmental organizations (NGOs), funders and other institutions are broken out by their roles in the project.
- IT Component Tab: Details about the software and platform used to mobilize the mHealth project's software application. Fields in this tab address basic issues of interoperability, incorporation into government data architecture, and level of expertise required for software configuration.
- Health Component Tab: Data on the health outcomes of the mHealth project, including any monitoring and evaluation reports, scale-up progress, links to impact evaluations and published literature, and area of the HIV cascade of care addressed.

Hyperlinked sources can be found at the end of each row for further investigation of a project.

We identified 105 mHealth projects with demonstrated potential utility in the HIV/AIDS cascade of care. Of these, 70 mHealth projects were included in the final inventory, and 35 projects were captured in the list of projects that lacked comprehensive data (see Appendix 3). The HIV team expressed a desire to achieve an 80/20 representation of mHealth projects for HIV and tuberculosis (TB) versus other areas of health, therefore 55 of the 70 projects included in the inventory were directly related to HIV/AIDS or TB and 15 were examples of prominent applications of mHealth projects in other disease or health areas. The number of projects with applicability in each stage of the HIV/AIDS cascade is shown in Table 3.

TABLE 3: NUMBER OF PROJECTS IDENTIFIED BY PHASE IN THE HIV/AIDS CASCADE OF CARE

Phase*	Find and Test	Link to prevention and care	Initiate ART	Adhere to ART with VL suppression	Retain in care	Supply chain, logistics
Number of projects	28	37	11	17	18	8

*Phases are not mutually exclusive; one application could address multiple phases in the cascade

Of the projects included in the inventory, a majority functioned with patients as end-users. Most client-based projects focused on health education and behavior change, treatment adherence support and appointment reminders as well as creating demand for health services. Provider-based projects mainly supported community health workers in efficient patient care and data reporting. Projects functioning at the facility-level were the least frequently identified (Table 4).

TABLE 4: NUMBER OF PROJECTS IDENTIFIED BY LEVEL OF FUNCTIONALITY*

Facility-based (n = 8)	Provider-based (n = 16)	Patient-based (n = 46)
• Supply-chain management • Lab result transmission/SMS printers	• Community health workers • Patient monitoring and tracking • Data collection and e-registers • Decision-making support, referrals • Point-of-care diagnostics	• Health education and behavior change • Demand creation for services • Treatment adherence support • Appointment reminders

*Some projects function across levels

OBJECTIVE 2

The second objective of the project was to develop a method to identify high-performing mHealth projects. To this end, the START team ranked projects in the inventory based on a target product profile (TPP) developed by the HIV team which outlines desired functionality of an mHealth application for HIV. All 70 mHealth tools in the inventory were scored against the TPP and ranked according to a simple algorithm to determine priority projects for further analysis by the HIV team.

METHODS FOR OBJECTIVE 2

A target product profile (TPP) was provided by the HIV team (Appendix 4), which described criteria defining the ideal characteristics of an mHealth tool in limited-resource, high disease burden African countries across phases of the HIV cascade of care. The TPP focuses on seven key elements: 1) monitoring and evaluation, 2) impact measurement, 3) government involvement, 4) implementing partners, 5) scale-up, 6) adaptability, and, 7) cascade of care.

A scoring algorithm was developed with scores ranging from 1 to 3 to evaluate each mHealth application against the TPP. Scoring definitions were developed by the START team in collaboration with the HIV

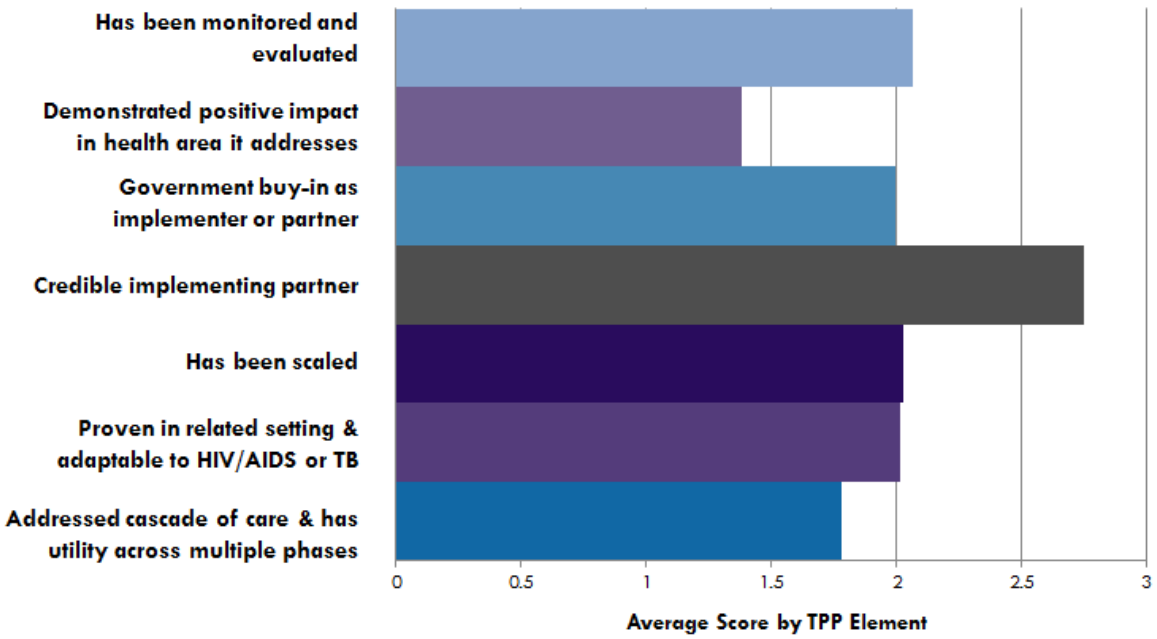
team. Each project was mapped across the TPP elements and scored according to the algorithm. In cases where information was not identified for specific TPP criteria, this was noted but did not quantitatively count against scores. The scoring algorithm is illustrated below in Figure 2. The individual score and color-coded scoring rationale for each project can be found in the TPP Scoring Tab of the inventory Excel file.

