

Mobile Technology in Support of Frontline Health Workers

A comprehensive overview
of the landscape, knowledge
gaps and future directions



Johns Hopkins University
Global mHealth Initiative
2016

Authored by:

Smisha Agarwal
Leona Rosenblum
Tamara Goldschmidt
Michelle Carras
Neha Goel
Alain B. Labrique

Acknowledgements:

This report would not have been possible without the input and support we received from all across the mHealth Community. We would like to thank all the mHealth implementers and researchers who responded to our multiple surveys, taking time out of their busy schedules to make this report the valuable resource that we hope it will be. We leaned heavily on the work of the African Strategies for Health Project in compiling the five USAID mHealth Compendia, and the team at the Center for Health Market Innovations for amassing a wealth of projects on their databases. We would particularly like to thank mPowering Frontline Healthworkers for their assistance in reaching out to members of their network. We appreciate that Lesley Anne Long, Sara Chamberlain, and Marc Mitchell provided their input to shape our recommendations for the way forward. Lastly, we would like to thank the Bill and Melinda Gates Foundation for the funding and support that made this investigation possible.

This report was commissioned by the Bill and Melinda Gates Foundation.

Cover art:

50 Frontline Health Workers receive Tablets in rural Bangladesh, as part of the JHU mCARE Project in collaboration with the Ministry of Health and Family Welfare in 2015.

Table of Contents

Executive Summary.....	3
1. Background.....	5
2. What mHealth interventions for FHWs work?	
Current state of evidence.....	6
A. FHWs - Who are they and what is their role?.....	6
B. How can mobile technology support FHW?.....	6
C. Current state of peer-reviewed evidence.....	8
D. Remaining questions and focus of this report.....	10
3. What do current programs tell us?	
Expanding the search for evidence.....	12
A. Methods.....	12
A.1 Database Search.....	12
A.2 Expert Survey.....	14
A.3 Literature Review.....	15
A.4 Survey of NGO's.....	15
B. Data abstraction, coding and analysis.....	16
4. Current trends in the use of mobile devices (phones/tablets) by FHW.....	17
A. How are FHW using mobile phones/tablets?.....	17
A.1 Geographic distribution of projects.....	17
A.2 Type of FHWs using ICT.....	18
A.3 Disease areas being addressed by programs.....	19
A.4 mHealth approaches employed.....	20
Program Case Study: CStock.....	21
B. Types of digital devices used by FHWs.....	22
Key considerations in device selection.....	24
C. Technical Platforms used by FHW.....	25
C.1 Considerations in platform selection.....	26
C.2 Platform functionality for FHW supported interventions.....	29
D. Cost Assessment for ICT-supported FHW interventions.....	32
D.1 Costs/Cost Drivers projects supporting FHWs....	33
D.2 Challenges in assessing cost-effectiveness.....	35
D.3 High Initial Costs, Cost-Savings in the Long Run?....	36
D.4 Framework for Costs and Savings of mHealth Interventions for FHW's.....	38
D.5 Cost of scaling programs.....	40
E. Scale and Complexity of Current FHW Projects.....	42
F. Profiles: India, Kenya, Tanzania, and Scaled Programs..	44
F.1 India Country Profile.....	45
F.2 Kenya Country Profile.....	47
F.3 Tanzania Country Profile.....	48
F.4 Projects with >1000 Active Users.....	49
G. Performance of Existing Programs.....	50
5. Summary of Findings and Future Directions.....	55
A. Framework Based on Findings.....	55
B. Limitations in Identifying Credible Data and Findings...	57
C. Gaps and Way Forward.....	58

Platform Case studies

CommCare.....	65
(part of MOTECH Suite)	
DHIS2.....	67
Open Data Kit (ODK).....	70

Appendices

Appendix A:

Descriptions of platforms most frequently reported as being used to support FHW programs.....	73
---	----

Appendix B:

Key costs and cost drivers of mHealth programs.....	75
---	----

Appendix C:

Summary of key costs considered by costing studies.....	78
---	----

Appendix D:

Inactive USAID Compendia projects overview.....	79
---	----

Appendix E:

Expert Survey Questions.....	80
------------------------------	----

Executive Summary

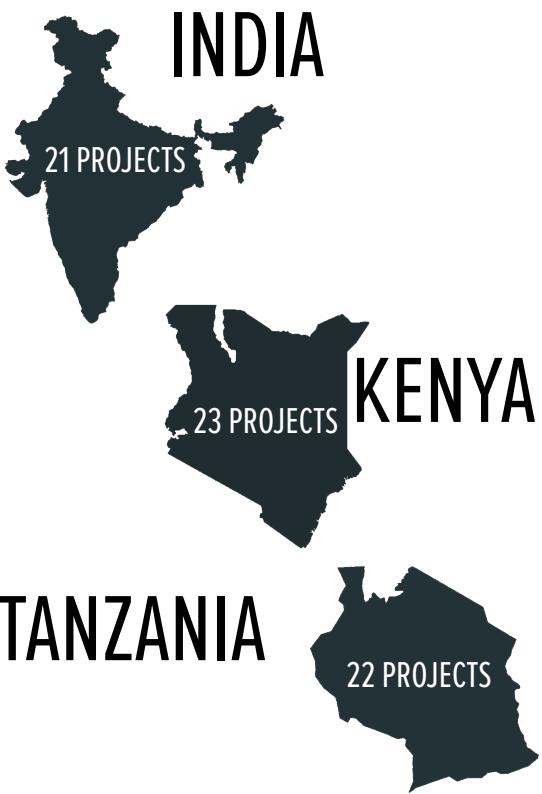
Mobile health (mHealth) interventions are rapidly gaining popularity for their potential to improve public health, and many developing countries see them as an important resource for frontline health workers (FHW). However, best practices for implementing and evaluating the effectiveness of programs and projects is lacking. This report summarizes current data from over 140 FHW-supported mHealth projects from developing countries to describe the emergent trends and best practices in the use of mobile phones, tablets, and technical platforms by FHWs over the last decade, understand the key considerations in choosing the type pf phone and platform and associated programmatic costs, present the evidence on the effectiveness of mobile approaches, and establish a framework for systematically deploying such tools. The report draws on self-reported data on relevant programs identified through a review of the USAID Compendia and Center for Health Market Innovations (CHMI) databases, a survey of projects reported by international NGOs, updated information collected through personal communication with project leadership, and a review of the literature. The findings of the report should assist donors in understanding high-impact best practices and emerging approaches in this space, and provide implementers and researchers with practical actionable understanding of key considerations in developing such programs.

Over the last decade, increasing use of smartphones and tablets over feature phones has been reported. Based on a review of the current projects, facility-based FHW are more likely to use smartphones and tablets, and more Community Health Workers (CHW) use smartphones. The most frequently mentioned considerations in the selection of type of mobile device included cost of the device, a long battery life to allow for frequent use and intermittent access to electricity for charging, screen size and attributes appropriate for task (e.g. a simple phone is not practical for extensive data entry but could be used for voice calls or rapid reporting) and local availability of the device and its service centers. Based on a survey of experts, 74% (N=52) of the respondents stated that mobile devices were provided to FHW's by the projects, and 26% (N=18) said that FHW's use their personal mobile phones.

Several popular platforms are used to support a range of functions. Just over 10% of the projects recorded in the database used some custom-made or proprietary software. The commonly appearing feature requests or functional requirements for a platform included SMS functionality, ability to work in a low bandwidth or offline environment, ability to create reports and dashboards, and the ability to design workflows. Other broad requirements included open source platforms, ease of use, low costs, interoperability and ease of customization. Interoperability remains a challenge for mHealth interventions, and there is little data on the use of

Key Findings

Regionally, the surveys captured 92 projects from Africa and 43 from Asia. India, Kenya or Tanzania have the highest number of reported projects (20-25 projects each). Projects primarily support community health workers and facility staff through facilitating electronic decision support or data collection activities. The large majority of the programs recorded in the database that use mobile tools and employ FHWs focus on reproductive health (including family planning), maternal health and child health, and infectious and vector-borne diseases. Nearly 20% of the projects report using mobile tools for data collection. Electronic decision support (17%), provider training and education (12%), and provider to provider communication (11%) are the other most commonly used functions. Most projects employed only one signal function (56%) at the core of their projects. Remaining 46% of the projects reported using mobile phones for two or more signal functions simultaneously.



standards for data architecture and interoperability for interventions. Most scaled projects address a single function, while more complex multi-function projects are limited to fewer users. The evidence on costs associated with FHW-supported mHealth interventions, and cost-effectiveness of such interventions compared to alternate approaches is fairly nascent. Initial costs comprising of the cost of development and testing of the technical system, and training FHWs in the use of the system are typically the largest cost drivers. Early evidence suggests that there is potential for cost-savings in the long-run resulting from increasing system efficiency. Opportunities for cost savings may result from use of open source technical platforms and content, discounts bulk purchases of equipment and phone services (e.g. minutes, SMS, data plan etc.). Currently, there is no standardization for how costs are reported and which costs are included when demonstrating cost-effectiveness. This presents challenges to understanding cost-effectiveness of mHealth interventions. It calls into question the reliability of cost analysis of individual mHealth interventions because completeness of the data is unclear. It also limits comparisons between interventions, and inhibits the aggregation of data to provide a macro level understanding of cost-effectiveness.

The strength of the findings to support the use of mobile interventions over alternate strategies is still limited; however there is more support for some strategies than others. Mobile phones have been widely used for data collection, and there is some low quality evidence to suggest that this can improve the overall efficiency and responsiveness of the health system. The evidence to support the use of decision support tools to help FHWs deliver a wide range of health services is fairly robust and growing. Several specific mobile sensors and diagnostic tools have strong support in their favor based on randomized trials. The overall effectiveness of each of these tools should be meta-analyzed to generate stronger recommendations for use, where appropriate. The specific application of mobile tools to support supply chain management has been quite varied; however, most of the operational research of the use of mobile tools for reporting stock-outs has suggested improvements in the system resulting from greater data visibility. cStock- one of the most successful programs for reducing stock-outs- emphasizes the value of a team and management approach to support the use of mobile interventions for them to be effective. Several large programs are exploring the use of mobile messages to support behavior change-however, we do not know if such interventions can result in sustained gains in knowledge and behavior. Given the resources that have already been invested in such programs worldwide, it is critical that its long-term effects are robustly studied.