FIGURE 2: TPP SCORING CRITERIA KEY

Scoring Definitions				
1 **Monitoring & Evaluation**	No info identified	1=Limited reported outputs or outcomes identified	2=Some recorded outputs or outcomes identified	3=Comprehensive reported outputs or outcomes identified
2 **Impact Measurement**	No info identified	1=No impact evaluation on health outcomes	2=Some reported evaluation without health impact indicators	3=Reported health impacts identified, ideally in published literature
3 **Government Involvement**	No info identified	1=Government not involved on any level	2=Government approves	3=Government as main implementing partner
4 **Implementing Partners**	No info identified	1=No major national, regional or international organization as partner	2=Major national or regional organization as partner	3=Major international organization as partner
5 **Scale-up**	No info identified	1=Scale-up planned, but with no info available on execution	2=Limited scale-up reported	3=Executed scale-up and reported on it
6 **Adaptability**	No info identified	1=Tested in an unrelated setting or without success or adaptability	2=Tested with nominal success in low-income setting with potential adaptability	3=Clear, demonstrated success in low-income setting with adaptability
7 **Cascade of Care**	No info identified	1=Utility in the cascade uncertain	2=Demonstrated ability to address 1 phase in cascade or >1 in comparable disease	3=Demonstrated ability to address 2 or more phases in the cascade

Projects were then ranked according to TPP scores. There was high variability in project performance across elements of the TPP criteria with the highest scores for "Credible Implementing Partner". The indicators of "Impact Measurement" and "Cascade of Care" had the lowest average scores (Figure 3). Notably, these categories are particularly important to the priorities of the HIV Team. Low scores in the "Impact Measurement" category likely reflect a true lack of impact measurement that is prevalent throughout the mHealth field, particularly the paucity of data demonstrating mHealth projects' impact on health outcomes. Low scores in the "Cascade of Care" category may reflect that many mHealth projects and tools target only one phase in the cascade of care, and that the inventory includes some non-HIV and non-TB specific projects which do not directly address any phases of the cascade of care. Since scoring for the element of "Cascade of Care" gave higher scores for projects with demonstrated ability to address phases specifically in the HIV cascade, HIV-specific projects scored higher in this category. See Figure 3 for completed scoring breakdown of "Cascade of Care".

FIGURE 3: AVERAGE PROJECT PERFORMANCE ACROSS CASCADE OF CARE

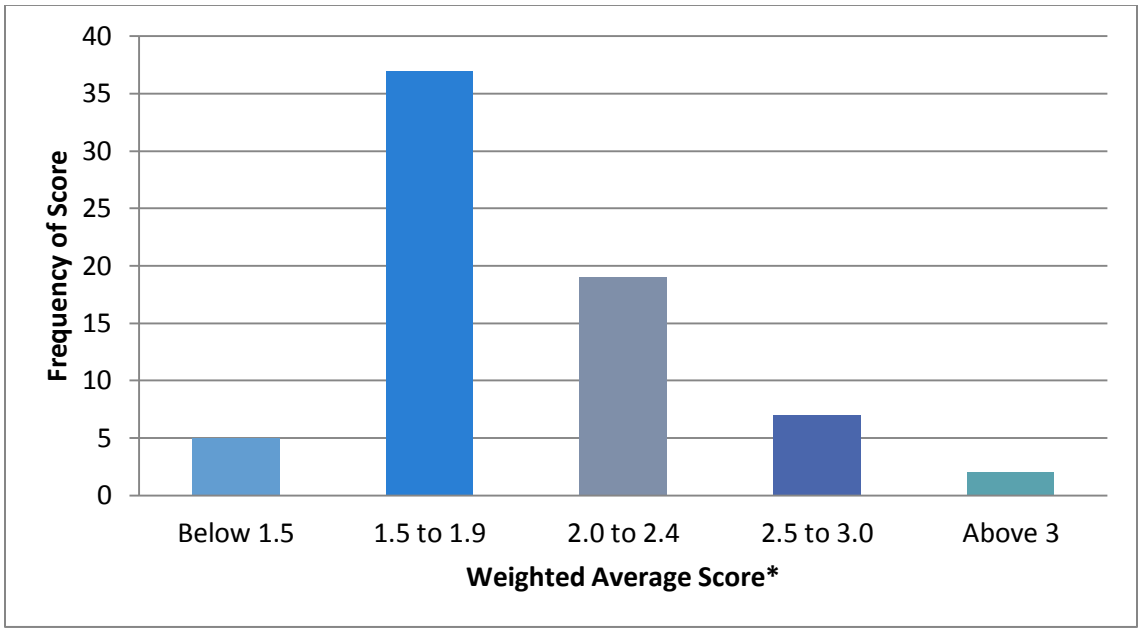


Because the "Impact Measurement" and "Cascade of Care" criteria represent high priority elements of the TPP for the Foundation, an algorithm that gives equal weight to these elements does not accurately represent these priorities. After discussions with the HIV team, it was decided that applying weights to key indicators would better reflect these priorities. Therefore, a new ranked list was generated by applying a multiplicative weight of 1.25 to both the "Cascade of Care" and "Impact Measurement" scores.

RESULTS FOR OBJECTIVE 2

The distribution of weighted average scores indicates that of the 70 mHealth tools identified, relatively few were considered high performers according to the TPP and weighted scoring algorithm. Frequency distributions of the weighted averages of projects are illustrated in FIGURE 4. Although the highest possible score was 3.21, few projects earned weighted average scores greater than 3 (2 out of 70) and most (42 out of 70) had an average scores less than 2.

FIGURE 4: WEIGHTED AVERAGE SCORES OF ALL 70 PROJECTS



*Impact and Cascade of Care indicators were each multiplied by a weight of 1.25

The TPP and scoring algorithms yielded two lists of top ten mHealth projects; one without weights and one with weights applied to the "Impact Measurement" and "Cascade of Care" elements. While both lists are presented in this report to illustrate the strengths and biases of the two approaches (see Figure 5) and illustrate the changes in ranking induced by the weighting scheme, the START team recommends utilizing the weighted average scores for determining which projects move on to further analysis. The weighting scheme returned the strongest projects with demonstrated ability to both be expanded to more than one stage of the cascade of care and also affect health outcomes.

The main rationale for weighting the "Impact Measurement" and "Cascade of Care" was the importance of these elements to a project's demonstrated potential to expand across phases of the cascade of care and to affect health outcomes. Three (3) of the top ten performing projects on the un-weighted list dropped out of the top ten when weights were applied (RapidSMS: Malawi, Lab Test Results via SMS (PING), and Text to Change: mHealth Tanzania), and this was because these projects did not have comprehensive impact evaluations available. Under the weighting scheme, other strong projects with available impact information achieved higher average scores (Early Infant Diagnosis (EID), e-Mamta, and IQSMS-Tanzania) replaced them.

FIGURE 5: TOP TEN PERFORMING PROJECTS BY WEIGHTED AND UNWEIGHTED AVERAGE SCORES

Rank	No Weights		Weights added to "Cascade of Care" and "Impact Measurement"	
	Project Title	Average Score Unweighted	Project Title	Average Score Weighted
1	FrontlineSMS: Malawi	3.00	FrontlineSMS: Malawi	3.21
2	WelTel Kenya	2.80	WelTel Kenya	3.05
3	MOTECH	2.71	MOTECH	2.89
4	***RapidSMS-Malawi****	***2.60***	SMS for Life	2.68
5	SMS for Life	2.57	TRACnet	2.68
6	TRACnet	2.57	Text Me! Flash Me!	2.63
7	Text Me! Flash Me!	2.50	Project Mwana Zambia	2.63
8	Project Mwana Zambia	2.50	***EID (Early Infant Diagnosis)****	***2.57***
9	***Lab Test Results via SMS (PING)****	***2.50***	***e-Mamta****	***2.57***
10	***Text to Change: mHealth Tanzania****	***2.5***	***IQSMS-Tanzania****	***2.39***

*Denotes change in ranking in/out of top ten performing projects

Despite these changes, a number of projects are featured on both lists, demonstrating robustness to the type of algorithm used to evaluate the mHealth tools. These include FrontlineSMS: Malawi, WelTel Kenya, MOTECH, SMS for Life, TRACnet, Text Me! Flash Me!, and Project Mwana Zambia.

The ten top performing projects based on the weighted algorithm are described below:

***FrontlineSMS: Malawi**:* This project was implemented in Malawi beginning in 2009 by the Ministry of Health, in collaboration with Stanford University. Community health workers (CHWs) use FrontlineSMS on phones or mobile devices to request doctor's visits, easily access patient information, or submit patient-level data directly to community clinics. Software also allows CHWs to access electronic medical records, and can be linked to patient information for messaging and data collection, therefore addressing linkage to care in the cascade of care. Growing from the first pilot at a single hospital in Malawi, programs are now established in 40% of Malawi's district hospitals and in nine other countries (as of 2012). This project has demonstrated increased efficiency and cost-savings for CHWs, facilitated

linkage to tuberculosis treatment, and improved CHW's ability to monitor patients on ART. The pilot's success has been published in the journal, Technology and Health (Mahmud 2010).

WelTel Kenya: WelTel Kenya was a randomized controlled trial that was designed to observe the effectiveness of SMS reminders for ART adherence among people living with HIV, funded by the U.S. President's Emergency Plan for AIDS Relief (PEPFAR). It addresses adherence in the cascade of care. Notably, this is one of the few randomized controlled trials in the mHealth field that shows an impact on patients' health outcomes. In 2007, patients were randomly divided into a control group and an intervention group at three clinic sites in Kenya. The control group received standard care, while the intervention group received weekly SMS messages and were required to respond within 48 hours. Patients in the intervention group had significantly improved ART adherence and rates of viral suppression compared with the control group. The WelTel results were published in the Lancet (Lester, Ritvo et al. 2010).

MOTECH: The MOTECH suite of applications included in our inventory are the Treatment Advice by Mobile Alerts (TAMA), Nurses' Application and Mobile Midwives applications which are described in detail below. The Nurses' Application and Mobile Midwives began in 2010 in Ghana and TAMA began in India in 2011. The MOTECH suite was developed and implemented by Columbia University, Grameen foundation and World Vision and the consortium has core funding from the Bill and Melinda Gates Foundation, as well as project-specific funding from Johnson & Johnson, USAID and the government of Norway. The three applications of the interoperable MOTECH suite optimize workflow across five key functional areas of 1) behavior change and increasing demand, 2) managing patient data, 3) improving worker performance, 4) last-mile supply chain and 5) patient adherence.

Established in 2011, TAMA uses an Interactive Voice Response (IVR) system to send reminders to patients to take medication or attend clinic visits in India. It also includes a web user-interface (UI) for nurses so they can record patient interactions and receive alerts when patients do not adhere to scheduled care. Patients with side effect symptoms can get feedback on what to do about them so they can continue their treatment. Nurses have a web-based tool which allows them to view patient adherence data and input/view patient medical data.

Nurses' Application has been implemented in Ghana since 2010. Through this application, nurses enter data about patients' clinic visits into forms on the mobile phone and send this to the MOTECH servers which then checks patients' healthcare information against the schedule of treatment recommended. If the system sees that a patient has missed care that is part of the advised schedule, the healthcare worker is informed so that they can follow up with the patient, reducing the number of clients defaulting on recommended healthcare. Healthcare workers can use the application to query the database for patient-level data to improve patient care. MOTECH also generates many of the monthly reports that facilities are required to submit to their district and regional management offices. As of January 2013, no impact evaluation had been reported. However, a MOTECH evaluation provided by the HIV team states that MOTECH did perform a Quality of Aggregated Data study in 2010 that reported much poorer quality data than expected (Grameen Foundation 2012). However, no specific detail on the

Quality of Aggregated Data Study was provided in the Grameen Foundation's 2012 MOTECH report nor was the actual Quality of Aggregated Data study identified through an internet search.