Going forward, this report recommends the use of a systematic framework in the development, implementation and evaluation of mHealth projects that can fill in these critical research gaps. This framework will ensure that considerations from the simple but overlooked (e.g., electricity infrastructure) to the complex but vital (e.g. intersection of platform cost, phone type and skills of FHW) are systematically incorporated into newly developed projects, allowing future mHealth developers to capitalize on prior knowledge and experiences. A rigorous approach to development and evaluation of future projects will ensure that scarce public health resources in developing countries are targeted to projects that will deliver the most improvement in outcomes with increasing cost-effectiveness as further best practices are identified.

Background

Frontline health workers (FHW) deliver much-needed primary health care at the community level (Frontline Health Workers Coalition, nd). Unfortunately, they often shoulder this burden alone, with insufficient training and organizational support, and this limits their ability to provide high quality care (Rednick, et. al, 2014; WHO, 2010). As the availability of mobile technology has spread throughout the developing world, public health practitioners have turned their attention to its potential to support FHW and thereby improve health outcomes.

Several recent reviews of the academic literature have been conducted to examine the effectiveness of the range of mobile based interventions for FHWs. (Agarwal, 2015; Braun, 2013; DeRenzi, 2011; Free, 2010; Kallendar 2013). However, the implementation of mHealth interventions is moving at a faster pace than the generation of evidence. Reviews that focus solely on evidence published in peer-reviewed publications provide an incomplete picture of the range of mobile health interventions currently being implemented to support FHWs. They also present an incomplete picture of the interventions themselves, with insufficient details about the type of technology being used and its adaptations to the specific health program area. Specifically, “what” the mobile health intervention is composed of in terms of hardware, technology type, software platform, and how it relates to its ability to scale is often a missed detail. To address this gap, this report examines **currently active** programs that use mobile phones and tablets to support FHWs, in order to provide a framework for understanding the existing mHealth ecosystem for FHWs. The findings of the report should assist donors in understanding high-impact best practices and emerging approaches in this space, and provide implementers and researchers with practical actionable understanding of key considerations in developing such programs.



This report is structured into three parts:

1

The first section describes the current state of evidence on the effectiveness of mobile-based interventions in the hands of CHW's based on a review of peer-reviewed literature and identifies the areas where evidence is inadequate.

2

The second part of the report expands on this to include projects documented in the grey literature which may not be captured in the academic literature. Based on this, the report provides a detailed analysis of the current trends in mobile phone applications in FHW-supported healthcare interventions, including the range of technologies used (such as types of mobile phones, and technical platforms), and the associated costs of such interventions.

3

Finally, in the last section, we summarize our findings and identify future directions for investments in, and development of this space.

2. What mHealth interventions for FHWs work? Current state of evidence

FHWs - Who are they and what is their role?

A

Frontline health workers (FHWs) are those who deliver health care and services to communities on the frontlines (FHW Coalition, nd). FHWs typically work and live within the communities they serve, often in remote, rural areas (FHW Coalition, nd). Often, they may be the only healthcare providers available in the areas where they serve. As such, they are under great pressure to perform complex tasks that require a wide breadth of knowledge and skills, often well beyond the level of their training. We define FHW as outlined by the Frontline Health Worker Coalition, to focus on all cadres of FHW providing primary health care at the community level in the developing world. FHW may include community health workers (CHWs), midwives, nurses, doctors, or pharmacists who are providing the first link to the health system for people who need it the most (Frontline Health Workers Coalition, nd).

Several developing countries are currently facing a severe shortage of all professional cadres of health workers, which will only be exacerbated by projected population growth (Every Mother Counts, nd; UNICEF, 2006). Globally, the WHO projects a shortfall of 12.9 million healthcare workers by 2035 (WHO, 2013). Clustering of health personnel in capital cities and other urban areas, and out migration to high-income countries further diminishes the numbers of healthcare providers available in rural areas (Dussault, et. al 2006). The lack of trained healthcare workers available at the community level has led to a push to focus on strategies for retention of community-level providers (Lehman et. al, 2008; WHO; 2007; WHO, 2010). The shortage has also prompted policy makers to explore shifting key tasks from higher to lower cadres of health workers (Baker et. al, 2007, WHO 2008). The recent years have seen an increased emphasis on the potential of FHW such as CHWs to fill these critical gaps in the healthcare system. While task shifting has shown great promise, there are still questions about the actual effectiveness of lower level cadres who are asked to perform tasks above their training level (Callaghan, et. al, 2010; Lehman, 2007). This recognition has resulted in a renewed focus on strategies to provide ongoing support these workers on the frontline.

How can mobile technology support FHW?

B

The persistent challenges with poor performance and retention of FHWs in the health workforce has led global health practitioners to explore mobile technologies as potential tools to support FHWs in their work. As mobile phone subscriber penetration continues to grow across the developing world, and the cost of phones and tablets drops lower, the increased ability to rapidly scale mobile-based solutions, makes them ever more appealing (GSMA, 2013). The advent and increasing ubiquity of smartphones and tablets has expanded the capabilities now available, and more importantly, affordable, in handheld devices. Where before, in most low income settings, only basic features such as voice calls and short message service (SMS) were commonplace, the pace of mobile technology growth increasingly allows low-cost access to the internet, high quality cameras for still and video footage, multimedia messaging service, applications stored on-device, pre-loaded audio or video clips and images, global positioning service (GPS), and the potential to connect additional sensors and devices – even in low resource settings.

2. Current state of peer-reviewed evidence

How can mobile technology support FHW?

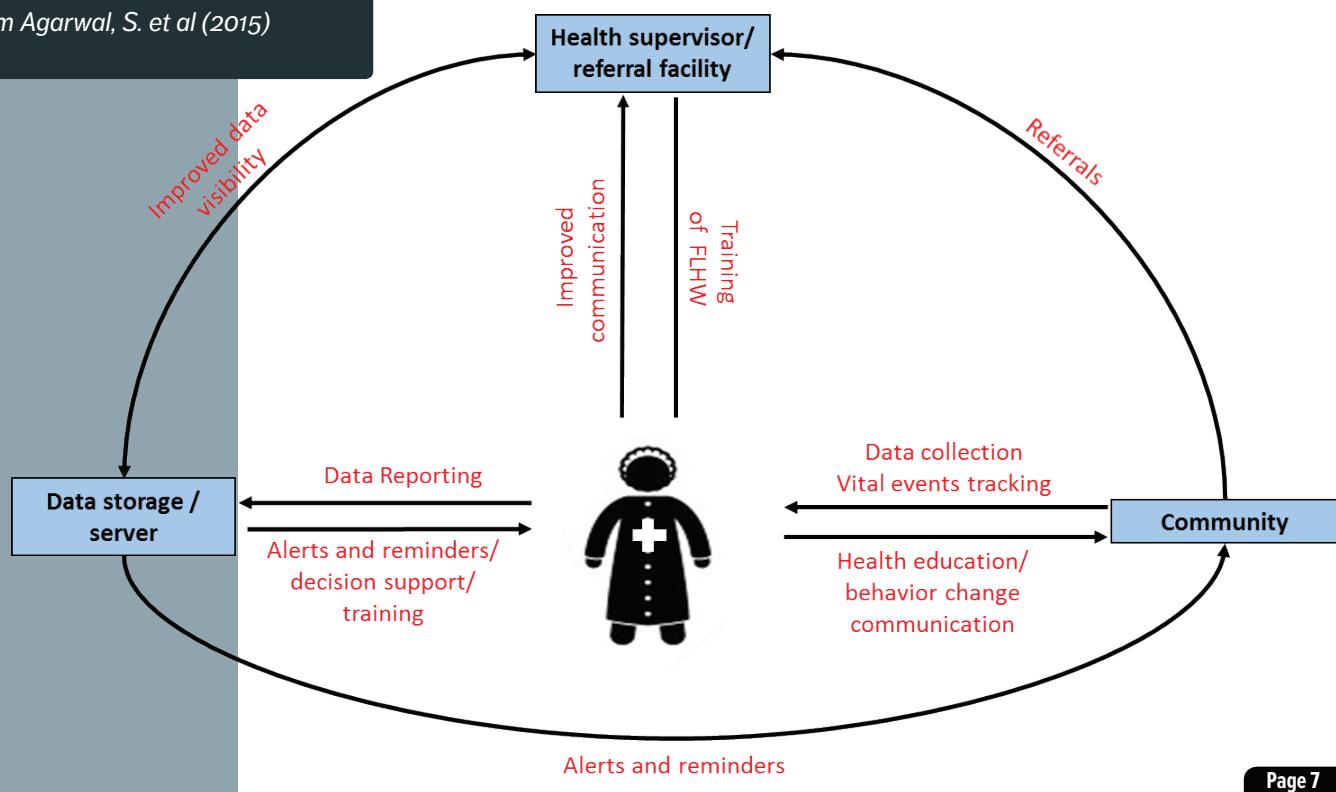
B

Figure 1: How can mobile technologies support Frontline Health Workers?

From Agarwal, S. et al (2015)

In early days of this digital ‘revolution’, mobile devices owned by health workers themselves began to be used to address work challenges. Besides the complex, “computing” functions these miniature devices are now capable of, early research into mHealth for FHWs documented how simple phone calls allowing workers to communicate with each other and with their supervisors was innately transformative to health programs (Kaonga 2013). This ecosystem shift was arguably driven by individuals purchasing phones for their own family use, but is now increasingly being institutionalized as programs appreciate the clear benefits associated with mobile use.