The Mobile Midwives MOTECH application has been implemented in northeast Ghana since 2010. Voice or text messages provide relevant health information during pregnancy and encourage women to seek antenatal care. After the birth of the child, information on essential vaccinations and the management of critical childhood diseases is sent. In addition, CHWs can keep electronic records and retrieve patient information using their mobile phone. Execution of an impact evaluation for MOTECH's applications in Ghana has been attempted three times (Grameen Foundation 2012). Although the 2012 MOTECH evaluation report does not provide concrete data on improvements of health outcomes attributed to MOTECH activities, it offers comprehensive descriptions of the challenges faced by the team in conducting an effective impact evaluation. For example, cross-contamination due to facility or provider-based randomization of patient-registration via SMS activities is described. MOTECH's evaluations have largely been identified in the grey literature, however a thorough analysis of the software architecture within the Ghana context for MOTECH's use has been published in the Online Journal of Health Informatics (Macleod, Phillips et al. 2012).

***SMS for Life**:* SMS for Life was designed to eliminate stockouts of ACTs for malaria treatment, but the platform could potentially be used to prevent stockouts of ARVs or TB medications as well. First implemented in Tanzania in 2010, SMS for Life enables health workers to use their personal cell phones to send a weekly stock count message. The district management and National Malaria Control Program management uses an Internet browser on any PC, or alternatively a Blackberry device, to access the data system information. This program has reduced the proportion of health facilities with stockouts from 26% to just 1% as published in the Malaria Journal (Barrington, Wereko-Brobby et al. 2010).. As of 2011, SMS for Life had been implemented across Tanzania, with over 5,000 facilities reporting on a weekly basis. The program is currently in use for tracking tuberculosis and leprosy medicines as well.

TRACnet: First implemented in Rwanda in 2005, TRACnet is a nationwide patient information management system that allows for complete tracking, monitoring, and reporting of patient-level and facility-level data for people living with HIV on ARVs. This web-based system provides monthly reporting on program indicators, weekly reporting on drug shortages and stockouts, and case-by-case reporting of CD-4 test results and addresses patient monitoring and tracking which cuts across phases of the cascade of care. The system has been deployed in all 225 health facilities in Rwanda and accounts for 100% of all patients on ART in the country. Results for the TRACnet projects from 2004-2010 have been published in the Journal of Acquired Immunodeficiency Syndrome (Nsanzimana, Ruton et al. 2012).

Text Me! Flash Me!: This mHealth program in Ghana was designed to provide most at-risk populations (MARPs) with friendly and accessible HIV/AIDS information, referrals and counseling services from qualified providers. The technology was implemented in 2008 utilizes an existing "flashing" practice in Ghana, in which one person contacts another person by calling the recipient's number and hanging up before the recipient picks up, thereby allowing for contact to be made at little or no cost to the user. In

this program, a person can "flash" an HIV/AIDS counselor. A counselor then calls each person back to answer questions, provide support, or share information about where to find services. Users can also send text inquires to the Helpline and receive an automated text in return. Although implemented in 2008; its current status is unknown as no up to date literature is available on this project. Results of the Text Me! Flash Me! project have been published in the Journal of Medical Internet Research (Déglise, Déglise et al. 2012).

***Project Mwana Zambia**:* Project Mwana Zambia was piloted by the Clinton Health Access Initiative (CHAI) in 2010 to improve early infant diagnosis (EID) and strengthen treatment services by decreasing turn-around time for lab test results. This RapidSMS-based project delivers HIV test results for infants born to HIV-positive mothers from reference labs back to the facility using SMS. When results from a test are ready, clinic workers get an SMS saying that the results are available. An evaluation of 21 health facilities showed a 28% decrease in overall turn-around time, with a 46% decrease in turn-around time for rural facilities, but no data on health outcomes were identified. Scale-up is planned, but no information on actual scale-up activities has been found as of 2012. Results of Project Mwana have been highlighted in the Bulletin of the World Health Organization (Seidenberg, Nicholson et al. 2012).

Early Infant Diagnosis (EID): Similar to Project Mwana Zambia, this EID program was piloted in 2010 by CHAI in Kenya and addresses linkage to treatment in the cascade of care. With EID, samples from infants are assigned a barcode and tested, and results are recorded in an EID database. Results are then sent by text message to SMS-enabled Hewlett Packard (HP) printers in rural clinics. Clinics with internet access can also receive results by email or access the data online. This project increased the speed of diagnosis for infants with HIV from 45 days down to just 2 days. In 2011, EID reached 65,000 infants in Kenya, with a goal to reach 120,000 in 2012. No health outcomes were reported. Although this project does not have an entire peer-reviewed publication devoted to reporting its results, it did contribute to the overall EID assessment in Kenya in the Journal of Tropical Pediatrics (Kageha, Okoth et al. 2012).

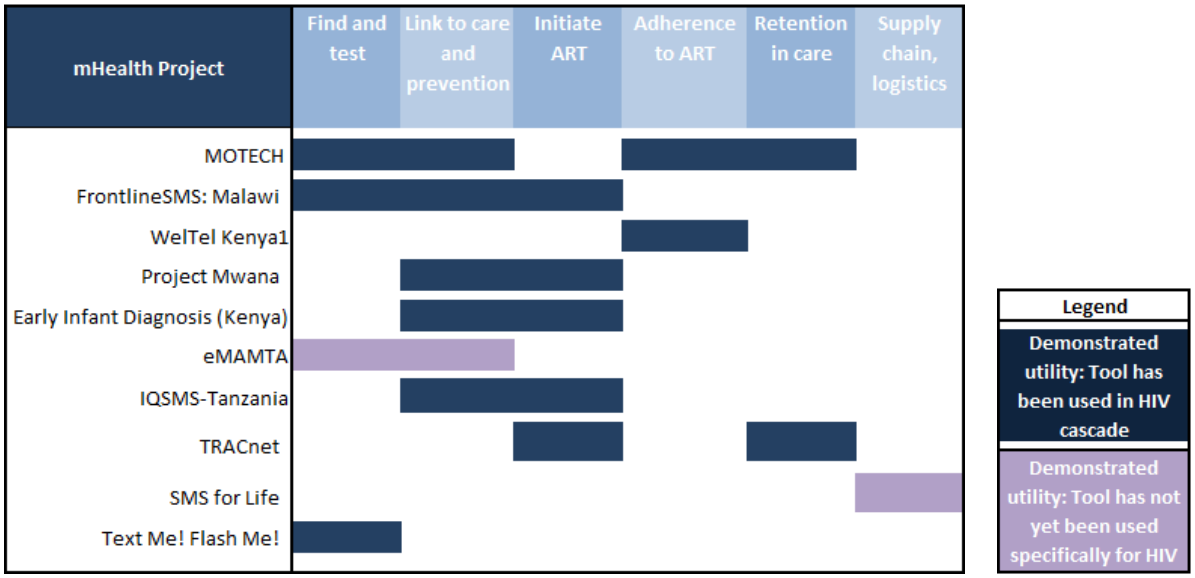
e-Mamta: This project was designed to improve the reliability and accuracy of state-reported data related to maternal and child health services and outcomes in India and has potential to be adapted to the HIV cascade of care for the patient monitoring and tracking and adherence phases. Implemented in 2010 by the National Rural Health Mission (NRHM) and National Information Center (NIC) Gujarat, this program supports the identification of every pregnant mother who visits a government health facility. Health workers monitor her from conception through 42 days after delivery using SMS. In the 2 years since the program's implementation, Gujarat's infant mortality dropped from 48 to 44 deaths per 1000 births (statistical significance not determined). The program has been especially successful in rural communities. To date, the START team has not identified peer-reviewed literature on the e-MAMTA project but links to the relevant grey literature can be found in the inventory.

***IQSMS-Tanzania**:* This is a PEPFAR project, piloted in 2009, that enables facilities to report on mother-to-child transmission (MTCT) indicators using an open source, freely available SMS reporting tool. Information is sent to a dedicated central laptop connected to mobile phones. The IQSMS software

aggregates incoming SMS reports into an SQL database. Automated data quality checks, business rules and immediate notifications are sent to users ensuring that only validated data is added to the database. In its first year, the program reduced time and costs associated with travel required for data reporting, and improved compliance with and confidence in accurate reporting in healthcare workers. Scale-up has been planned for regions not currently served by AIDSRelief. There are no peer-reviewed publications available for IQSMS, however there are some reports publicly available in the grey literature which support the project's success in reducing EID turnaround time (Karanja, Mbuagbaw et al. 2012, 2013).

These top ten projects were mapped against their actual or potential utility in the HIV cascade of care (see Figure 6). Many of the top performing tools apply to the "Linkage to Care and Prevention" and "Initiation of ART" phases of the cascade of care. Notably, few of the top performing tools apply to the "Adherence to ART," "Retention in Care," and "Supply Chain/Logistics" phases of the cascade of care. Despite the number of projects in the full mHealth inventory with utility in these categories (n=43), low scores indicate that these projects may not have demonstrated impact, reliable partners, applicable scale-up strategies, or other elements that define high-performing mHealth tools. To optimize the effectiveness of combination prevention interventions, a project should reach across multiple phases of the cascade of care or demonstrate potential to do so through functionalities engaged elsewhere in other non-HIV projects. The START team did not find any single project with utility across the entire cascade. However, MOTECH and FrontlineSMS demonstrate the most extensive range of utility across the cascade of care.

FIGURE 6: TOP TEN PERFORMING PROJECTS ACROSS PHASES OF THE CASCADE OF CARE



STRENGTHS AND LIMITATIONS

STRENGTHS

This assessment for the *mHealth for HIV Landscape Analysis* project was characterized by a number of strengths:

- **All aspects of the project were planned and executed with the specific priorities of the HIV Team in mind.** The TPP and the scoring algorithm allowed for custom evaluation of mHealth tools based on the specific criteria and priorities of the HIV Team. The TPP developed by the HIV Team provided a framework to understand the ideal elements of an mHealth tool in the African context.
- **A focus on complete data gathering during Phase 1 of the project yielded a solid foundation of information to draw from in later evaluation and synthesis of results**. A flexible approach to data gathering included grey literature as well as peer-reviewed literature and ensured that our inventory reflected the most up-to-date information available.
- **The scoring algorithm paired with the weighting scheme returned a list of top ten performing mHealth projects with demonstrated utility in one or more phases of the cascade of care and potential for expansion to others.** The successes of the top performing projects are well documented and can be used as a basis for evaluating software platforms in the next phase of the analysis.
- **Non-HIV projects included in the inventory reflect strong examples of mHealth applications with functionalities aligned with elements of the cascade of care and demonstrated adaptability**. Some of the platforms of the non-HIV projects included are also utilized in HIV projects in other capacities. This demonstrates the robustness of the software platform to adapt and cross-cut a number of functionalities. The inventory allows for the user to scroll by platform.