Mobile technology is being used within health programs and health systems in both developed and developing countries to support patient care, manage information and change behaviors of both patients and providers. Within these broader categories, twelve “signal functions” of mobile health (mHealth) tools for health systems strengthening have been identified (Labrique, 2013). These are: 1) client education and behavior change, 2) sensors and point of care diagnostics, 3) registries/vital events tracking, 4) data collection and reporting, 5) electronic health records, 6) electronic decision support, 7) provider-provider communication, 8) provider work planning and scheduling, 9) provider training and education, 10) Human resource management, 11) supply chain management, 12) financial transactions and incentives (Labrique 2013). While many mobile health interventions, particularly in developed countries, focus on instantaneous and ubiquitous mobile phone access as a way to target the population and patients directly, in developing countries mobile phones or tablets are often the only electronic tool in the hands of the health worker.



2. What mHealth interventions for FHWs work?

Current state of evidence (*continued*)

How can mobile technology support FHW?

B

Current state of peer-reviewed evidence

C

Kallander's 3 Axes Framework

1

Communication Type

1 way, 2 way, 3way

2

Themes

Education and awareness, data access, monitoring and compliance, disease and emergency tracking, health information systems, diagnosis and consultation

3

Considerations for Success

Collaboration, costs and sustainable financing, literacy and cultural specificity, health worker partnership, engagement, training, compliance, technical considerations

Prior reviews of the use of mobile technologies to support FHWs and health care delivery processes have identified the use of mobile technology to support providers through medical education/training, clinical diagnosis management, and facilitating communication between providers (Free, 2013). For CHWs in particular, there has been an emphasis on the use of mobile phones to support data collection, decision support, alerts and reminders, and information access tools in the published literature across low resource settings (Braun et. al, 2013). The most recent review that specifically focused on mHealth tools for FHWs additionally identified mobile phones being used to facilitate emergency referrals (Agarwal, 2015).

As the field of mobile health has emerged over the last two decades, academic research has sought to measure the feasibility, usability, and impact of mobile technology on health across contexts, user groups, and for a variety of purposes. By the end of the last decade, there were enough papers published for the first systematic reviews to appear. These were generally focused on high-resource settings, and primarily examined the effectiveness of the use of SMS reminders for patients and health care workers (Krishna, 2009). In the 2000's academic research on mobile health tended to follow particular devices or features (i.e. PDAs), but was still often limited to high-resource contexts as the technology was not yet widely available in low-resource settings (Kho, 2006).

The first groups of literature reviews on the effectiveness of mHealth in developing countries were published in 2012-2013. Kallendar, et al examined the use of mobile technologies to support CHWs, and categorized these projects by communication type (1-way, 2-way, and multiway), as well as by six themes (education and awareness, data access, monitoring and compliance, disease and emergency tracking, health information systems, and diagnosis and consultation) (Kallendar, 2012). They also identified key considerations for the success of mHealth projects, including: collaboration; costs and sustainable financing; literature and cultural specificity; health worker partnerships, engagement, training and compliance; and technical considerations. Kallendar et al's three axes (communication type, intervention theme, and considerations for success) laid out a helpful framework for understanding the use of mHealth in low resource settings, identifying that mobile tools are primarily used for messaging and phone reminders for appointments, for promoting healthy behaviors, and for data gathering. They found a limited number of evaluation studies on mHealth projects specifically targeting CHWs; most projects focused on improving data submission, and diagnostics, but none of the associated studies assessed the impact of these interventions.

2. What mHealth interventions for FHWs work? Current state of evidence (*continued*)

Current state of peer-reviewed evidence

C

While it was helpful that the Kallendar review included non-peer-reviewed projects, this portion was mainly designed to provide illustrative examples of each intervention type. Since the non-peer-reviewed portion of the Kallendar data collection took place in 2010, the range of possible projects for inclusion was limited to those that were already active at this point (which explains why there was such a large emphasis on SMS-based intervention within their review). Though the authors label the peer-reviewed phase of their work systematic, because they do not provide a description or diagram of the literature search strategy, it is difficult to ascertain how many records were reviewed in 2010/2012, and how many met the inclusion criteria (Kallendar, 2012).

Braun et al's paper (published in 2013) fills this gap, providing a systematic review of the use of mHealth specifically by CHWs in the academic literature (Braun, 2013). Of the 25 studies that met their criteria for inclusion, the majority were conducted in rural areas, and in Sub-Saharan Africa, with a strong focus on reproductive health, maternal and child health, and HIV/AIDS health program areas. Braun classified the technology purposes into four categories: data collection; decision support; alerts and reminders; and information on demand, with sixteen of the papers falling in the data collection category. Braun uses the strategies for improving organizational performance and their measurement outlined by the World Bank in Improving the Delivery of Health Services: A Guide to Choosing Strategies to determine the framework for analysis. Projects are therefore categorized according to how they seek to improve CHW provision of health services: process improvement and technology development (96%); standards and guidelines (32%); education and training (28%); and leadership and management (25%), and then again by how they seek to measure improved outcomes related to CHW performance: quality of care (71%), efficiency of services, learning by CHWs (32%), and utilization of services. Since many of the projects focused on improving adherence to standards and guidelines, improved quality of care (defined as improved adherence to treatment protocols) was one of the most common impact measures (Braun, 2013). Braun's sample of CHW specific peer reviewed literature, though small, shows a marked increase in academic papers published on the topic in the limited time between this systematic review and the review by Kallander et al(Braun, 2013; Kallenar, 2012). Not only are there more CHW-specific articles, but some of these papers do go beyond feasibility studies to include some measures of impact. It is noted that they are mainly pilot studies which provide little information about how these types of programs would operate at scale.

2. What mHealth interventions for FHWs work? Current state of evidence (*continued*)

Current state of peer-reviewed evidence

C

Most authors have found that the heterogeneity of study designs and contexts, combined with the lack of outcome and impact measures in the published literature prevented the conduct of a formal meta-analysis. Most recently, in 2015, Agarwal et al published a systematic review of both the feasibility and effectiveness of the use of mHealth to support FHWs in the developing country context (Agarwal, 2015). That paper takes the most similar approach to this report, focusing on the same cadre (FHWs) in the same context (low-resource settings). The literature was reviewed in December 2013, and 42 articles were included in the final analysis. Though Agarwal's exclusion criteria were stricter than Braun's (data had to be collected by FHW themselves, not by specially hired enumerators), in the intervening year the number of papers published on this topic had nearly doubled. Fourteen of the papers examined the feasibility of the use of mHealth tools by FHWs, and the overwhelming consensus found that this was a feasible context for the use of mobile technology to support health service delivery. Agarwal, et al found that interventions focused on five key functions: data collection and reporting, decision-support tools and training, emergency referrals, alerts and reminders, and supervision. (See Figure 1). The review provides some evidence to support the use of mobile tools for data collection, for training of FHWs and for use as decision support systems. In particular, there is evidence to support the use of mobile devices to improve accuracy, speed and completeness of data collection. There is also evidence from two robust studies that points to the effectiveness of SMS or decision-support system based tools to improve adherence to treatment protocols. Given the same dearth of impact evaluations noted in the prior reviews, the systematic review concludes with a call for further research (Agarwal, 2015).

Remaining questions and focus of this report

D

As discussed above, the literature reviews conducted in the last five years provide a thorough description of the state of the academic literature on effectiveness of FHW-supported mHealth interventions. They show that there is strong evidence for the feasibility of incorporating mobile technologies into the work of FHWs, and evidence that FHWs welcome the addition of this new technology into their work streams. There are positive trends to support the effectiveness of mobile tools in improving data collection and adherence to treatment algorithms. The reviews discussed above present the state of the evidence on mHealth, and identify significant gaps in what we know about the implementation and effectiveness of mHealth interventions. Systematic reviews have limitations of their own- primarily, the temporal lag in peer-reviewed literature results in an assessment of the landscape which, by the time the manuscript is published, is already largely outdated.

2. What mHealth interventions for FHWs work? Current state of evidence (*continued*)

Remaining questions and focus of this report

D

Research vs Practice

Though it is important to review the academic literature, this provides limited information about the ways in which mHealth is currently being used in practice. The use of mobile technology to support FHWs in various aspects of their work has become widespread over the last ten years, but much of it is only captured in grey literature (if at all). Very few projects that incorporate a mobile technology component do so as part of a rigorous research study. These mHealth projects are completely absent from the academic literature, even if they reach considerable scale. Depending purely on the academic literature to understand the current state of the field places an overemphasis on pilots (which are often rigorously studied but never designed to continue or scale after the study is completed). The pace of rigorous academic research is also much slower than the pace of technological innovation. Systematic reviews can only review that which has already been published, and grant, research and publication cycles that take several years means that even the most recent systematic review is limited to projects that began when the mobile landscape in developing countries was significantly different from what it is today.

Clarity and specificity of interventions

Academic papers have space limitations, and tend to focus on outlining research methods and outcome findings. These pieces are important, but in the literature on mHealth this tends to come at the expense of describing the actual intervention. For any type of mHealth intervention, there are many permutations of software, hardware, and system design. These specifics are often glossed over in the peer-reviewed literature, particularly in outcomes-focused papers. Even if a study shows evidence that an intervention works, when there is insufficient specificity as to what the intervention is, this evidence is not actionable or replicable. Without a clear understanding of the components of successful interventions, practitioners are left without guidance on what exactly they should implement.

Need for further research

While the research highlighted above supports some intervention approaches over others, the heterogeneity of interventions, study design, and outcome measures precludes clear consensus on the effectiveness of these tools. The issues related to clarity and specificity in the explanation of various interventions makes it difficult to compare the results of one paper to another, even if they purportedly examine similar programs. Outcome measures are as diverse as the interventions. Though progress has been made, the field is still nascent and there is still work to be done to develop standardized measures of effectiveness. There is a need for more studies to not only determine what works, but define the standards by which we determine effectiveness.