LIMITATIONS

Despite the strengths of this tailored approach, the current *mHealth for HIV Landscape Analysis* project inventory has limitations in the following areas:

- **The primary inventory of mHealth projects is not exhaustive**. The major challenge in compiling the inventory was that the mHealth universe is ever-evolving and a large number of mHealth projects are undocumented pilots and can only be identified in the grey literature rather than peer-reviewed literature. Therefore, it is difficult to estimate the proportion of the mHealth universe captured in our inventory. However, our inventory compiles projects with the most comprehensive and accessible information available given the HIV team's desired data elements and priority opportunities identified from November 2012 to January 2013. mHealth projects that lacked information in fields of interest to the HIV team were listed in a separate data file (Appendix 3).
- **Information on scale-up efforts is of variable quality due to limited formal evaluation reports and outdated sources.** Monitoring and evaluation data is often centered around evaluation of the implementation process rather than the actual impact of the project on health outcomes. Some projects, such as Project Mwana, had concrete successes and reported results to specific

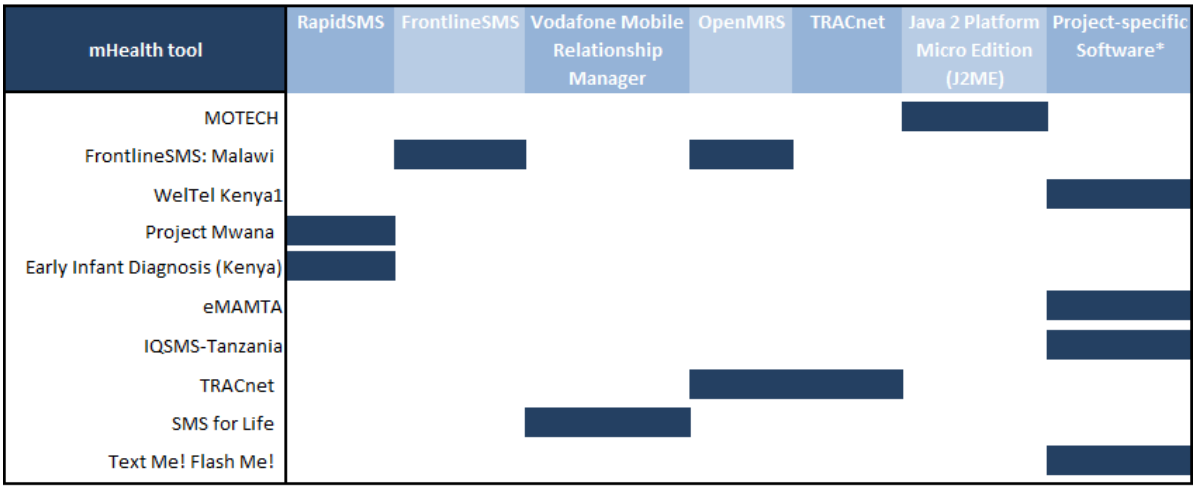
targets, yet failed to show effectiveness in actually improving health outcomes. Furthermore, it is challenging to compare outputs from projects that have very different aims. Most projects were not specifically targeting the cascade of care in its entirety as a continuum and therefore did not report indicators reflecting utility across the cascade.

- **Country-specific capacity regarding mobile technology is captured at the national-level; however the majority of projects have been rolled out at the community, district or regional level.** Therefore, strategic information regarding the mobile technology capacity in project or pilot sites cannot necessarily be inferred from the country-level data on cell-phone coverage and/or electricity coverage.
- **The scoring algorithm for prioritizing projects remains imperfect.** Each element in the TPP is scored on a scale of 1 to 3, with missing elements receiving no score. Without further information about which elements have the greatest impact on a tool's potential utility, it is difficult to know whether scoring each category equally fairly prioritizes these tools. To explore the algorithm's bias and better reflect the HIV Team's priorities, we introduced a weighting scheme to up-weight key elements of the TPP.

RECOMMENDATIONS AND CONSIDERATIONS FOR FURTHER ANALYSIS

Looking forward, the HIV team at the Foundation can utilize the mHealth inventory, TPP, and scoring algorithm as a basis for further analysis of the IT components of high-performing mHealth projects. Many projects, including most of the top ten projects identified by the weighted algorithm, use common IT platforms that also were identified for multiple projects in the full mHealth inventory (see Figure 7).

FIGURE 7: PROJECTS BY SOFTWARE PLATFORM



*Platform shares name with project

The START team has developed a compilation of key considerations and recommendations for future analysis of mHealth projects for HIV:

- The findings of this landscape analysis support focusing further analysis on *platforms* with demonstrated ability to expand across multiple phases of the cascade of care rather than

discrete *projects.* Many software platforms are utilized in multiple HIV & non-HIV projects and functionality can be leveraged into comprehensive tools.

- The findings of this analysis also support using lessons from evaluations that failed to capture impact in designing future projects. Although impact evaluations are scarce, some projects had valuable descriptions of the challenges faced in attempting to capture impact, the most comprehensive of which was MOTECH. This is vital information for future decisions regarding embedding an impact evaluation within a funded project.
- There are many examples of multiple projects using the same mHealth approaches within discrete phases of the cascade of prevention, care and treatment. For example, there are a plethora of early infant diagnosis (EID) and ART adherence projects. However, there is extreme variability in the quality of results and magnitude of effect amongst similar projects with congruent aims. Therefore, the implementation aspect of mHealth projects is key in driving effects more than the software platform itself.
- Assessing potential scalability is multifaceted and context specific. For example, large scale patient registration projects utilizing CHWs have been successful in countries where CHWs are heavily utilized within communities. However, some heavy-burden HIV countries of Southern Africa have more facility-based health care systems and therefore scaling a CHW-driven project would yield poor results. Patient registration software platforms are powerful tools and would need to be harnessed by facility-based providers in health systems where CHWs are not utilized.
- Some of the most promising projects included in the inventory have *process* oriented evaluations. For example, many EID projects achieved their aim of reducing lab result turnaround for infants born to HIV positive mothers. However, these projects failed to achieve a larger proportion of infants receiving ART, thus not improving health outcomes. In these instances, perhaps the ART program was not as robust as the EID system to reach coverage of all individuals in need. Therefore, a health systems approach to utilizing mHealth applications is needed to truly strength the cascade of care. Up to now, many mHealth projects have been filling roles as stop-gaps to larger health systems weaknesses and therefore have not achieved their true potential to affect change.

APPENDIX 1: "WORK ORDER"

Research Request Form

Date: October 1, 2012

Request Name: Chris Duncombe

Work Order ###, Request ###

This Request scope ("***Scope***") is agreed pursuant to and hereby made a part of Work Order ### (the "***Work Order***"), by and between the Bill & Melinda Gates Foundation (the "***Foundation***") and the University of Washington ("***University***"). Capitalized terms not otherwise defined in this Scope shall have the same meaning as set forth in the Agreement between the parties dated March 31, 2011. The Work Order's terms will control over any conflicting terms in this Scope, unless this Scope expressly states otherwise.