2. What mHealth interventions for FHWs work? Current state of evidence (*continued*)

Remaining questions and focus of this report

D

This report

In preparing this report, the emphasis was placed on conducting a thorough and extensive review of the non-academic literature, and on ensuring that the information presented here was as up-to-date as possible. This report does not seek to give an overview of all the mobile interventions that have been attempted and tested over the last decade but instead provides a snapshot of how mHealth is supporting FHWs right now. To that end, grey-literature sources and program documents describing projects that are still currently active have been included. By identifying how mHealth is being used, and clarifying in what contexts and for what purposes it has been able to reach significant scale, we can complement the rigorous academic evidence and provide a more robust picture for where things could and should be moving.

3. What do current programs tell us? Expanding the search for evidence

Methods

A

Database search

A.1

A varied number of data sources were used for the development of this report, and we used several separate approaches to ensure that a comprehensive and representative sample of existing FHW projects employing mobile tools are captured. Figure 2, on page 13, presents a snapshot of the 4-part search process and data sources, described in more detail here (A.1-A.4).

A number of databases were searched to identify relevant projects. These included the USAID mHealth Compendia 1-5, Center for Health Market Innovations (CHMI) database, NetHope and WHO eHealth Observatory. Projects were included if they involved the use a mobile device by a FHW. FHW was defined as workers involved in the direct provision of health services at the primary healthcare level and included doctors, CHWs, nurses, local pharmacists, midwives and others kind of health workers on the frontlines.

USAID mHealth Compendia: These compendia served as a major data source for this report. A total of 157 case studies were reviewed for inclusion from all the five mHealth Compendia. Of these, 97 projects involved the use of mobile tools by FHWs and were included. It was noted that several of these projects, especially those included in the earlier Compendia, were either no longer operational or did not have up to date information on the program approaches and reach. Therefore, a follow up online survey was conducted to identify if the project was active and update project activity information, particularly current scale. All the project contacts listed in the USAID Compendia were given two weeks to respond to the survey. If the contact did not respond within the allotted time, they were contacted individually and encouraged to update their project information. 69% (67/97) of the project contacts responded to the survey and updated their project information. **Only 65% (43 projects) of the 67 projects who responded are currently active.**

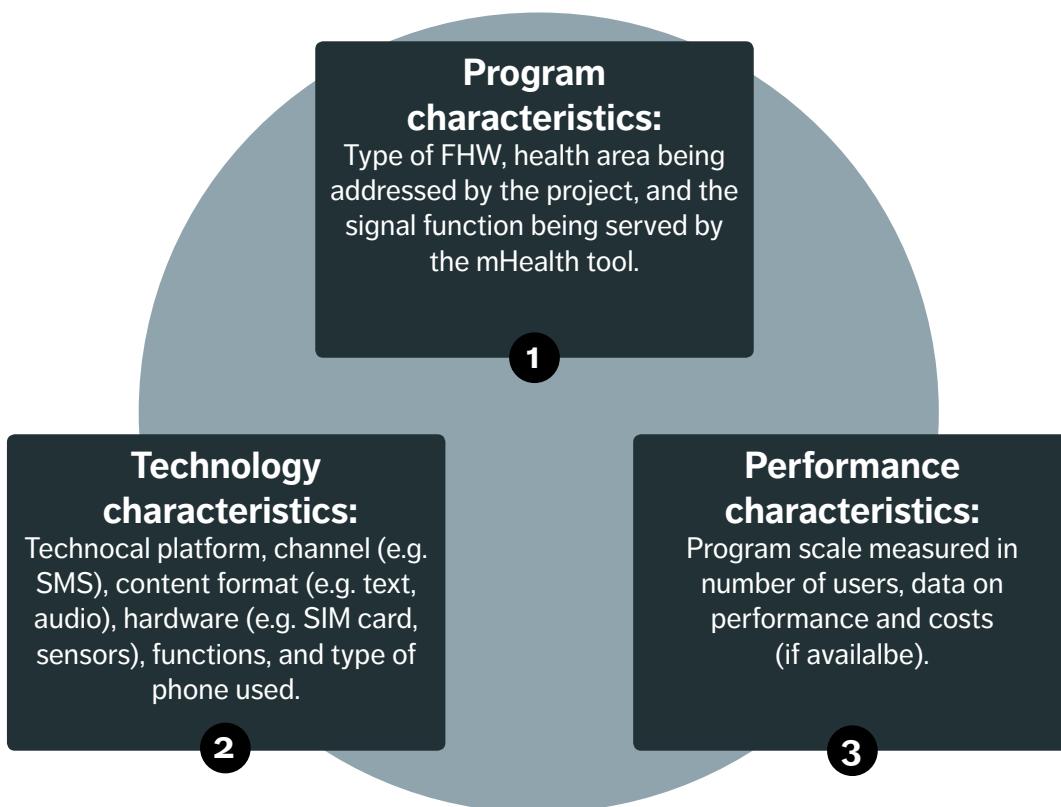
3. What do current programs tell us? Expanding the search for evidence (*continued*)

Database search

A.1

CHMI database: Relevant projects from the CHMI database, which were in the post-pilot stages were identified using three key themes- Nurses and midwives (N=103), CHWs (N=53), Informal Provider (N=53); and using the “technology” filter which included phones (N=399), PDA/Tablets (65), and remote diagnostic tool (61). After removing duplicate projects, 409 projects were reviewed in depth to identify those that meet all the inclusion criteria (phone was used by FHW, project was past pilot stage). Projects which met the criteria but did not have any relevant information available were dropped. 63 projects were finally included in the analysis. Survey follow-up was not conducted for CHMI projects with incomplete data.

Key data points about the projects were abstracted from the databases if available, this included:



3. What do current programs tell us? Expanding the search for evidence (continued)

Expert Survey

A.2

A brief 10-question survey (Appendix E) was administered to all major known mHealth communities of practice to capture perspectives from mHealth program implementers/policy makers who may not have published information about their mHealth programs in the peer-review or grey literature. **Results from the expert survey depict more current trends in use.**

The survey was widely publicized across several communities of practice including the mHealth Working Group, Global Health Delivery online Health IT Group, United Nations Innovation Working Group, Information and Communication Technologies for Development (ICT4D), Information and Communication Technologies for Community Health Workers (ICT4CHW), mPowering FHWs, Health Information for All (HIFA) and other networks over a period of 3 three weeks in October 2015. A total of 74 responses were received.

The purpose of the survey was threefold:

- Identify any scaled projects that may not have an active web presence.
- Understand the key knowledge gaps/concerns of the mHealth community when choosing a technical platform to develop a mHealth intervention and type of mobile phones for the interventions.
- Identify key strategies that are being employed to improve health service by using mobile devices.

Figure 2: Overview of data sources and methods used for the report

Phase	Purpose	Results
PHASE 1- Database Search  USAID Compendia 1-5 and follow-up survey Center for Health Market Innovations database (post pilot stage projects)	<ol style="list-style-type: none">Identify breadth of FHW-supported mHealth projectsSummarize key characteristics of projects, including type of platform and phone/tablet used, and number of deployments	<ul style="list-style-type: none">104 relevant projects were identified from the USAID Compendia 1-5. Follow-up surveys were sent to all projects to update their information. 65% who responded were included in the final analyses.409 projects were screened for inclusion from CHMI, and 64 were finally included in the analyses.
PHASE 2- Expert Survey  Brief survey administered through the mHealth Working Group, GHDonline* Health IT Group, UN Innovation Working Group, ICT4D**, ICT4CHW#, mPowering FHWs, Health Information for All (HIFA) and other networks.	<ol style="list-style-type: none">Identify FHW-supported mHealth projects that may not have web presenceIdentify projects and platforms that are considered to be operating at scaleSummarize considerations for selection of a platform, and type of mobile phone/tablet	<p>75 mHealth experts responded to the call. Over half of the respondents were project implementers, about 20% were researchers, 12% were software programmers, and 7% were policy-makers/government officers</p>
PHASE 3  Literature Review: Peer-Reviewed and Grey Literature searches tailored to the specific knowledge gap International NGO Survey- Survey to learn about pertinent interventions by international NGO's	<ol style="list-style-type: none">To summarize the evidence in support of mHealth strategies identified in Phases 1 and 2.Fill in gaps, based on literature, on costs, cost-effectiveness <ol style="list-style-type: none">Identify additional FHW-supported mHealth projects that have not been captured in prior searchesDetails about type of interventions, associated approaches and costs	<ul style="list-style-type: none">Several international NGOs' were identified as having multiple unreported relevant projectsPeer-reviewed and grey literature studies were identified summarizing costs/cost-effectiveness of mHealth solutionBrief survey sent to ICT leaders at MSH, FHI360, CRS, Pathfinder, Palladium Group, Jhpiego and other i-NGOs.39 additional mHealth for FHW project details received.

*GHDonline is part of Global Health Delivery Project at Harvard University

** Information and Communication Technologies for Development

Information and Communication Technologies for Community Health Workers

3. What do current programs tell us? Expanding the search for evidence (continued)

Literature Review

A.3

In addition to the review of systematic reviews on the effectiveness of FHW-supported mHealth interventions presented in Section 2, a review of peer-review and grey-literature was undertaken to address the following questions:

- a.) What is the evidence in support of mHealth strategies identified through the database search and expert surveys?
- b.) How do the functionalities of the existing technical platforms for mHealth align with the priorities and considerations of the mHealth community in choosing a platform?
- c.) What is currently known about the costs associated with implementation of mHealth programs? What are the key cost drivers? What is the evidence on the cost-effectiveness of mHealth interventions?

The review and analysis of pertinent literature for each of these questions yielded an understanding of the critical knowledge gaps and future direction.