SPECIFIC DESCRIPTION OF BRIEFING/PROJECT, INCLUDING PURPOSE AND AUDIENCE:

Background:

The foundation's HIV Treatment Optimization strategy is focused on reducing the cost of antiretroviral drugs, bringing HIV diagnostics to the point-of-care and improving the delivery of prevention and treatment services, with the objective of improving access for people living with HIV in the countries with highest disease burden. The core of the service delivery strategy is the prevention, care and treatment cascade, a model which describes the steps through which HIV positive people pass from diagnosis to active linkage into care, to initiation of antiretroviral therapy, retention in care, and eventual viral suppression. For those diagnosed HIV-negative, the cascade is linkage to combination prevention interventions and re-testing.

There is increasing use of mobile technology to improve health outcomes in the delivery of services and mobile phone penetration in Africa is exploding. mHealth has a wide range of applications including tracking patients who are lost to follow-up, reducing stockouts of drugs and diagnostics, reminding people to take their medicine, and ensuring that test results are returned from the laboratory to the clinic.

While our initial research suggests that the mHealth landscape is very active, there appear to be a large number of pilot studies but little clarity on which approaches are scalable, and have the capacity to produce impact at a national level. There is no structured compilation of key facts.

Objective:

Phase 1 consists of two parts:

- Online research to conduct a landscape analysis ('who is doing what and where') of the use of mHealth applications relevant to the cascade of HIV and TB prevention and care in resource limited settings
- Up to five interviews with BMGF employees (identified by the foundation) to understand who else at the foundation is working in the field of mHealth

The following data (project inventory) will be collected in the landscape analysis:

Project title	Type/source of software
Sponsor/funder	Type/source of hardware
Geography	Open source or not
Implementing partner (MSF, PEPFAR)	Health area addressed (HIV, MCH, supply chain management)
IT partner	Problem addressed
Academic partner	Started when
Other partners (e.g. Pharma)	Results of pilots
Government involvement/ buy-in	Any scale-up
Multi country involvement	Impact evaluation and published literature

The systematic search will be guided by the components of an HIV/AIDS program identified in the WHO's "Priority Interventions for HIV/AIDS Prevention, Care and Treatment" (2010). Interventions and activities in each stage of the HIV/AIDS prevention, care and treatment cascade have been identified from the WHO (2010) report. Interventions and activities from WHO (2010) at each stage have been used to describe the functional need mHealth applications could potentially meet to achieve/improve continuity of care across the cascade. A list of search terms will be created from the described functional needs in collaboration with the Foundation team after sharing the framework of our review.

A template for our project inventory will be created with the guidance of the Foundation team and will be populated with the findings from our systematic search.

Phase 2

In-depth telephone interviews, using a structured questionnaire, with key players identified in phase 1 to understand successful mHealth projects in more detail.

Phase 3

Publication and dissemination of results, details to be determined in consultation with the foundation.

TIMELINE / DUE DATE:

For phase 1, first checkpoint before the end 2012, aiming to complete phase 1 by the end of January 2013. The first checkpoint will include a finalized framework, list of search terms and spreadsheet template for inventory of projects. The target date for the first checkpoint will be mid-December. Phase 2/3 to be determined.

DELIVERABLES:

Excel spreadsheet summarizing phase 1, descriptive narrative of telephone interviews and publication(s) in a peer-reviewed journal.

SHARING PERMISSION: Yes, details to be confirmed after discussion between the foundation and the university team.

Do you allow the contents and deliverables developed from this work order to be shared and published to the public? If the contents resulting from this work order are shared, the university team will determine the authorship, as well as, any medium and publications used; including, but not limited to: journals, external websites, and symposiums.

APPENDIX 2: "MHEALTH DATABASES"

In compiling a comprehensive inventory of mHealth tools relevant to the HIV cascade of care in low-resource, high disease burden African countries, the following directories were particularly useful:

MobileActive.org

MobileActive.org is a comprehensive website that includes information about non-governmental organizations, information technologists and projects using mobile phones for social change. At the completion of the inventory (January 2013), this website included a directory of mobile tools relevant to the areas of health, economic empowerment, advocacy and organizing, accountability and human rights – including 42 mHealth services. Directory listings included information on key partners, funding, project goals and links to relevant websites. As of April 1, 2013, MobileActive.org is undergoing an organizational change, including a re-naming process. No further information on the status of MobileActive.org was available at the time this report was prepared.

GSMA mHealth Tracker

GSMA mHealth Tracker is an online tool that collates mHealth services across the globe. At the completion of the inventory (January 2013), GSMA mHealth Tracker included 903 projects. Its directory is searchable by country, organization, type of organization and health category. The health category feature is particularly useful, and allows searching by mobile health services in areas of diagnosis, health systems, health worker empowerment, monitoring, prevention, treatment and wellness. Listings of mHealth services feature information on the implementing organization, project status, launch date, partners, project summary and links to relevant websites where applicable.

HealthUnbound.org

HealthUnbound.org is an interactive network and online resource powered by the mHealth Alliance (mHA). Among many other features, this website includes a directory of mHealth tools that is searchable by country and topic, and can also be searched by keywords. Directory listings include information on geography, project status, affiliated organizations, start dates and project summaries. At the completion of the inventory (January 2013), 103 mHealth tools were identified through this database. Notably, HealthUnbound.org also maintains up-to-date information on research in the mHealth field, expert summits and areas for greater impact and growth.

APPENDIX 3: "MHEALTH SOLUTIONS LACKING COMPREHENSIVE INFORMATION (N=35 SOLUTIONS TYPICALLY ONLY HAD INFORMATION ON PROJECT NAME, COUNTRY AND A BRIEF DESCRIPTION)"

Name	Country	Website
1298 Ambulance	India	http://1298.in/index.html
CycleTel	India	http://www.mhealthinfo.org/project/cycletel-family-planning-mobile-phones
STARS (sales tracking and reporting system)	India	http://voxiva.org/images/site/PSI-STARS%20Case%20Study.pdf
H-bookmark	Italy	http://mobile.softmenu.org/android-apps/medical/h-bookmark-android-1.0.1.html
FAMPLAN	Jamaica	http://www.fhi360.org/en/HIVAIDS/pub/Archive/articles/AIDScaptions/volume2no3/cap235.htm
Medical Smart Card	Kenya	http://www.mhealthinfo.org/project/medical-smart-card
KimMNCHip	Kenya	http://www.care.no/Global/Campaigns/Konferanser/Stefan%20Germann%20-%20Safaricom.pdf
Pambazuko PALM	Kenya	http://www.pambazuko.org/
Vista mHealth	Lesotho	http://www.prweb.com/releases/2011/4/prweb8330088.htm
IMPACT	Malawi	http://www.d-tree.org/our-projects/ovc-and-community-imci-malawi/
Project Zumbido	Mexico	http://www.shmfoundation.org/zumbido.php
EID: SMS printers in Mozambique	Mozambique	http://www.sequoia.co.uk/components/awards.php
OpenDataKit	Mozambique	http://opendatakit.org/
GATHERdata	Mozambique	http://www.healthnet.org/gather
CAP-3D	Myanmar/ Regional	http://www.pactworld.org/cs/myanmar/cap3d_myanmar
Health Education Response	Namibia	http://healthmarketinnovations.org/program/health-education-response-her
SPS Namibia	Namibia	http://www.msh.org/projects/sps/SPS-Documents/upload/about_sps_namibia.pdf
Lady Health Workers	Pakistan	http://www.gsm.org/documents/lady_health_worker_pakistan.pdf
Cell-Pos	Peru	http://www.healthunbound.org/content/cell-pos-0

Colecta PALM	Peru	http://faculty.washington.edu/wcurioso/emulator/emulator.htm
Proyecto Habla	Peru	http://www.proyectohabla.org/peru_atencion_de_calidad_personas_enfermas_tuberculosis/
Colecta-PALM Emulator	Peru	http://mhealthinfo.org/project/colecta-palm-emulator
Ipas Sexual and Reproductive Health Project	South Africa	http://www.cell-life.org/projects/ipas/
Mobile Data Collection for Mother2Mothers	South Africa	http://www.cell-life.org/projects/mothers-2-mothers/
Distance Diagnosis	Tanzania	http://www.mhealthinfo.org/project/distance-diagnosis-rural-tanzania
ICT4MPOWER	Uganda	https://service.projectplace.com/pub/english.cgi/0/163130653
Reaching Hard-to-Reach Populations	Vietnam	http://www.pathfind.org/our-work/projects/reaching-hard-to-reach-populations-with-health-information-mhealth-in-vietnam.html
MiHope	Zambia/ Malawi	http://www.rareloop.com/portfolio/article/mihope-survey-on-an-android-tablet/
Nokia Data Gathering	Zimbabwe	http://www.i-m-s.dk/hifc-completes-nokia-data-gathering-pilot-project-in-zimbabwe/
EpiSurveyor	Multiple	http://www.episurveyor.org/user/index
HealthPhone	Multiple	http://healthphone.org/
mPedigree	Multiple	http://mpedigree.net/mpedigree/index.php
Sproxil	Multiple	http://www.sproxil.com/
Stop Stockouts	Multiple	http://stopstockouts.org/

APPENDIX 4: "TARGET PRODUCT PROFILE (TPP) FOR MHEALTH APPLICATION"

Use case	**Resource limited and high disease burden countries in Africa**
Target Use	**Improve testing, linkage to prevention and care, initiation of ART, adherence and retention for HIV-infected adults and children**
Project characteristics	
Cascade of care	The project has utility for use in multiple elements of the HIV cascade care of prevention, care and treatment
Monitoring and Impact evaluation	The project or pilot project has been independently evaluated with publication of results in a peer-reviewed journal and has been shown to have a positive impact on the outcomes in the health area it addresses
Government involvement	The government (Ministry of Health, national AIDS program) is involved in the project implementation and the project has been incorporated into the government's data architecture
Implementing partners	In addition to the government, the project has a credible implementing partner, defined as PEPFAR, international NGO (e.g. MSF, FHI), CHAI, CDC, USAID, other country AID agency, UN agency, Pharma, US or foreign academic institution or private foundation
Scale-up	The project has been scaled up, defined as reaching a significant number of the target population in a specific geographic area
Adaptability	The project has been proven in a related setting and potentially adaptable to HIV/TB (e.g. SMS for rapid turnaround of early infant diagnosis)
Platform characteristics	
Platform design	The platform is horizontal, supporting multiple services for patients, health care workers and supply chain management on one platform
Hardware	The platform is capable of operating on current widely available non-smart phones and capable of additional functionality as smart phone become more available in sub Saharan Africa
Software	The platform uses open source software and is location aware
Support interoperability	The platform can communicate with other systems being used in the country's health care system
Government's data architecture	The platform is incorporated into the government's existing information system

Interface	The platform is capable of sending SMS/voice message to target population and automatically sending individualized messages to specific individuals based on their health status
Patient registration	Platform supports patient registration with unique ID number and biometrics (e.g. finger print).
Tracking	Then platform automatically generates a list of patients who missed a clinic visit and informs outreach workers.
Adherence	The platform supports customizable alerts to remind patients to take their ART
Database	The platform maintains a database of patient health status
Health care worker (HCW) support	The platform generates HCW daily service delivery schedules, provides diagnostic and treatment decision trees for HCWs, supports HCW training, referrals to other HCWs and transactional systems for HCW payments, and tracks HCW progress
Reporting	The platform produces automated activity reports
Supply chain management	The platform monitors real time consumption of commodities and stock levels over the 'last mile'

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