Survey of NGO's

A.4

Lastly, we recognized that the multiple mHealth databases and mHealth community surveys did not capture several of the widely known projects. To address this gap, a brief survey was sent out to leading NGO's that are implementing multiple mHealth projects under their umbrella. Surveys were individually addressed to the ICT/mHealth leads of MSH, FHI360, Intrahealth, CRS, Pathfinder, Palladium Group, Jhpiego, IPAS, and Center for Communication Programs (CCP), and JSI. The survey had questions on the purpose of the mHealth project, mHealth strategies being used, the scale of the project, technical platform and type of phone/tablet being used for the project, and the evidence on costs and effectiveness of the project. After removal of duplicate entries (i.e. projects that were also abstracted from the USAID and CHMI databases), an additional 34 projects were added to the database.

3. What do current programs tell us? Expanding the search for evidence (continued)

Data abstraction, coding and analysis

B

Results from the database searches (i.e. USAID compendia and CHMI compendia) were combined with the survey responses received from NGOs. All the data were imported in Stata for cleaning, coding and analysis. We abstracted information on several variables from text and numerically-coded data, including countries where projects were deployed, technology platforms and mobile device types, functions of the project, type of frontline health worker, health domains and subdomains and number of users. We verified this process by comparing the original text variables with their coded equivalents. We created indicator variables for these variables and created additional categorical variables, collapsing across categories such as smartphone (which includes Android, iOS and Windows types) and facility staff (which includes doctors, nurses, dentists, pharmacists and other professional staff) to create meaningful groupings that were more easily describable in analyses. We created count variables such as the total number of functions a single project had and the number of countries where a project was deployed. We then concatenated the three databases into a single database and did additional validation.

As our performance question was a free text response, we did a qualitative analysis to determine how respondents reported performance for their projects, using only the USAID database, since that had the most up-to-date information on performance. One researcher (SA) read each of the entries several times to ascertain major domains of reporting. Once themes converged, she created text codes to describe performance reporting such as “sensors and diagnostics”, and “training of health workers”. The codes were applied to all of the entries. These codes were then discussed with another author (MC), who then independently coded 3 (7%) of the entries. Results were discussed and codes refined, with each entry being recoded with new codes as necessary. This process was repeated until high inter-rater reliability was achieved.

We performed exploratory analysis by reporting numbers and frequencies of individual variables of interest and cross-tabulated with other relevant variables. We report here a narrative that includes our quantitative analysis of several variables, a qualitative analysis of themes surrounding performance, and comparisons of quantitative and performance indicators.

Right: In-country infrastructure assists in data capture and accuracy checking



4. Current trends in the use of mobile phones/tablets by FHW

Geographic distribution of projects

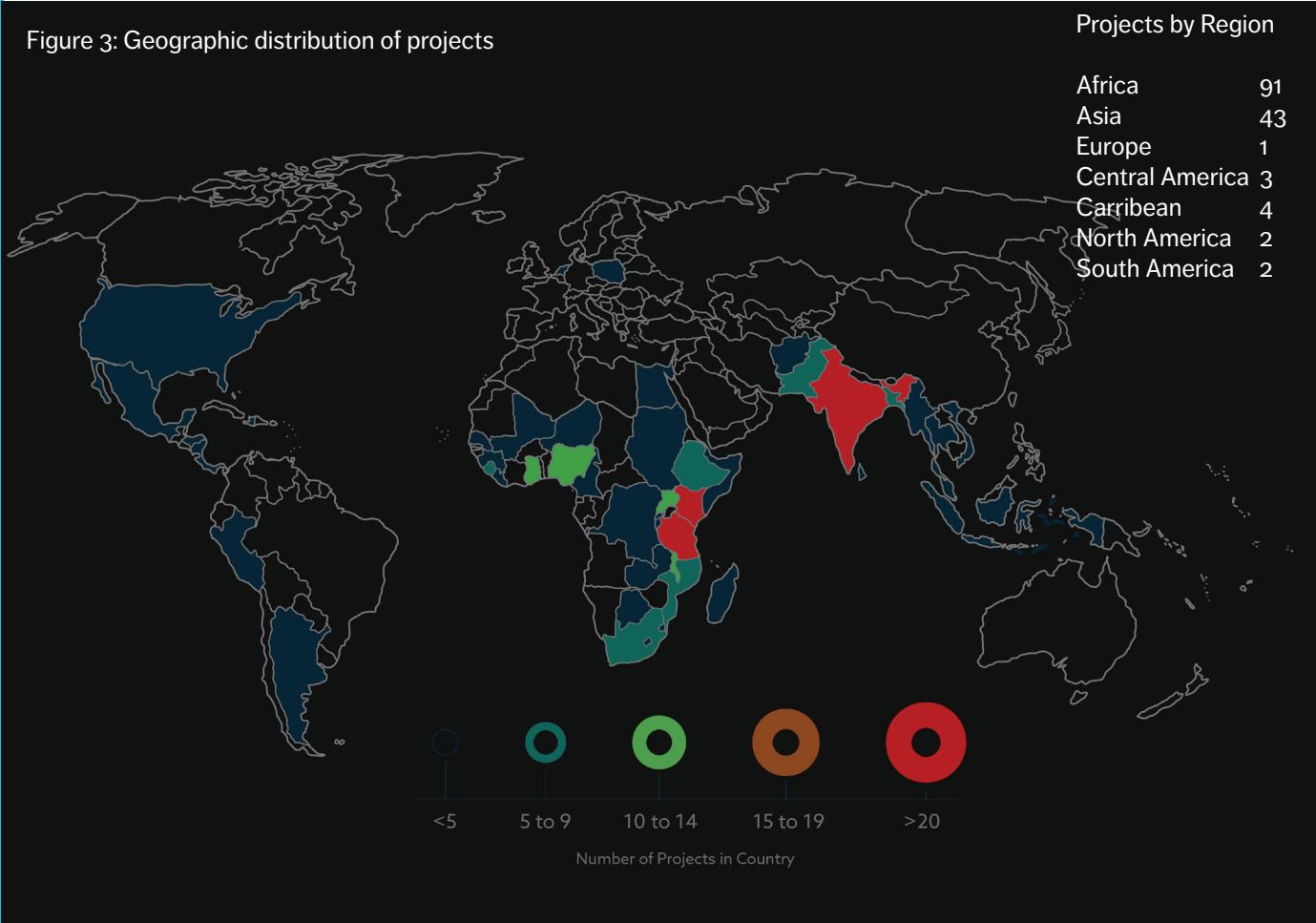
A.1

Figure 3 shows the distribution of projects by country and by geographic region. Of the reported projects, India, Kenya and Tanzania had the highest number of projects (20-25 projects). Other countries with the highest number of projects include- Uganda (12), Ghana (11), Nigeria (10), Malawi (10), Ethiopia (8), Pakistan (7), and Philippines (7). Section 4-F presents profiles of the state of mHealth for FHWs in India, Kenya and Tanzania. Regionally, 92 projects were reported from Africa, 43 from Asia and less than 5 each from other regions. Our surveys and data sources may not have captured a representative sample of projects from non-English speaking regions.

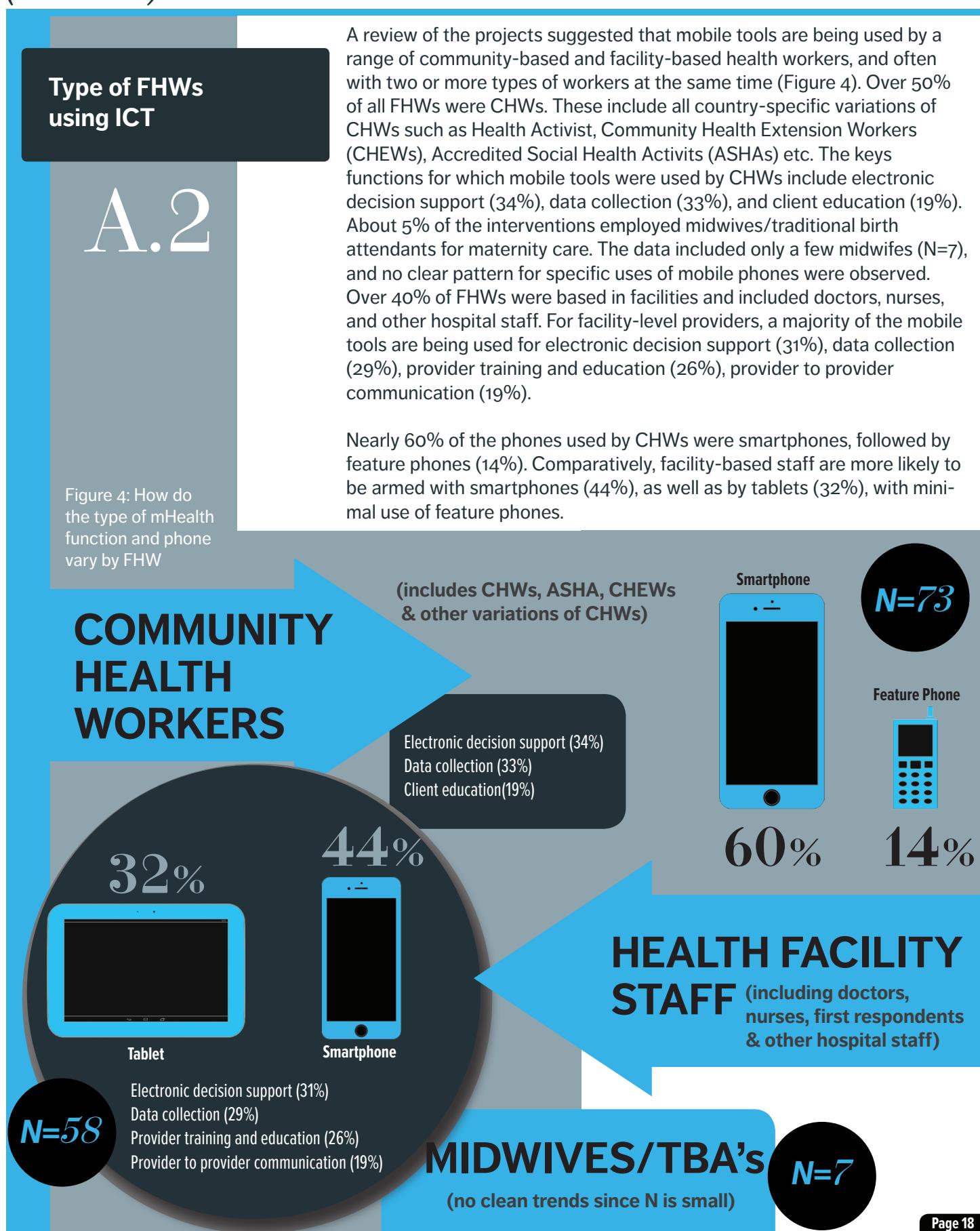
10 countries with the highest number of projects reported

Kenya 23	Nigeria 10
Tanzania 22	Malawi 10
India 21	Ethiopia 8
Uganda 12	Pakistan 7
Ghana 11	Philippines 7

Figure 3: Geographic distribution of projects



4. Current trends in the use of mobile phones/tablets by FHW (continued)



4. Current trends in the use of mobile phones/tablets by FHW (continued)

What disease areas
are these programs
addressing?

A.3

Health domains
addressed by
projects

The large majority of the programs that use mobile tools and employ FHWs focus on reproductive health (including family planning) and maternal health and child health (Figure 5). Nearly 20% (N=22) projects focus on family planning and reproductive health, 28% (N=32) on maternal health, and 23% (N=27) on child health. Of the 20 projects that addressed two or more health domains, most were focused on the continuum of care involving components of family planning, maternal health, and child health (including immunizations). A quarter of all projects focused on infectious (including HIV/AIDS), parasitic and vector-borne diseases. Only a few (N=1-2) projects focused on non-communicable disease, nutrition, mental health, and violence.

Maternal Health	24% (32)
Infectious, Parasitic & Vector-Borne Disease	22% (29)
Child Health	20% (27)
Family Planning & Reproductive Health	17% (22)
Other Health Problems	17% (18)
Nutrition	2% (1)
Non-Communicable Disease	1% (1)
Mental Health	1% (1)
Violence	1% (1)

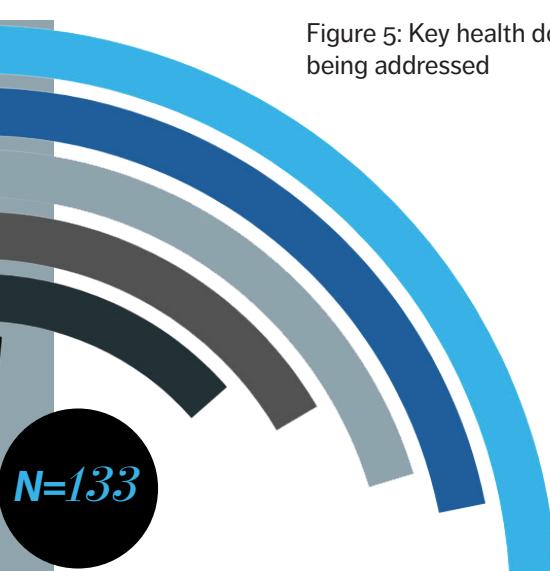


Figure 5: Key health domains being addressed

1
58% (n=82)

N=141

Unknown
24% (n=34)

5+
2% (n=3)

4
1% (n=1)

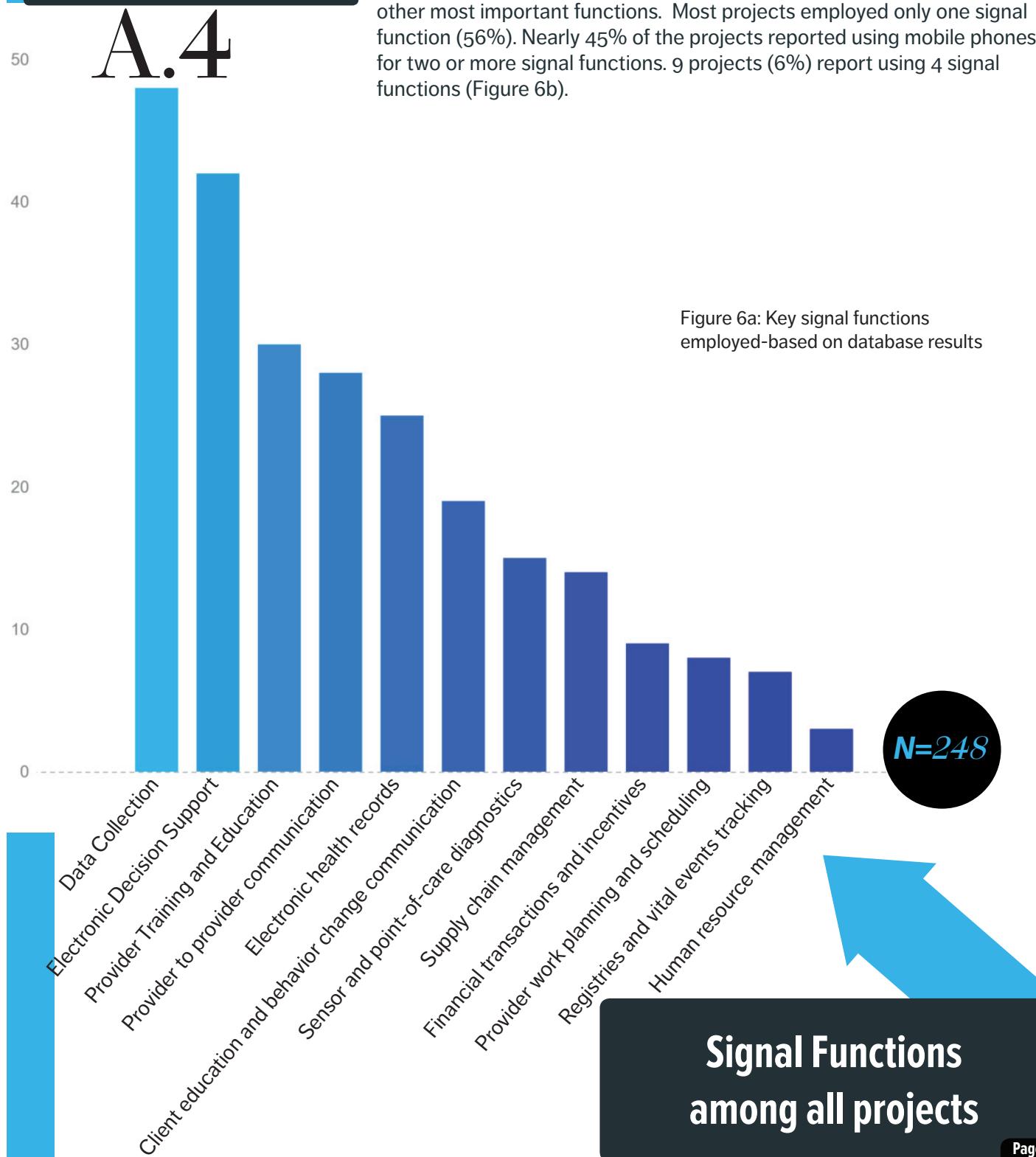
2
13% (n=19)

3
1% (n=2)

Number of health
domains addressed by a
given project

4. Current trends in the use of mobile phones/tablets by FHW (continued)

What mHealth approaches are being employed?



4. Current trends in the use of mobile phones/tablets by FHW (continued)

What mHealth
approaches are
being employed?

A.4

Number of total Signal
Functions mHealth
strategy uses

N=141

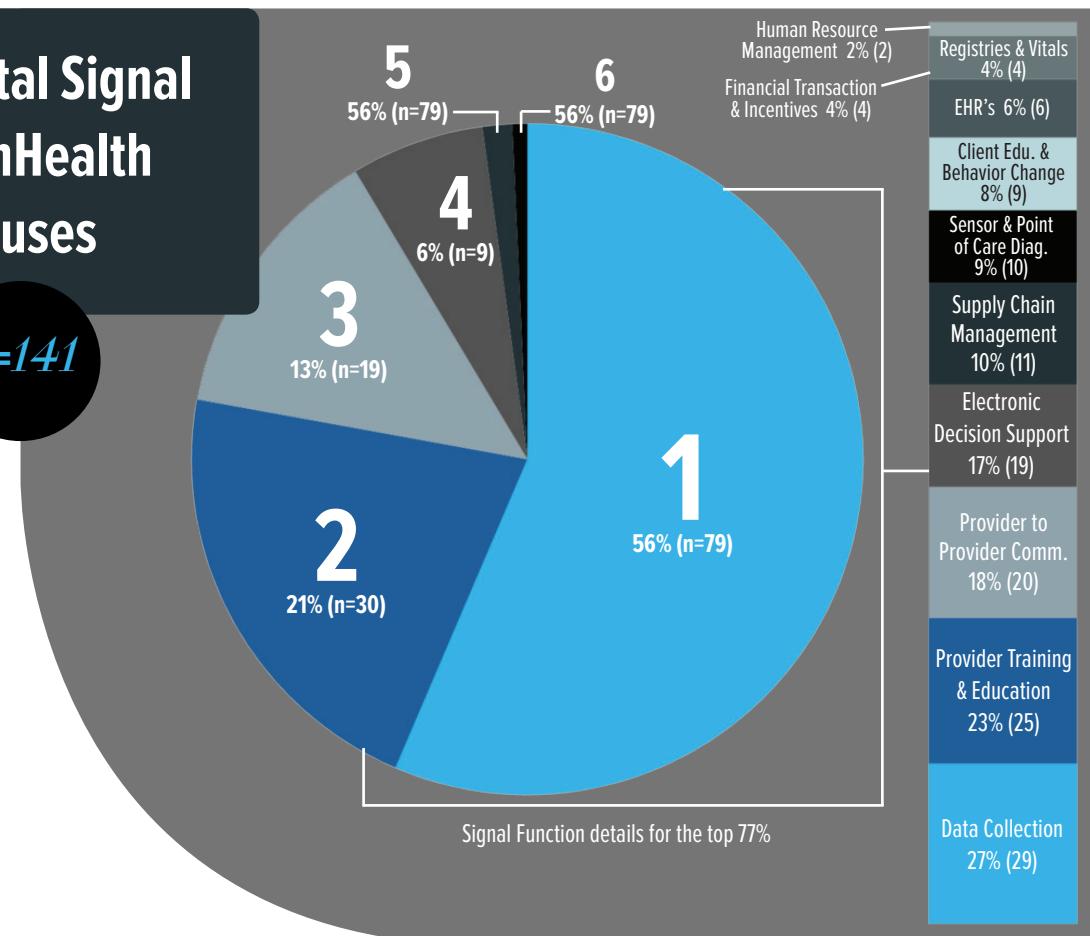


Figure 6b (pie chart): Number of simultaneous signal functions used by each project based on database results

Figure 6c (vertical bar):
Key signal functions employed-based on expert survey

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Program Cast Study: cStock

What does the program do?

cStock is an text message based supply chain management system for community health workers in Malawi.

What health domains it address?

Child Health, Infectious, Parasitic and Vector-Borne Diseases

Signal functions?

Supply Chain Management

Phone Requirements

Any phone

Platform

cStock is a platform built on RapidSMS by Dimagi. Some of the functions of CommCare Supply were designed to incorporate cStock functionality. However, CommCare Supply has undergone several new additions since cStock was implemented in Malawi.

Number of Users

3000+

About

Community health workers in Malawi, known locally as Health Surveillance Assistants (HSAs), are supposed to provide Integrated Community Case Management (iCCM)for a range of childhood illnesses and other infectious diseases. In order to do so, they manage up to 19 health commodities. However, when the Supply Chains for Community Case Management (SC4CCM) project ran a baseline assessment in 2010, only 27% of HSAs were fully supplied. cStock was developed to improve reporting and resupply for the HSAs, and provide data visibility into community level supply chains for decision makers at the facility, district and national level. HSAs send a monthly text message with their current stock on hand for the commodities they manage. The cStock system then sends a message to their health facility, alerting them to the order. The facility packs the order and sends a message to the cStock system indicating it is ready (or indicates a stock out if appropriate). cStock then sends a message to the HSA that the order is ready for pickup. In this way, the burden of reporting is dramatically reduced for the HSA, and the calculation of the appropriate resupply quantities is shifted to the cloud-based logistic management information system.

All 3000+ HSAs across all districts in Malawi who are responsible for iCCM are trained and registered on the cStock system. District Product Availability Teams use cStock data to regularly monitor supply chain indicators and inform their decisions. More information about the successful implementation of the cStock approach in Malawi is available in the article *"Strengthening community health supply chain performance through an integrated approach: Using mHealth technology and multilevel teams in Malawi"* and in the fifth edition of the USAID mHealth Compendium.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Type of digital devices used by FHWs

B

Experts were asked about the type of mobile devices that are currently being used by FHW's. 35% reported the use of only one type of device (e.g. feature phone only) and 65% reported the use of two or more type of devices being used by different types of providers within the same project (e.g. CHW use feature phones to report to their supervisors, and supervisors use tablets to monitor all CHW activities as part of the same intervention). This (and the results presented in 4.A.2) might suggest how within the health system, type of devices are being tailored to the type of user and their expertise, as well as the unique needs of the procedures that are conducted at that level of the health system. Figure 7a presents combined results from the database repositories and the expert surveys. It shows that smart phones are now the leading type of mobile devices that are being used for FHW-supported programs, followed by tablets. Simple phones (i.e. SMS and call functions only) and feature phones are less frequently used at 7% (data repositories) and 27% (expert survey). The category of "any phone" was coded for projects that were phone agnostic and the mobile application could function on any type of phone including feature phones and smart phones.

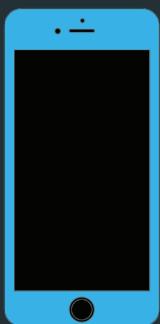
The results from the expert survey corroborate well with the results from the current project database. Similar to the expert survey results, the projects in the database suggest that smartphones are being used most widely (40% of the total projects). Additionally, figure 7b suggests that the widespread use of smart phones and tablets is a recent trend. Based on the projects reported, less than a quarter of projects that started before 2005 used smartphones. Comparatively, nearly 50% projects that started from 2011-2015 use smartphones. The use of tablets has been a fairly recent trend with nearly a quarter of all projects reporting their use. The use of feature phones declined from 17% before 2005 to 9% in 2011-2015.



Right: FHW training session with solar chargers

RESULTS BASED ON DATA REPOSITORIES

36%



N=141

16%



14%



8%



26%

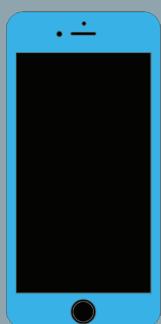


Unknown

DEVICE TYPE USED

N=173

34%



27%



21%



18%



RESULTS BASED ON EXPERT SURVEYS

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Key considerations in selecting type of phones

B

Key considerations for selection of a type of phone are presented here based on the expert survey (Appendix E). The most frequently mentioned considerations in the selection of type of mobile device included cost of the device, a long battery life to allow for frequent use and intermittent access to electricity for charging, screen size and attributes appropriate for task (e.g. a simple phone is not practical for extensive data entry but could be used for voice calls or rapid reporting) and local availability of the device and its service centers. Other less frequently stated considerations included internet connectivity, ease of use, 3G connectivity, multimedia capability, compatibility with other platforms and ease of typing in the local language.

Free mobile devices for FHWs?

Based on the expert survey, 74% (N=52) of the respondents stated that mobile devices were provided to FHW's by the projects, and 26% (N=18) said that FHW's use their personal mobile phones (sometimes referred to as a 'BYOP' or 'Bring Your Own Phone' model). Several cost and use considerations should be evaluated when deciding whether the project should give CHWs phones. The advantages of giving phones are several. Arming CHWs with project-selected phones would ensure that all critical members of the health team can participate in the intervention, and standardized tools optimized to the specific phone can be made available. (The wide variability in phone functionality, even within the "smartphone" category is an important consideration. Application performance, power management and Android version compatibility – not to mention GPS precision, screen responsiveness, system stability – are all variables which may dramatically affect FHW application performance if devices are not standardized.) However, giving mobile phones to FHW's also has significant cost considerations. It has been suggested that when phones are provided to FHW's, they are more likely to be lost or broken compared to the use of personal phones. Local governments may not have the ability to financially support the loss and ongoing maintenance of existing phones. BYOP models are often considered more sustainable as they do not require the project or ministry to manage a mobile device supply chain. If FHWs use their own phones, they have also already found solutions to allow them to keep the device charged, which is often a sticking point on mHealth projects which provide devices.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Technical Platforms used by FHW

C

MOTECH Suite

As development programs mature, there is a growing need for mHealth approaches that cut across geographies as well as use cases, including patient tracking, supply tracking, surveillance, service delivery of content, etc. There is a need for countries to develop a foundation or platform to enable multiple, integrated mHealth projects at scale, rather than focus on scaling a single project or use case.

MOTECH Suite is an industry-leading suite of mobile and cloud-based technologies, starting with the components CommCare and MOTECH. Led by Dimagi with support from the Grameen Foundation, MOTECH Suite was formed to combine the power of frontline mobile applications with integration and orchestration of data across an entire ecosystem. Components of MOTECH Suite already support a wide range of frontline programs, including many at national scale. For example, BBC Media Action is using MOTECH Suite to deliver maternal and child health mobile phone content in 35 states in India (already in 6 states with 1 million users). The MOTECH Suite has also been used by the NGO TulaSalud to efficiently deploy numerous mHealth use cases on a single platform in Guatemala. In Tanzania and Ghana, MOTECH Suite has been utilized to deploy national-scale last-mile logistics solutions. World Vision has been able to leverage similar health and nutrition content across 13 different countries with deployments on MOTECH Suite. MOTECH Suite is supporting the Ebola vaccine trial in Sierra Leone in conjunction with Johnson & Johnson, World Vision, and the London School of Health and Tropical Medicine.

The breadth of use cases that MOTECH Suite is able to support at scale is at the forefront of the change happening in the mHealth industry in general, as it transitions from deploying individual projects to multi-faceted programs at national scale.

The need for easy and rapid development of mobile applications for FHWs using best practices and evidence-based tools has led to the development of “platforms” for addressing key health system constraints. The use of existing software tools is an alternative to developing custom software for mHealth programs. In this section of the report, key characteristics of the commonly used platforms in mHealth are summarized. Software applications that have been developed for a specific project or for internal use by an organization that are not accessible to other organizations or projects to adopt, customize and extend have been excluded. Also, platforms that are not directly used by a frontline health worker (eg: research platforms like RedCap, data visualization platforms such as Tableau) have not been reviewed.

Platforms allow for technology developed by one organization to be shared with other projects that require software applications with similar functionalities. Platforms to support FHW's may be developed by a parent company that distributes it as proprietary software or as open source projects heralded by a parent developing organization with groups of implementers and developers that contribute to the overall development of the technology, expanding its functionality beyond what a single organization or project could have achieved. Over 10% of all projects recorded in the database used some custom-made or proprietary software. Commcare was the most frequently used platform (N=17), followed by MOTECH (N=6), and Mangologic (N=5). Often, a platform was not explicitly specified but the described functionality leads us to believe that this number is actually higher. The survey of experts suggested a broader range of platforms that are being widely used. This includes Commcare (N=27), ODK (N=11), DHIS2 (N=11), OpenMRS (N=9), Mangologic (N=8), OpenSRP (N=5), MOTECH (N=5), and Magpi (N=5). It should be noted that as per the latest development, CommCare and MOTECH form the key components of MOTECH SUITE, where CommCare primarily supports the front-end involving collection of data, and MOTECH supports the backend involving data storage, analytics and use. The correct terminology for the type of platform used by independent programs is still evolving, and the survey respondents may not have made this distinction between the use of a prior version of CommCare or MOTECH versus MOTECH Suite (refer to box on left).

Appendix A presents a brief description of the platforms use by FHW-supported health programs reported in our study. Of the 30 different platforms recorded from the database, more than half open-source and the source code is freely available to download and use. Such platforms are usually supported by strong developer communities (eg: MOTECH, OpenMRS, DHIS2). Open-source platforms while being freely available, require a team of programmers to be able to implement, adapt and customize the platform to meet project needs. Another common software model being used is Software as a service (SaaS) where the database and application being hosted in the cloud and a standalone application being installed on the health worker's phone. The software is available to use at a per-user or per month fee, often the platform is available for use free of cost up to a number of users or with limited functionality (eg: Magpi).

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Considerations in selection of a technical platform to support FHWs

C.1

The survey of experts and review of literature aimed to identify the key considerations that go into the selection of an mHealth platform. The choice of the appropriate software platform depends on: A.) Alignment between the platform's features and the project's requirements; B.) The total cost of ownership (TCO) of the software (Grevendonk, 2013).

We categorize these project requirements into two groups: functionality specific and broad requirements (Grevendonk, 2013). (Table 1)

Functionality-specific requirements are what the system must do. These are usually project specific and are tied to the tasks that the users in the system have to perform, for example, it must be able to send text messages to clients or must be able to generate a specific report. Broad requirements are the salient abilities such as ease of use, interoperability or the ability to address technical and environmental constraints.

The key considerations in platform selection from the survey of experts show a high degree of overlap with the ICT4D Principles for Digital Development ("Principles for digital development," 2008). In particular, adherence to the principle of the use of Open Standards, Open Data, Open Source and Open Innovation emerged as the most important consideration in platform selection. The top five considerations that emerged from the survey responses were all broad features (e.g. ease of use). The commonly appearing feature requests or functional requirements for a platform included SMS functionality, ability to work in a low bandwidth or offline environment, ability to create reports and dashboards, ability to design workflows.

Table 1:
Functionality-specific
considerations and
broad features
identified as useful
for platform selection

Functionality-specific	Broad Features
<ul style="list-style-type: none">User Interface/Usability<ul style="list-style-type: none">- Able to create reports and dashboards- Able to design workflows	<ul style="list-style-type: none">User Interface/Usability<ul style="list-style-type: none">- Easy to use/User-friendly- Easily customizable- Availability of long term technical support from vendor- Availability of programmers or a developer community who are familiar with the platform
<ul style="list-style-type: none">Functional capabilities<ul style="list-style-type: none">- Messaging functionality/ SMS functionality- Able to work in a low bandwidth or offline environment- Interactive voice messaging system- Able to support local languages- Content scheduling- Support rich content / multimedia- Web-based- Ability to develop forms and content by non-developers- Can handle complex logic	<ul style="list-style-type: none">Software Characteristics<ul style="list-style-type: none">- Open-source- Interoperable/scalable: Able to share data with other health information systems, to integrate with existing systems, and use data standards- Easy management of back-end processes (data transmission, data warehousing)- Can work on androids and/or feature phones
<ul style="list-style-type: none">Security requirements<ul style="list-style-type: none">- HIPAA compliance	

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Considerations in selection of a technical platform to support FHWs

C.1

The most common considerations reported as important in platform selection and their implications are discussed below:

Open source

44% of respondents to the expert survey listed open source as a key consideration in platform selection. In an open source platform, the source code is freely available to download, extend and customize. Successful open source projects have a strong and active developer community and rich resources for implementers and developers. It was observed that the adoption of an open source platform requires a technical team and has a significant learning curve associated with adoption. The steepness of the learning curve depends on the availability of learning resources for new implementers and programmers while getting started with the platform and the completeness and comprehensiveness of user documentation. Up-to-date documentation is a key focus for open source software platforms. Creating an active community of contributors and having a core team for coordinating platform development are crucial to the success of the platform.

Open source does not necessarily mean free. Open source platforms are free to download and use, which appears to bring down the total cost of development but have other costs associated with them such as developer time for customization, deployment and set up. More data is required to be able to assess whether the use of open source software brings down the total cost of ownership of the platform. One of the most successful open source platforms widely used in mHealth is OpenMRS, a patient-centric medical record platform developed in 2004 by partnering institutions the Regenstrief Institute, Partners in Health and AMPATH (Academic Model Providing Access to Healthcare). Though it was originally not intended to be an open source platform, it is now being used in over 169 countries (OpenMRS, 2011).

Ease of use

The overwhelming majority of respondents for which this was a key consideration were project implementers. Ease of use refers to how easy it is for health care workers and low literacy users to interact with the platform. It refers to a simple user interface and an effortless user experience. The WHO Planning an Information Systems toolkit provides a number of “usability metrics” to evaluate the performance of a platform. For example, some of the usability metrics include (Grevendonk, 2013):

- Transmit information in a language (script or voice) that is understood by the user population
- Emphasize ease of use and learnability to reduce training costs
- Allow users to find features in two clicks or less
- Easy end-user interactions

Ease of use can refer to use by the end user (the FHW), but can also refer to use by the data users and the project managers. It is not just the interface for entering data that must be simple and seamless. Reports need to be configured in a way that decision makers see the data that they need access to, in visually clear and compelling ways. Project managers also need easy-to-use systems that allow them to quickly and painlessly register or modify users, and monitor the system.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Consideratoins in selection of a technical platform to support FHWs

C.1

Cost

A number of different factors contribute to the overall cost of the software but can be broadly categorized into – the cost of development, cost of deployment or implementation and cost to sustain and maintain. These costs typically vary at different stages of the project cycle with the development costs being high in the pilot phase, the cost of deployment being higher during scale up and the maintenance costs being high once the project has reached its goal for sustainability (Grevendonk, 2013). A complete understanding of the costs is addressed in section 4D of this report.

Interoperability

Interoperability refers to the ability to share data with other health information systems – at the local, regional and national level. It may also refer to the ability to integrate and share data between different software systems within the same project. Interoperability requires the use of data standards for communication. More information is needed for assessing the need for developing end-to-end interoperable systems and the impetus to do so. Lack of data standards and complexity of making systems interoperable makes this a challenging requirement to operationalize despite the growing need for interoperable systems.

Ease of customization

Ease of customization may refer to the ability to customize the user interface and the way data is presented to the end user, the ability to customize workflows based on the tasks of the user, availability of custom developed reports and dashboards, the ability to create custom forms with embedded electronic decision support & complex logic. Customizability is high in platforms that follow a modular approach and allow project implementers and programmers to extend the core functionalities of the platform to suit their needs by adding or removing modules. The use of graphical user interfaces for customization that allow non-programmers to custom develop forms, and modify what is displayed to the user is a large value proposition for platforms. For example, CommCare users can create custom forms with complex logic using their web application CommCare HQ.

Right: Chat Salud participants demonstrate Paper prototyping



4. Current trends in the use of mobile phones/tablets by FHW (continued)

Platform functionality for FHW supported interventions

C.2

Platforms are being used to address a variety of health system constraints. Few platforms are developed to fulfil a single function, most are multifunctional. The platforms that are developed for a single function are typically those for provider training and education (OppiaMobile, MediaWiki) or for supply chain management (Mango, CommCare Supply). Using the 12 common signal functions framework presented by Labrique et al (Labrique, 2013), Table 2 presents some commonly used platforms and the signal functions they are most optimized for. It should be noted that though the platforms may have a broad range of functionality, mapping the actual use of the platforms (as used by the projects) against these functionalities suggested a narrower range of use. This might suggest that though the functionality is feasible, it may be in initial stages of development, have limited deployment, or is not considered as easy-to-use by users.

Table 2: Core platform functionality

	Client Education & BCC	Sensors & POC diagnostics	Registries/vital events tracking	Data collection & reporting	Electronic health records	Electronic decision support	Provider-to-provider communication	Provider workplanning & scheduling	Provider training & education	Human resource management	Supply chain management	Financial transactions & incentives
CommCare	X		X	X		X		X	X			
CommCare Supply											X	
DHIS2			X	X							X	
Frontline SMS	X		X	X			X		X			
iHRIS											X	
Magpi				X	X							
Mangologic				X	X		X					
Medic Mobile				X	X			X			X	
MOTECH	X		X	X		X	X	X			X	
ODK	X	X	X	X	X	X						
OpenLMIS											X	
OpenMRS			X	X	X	X	X					
OpenSRP	X		X	X	X	X		X				
OppiaMobile									X			
RapidPro	X						X					

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Platform functionality for FHW supported interventions

C.2

Over the last five years, a gradual transition has been observed from simple/feature phone to the use of smart phones. Table 3 describes the mobile compatibility of some of the most frequently reported platforms. Web interfaces for the platform allow for managing data and other server-side operations. They can also be used for application building such as in the case of CommCare, ODK and MagPi. Oppia Mobile's web interface allows users to develop the training course and upload content for FLW learning.

Table 3: Mobile compatibility for commonly used platforms.

Technology Platform	Type of phone				Primary Technology channel ¹		
	Simple phone	Feature phone	Smart phone	Web based	Internet	SMS	Voice
CommCare		X	X	X	X	X	X
CommCare Supply	X	X	X	X	X	X	
DHIS2		X	X	X	X	X	
Frontline SMS	X	X	X	X		X	
iHRIS				X	X		
MagPi	X	X	X	X	X	X	X
Mangologic			X	X	X	X	
MedicMobile	X	X	X	X	X	X	
MOTECH	X	X	X	X	X	X	X
ODK			X	X	X		
OpenLMIS				X	X		
OpenMRS		X	X	X	X		
OpenSRP			X	X	X	X	X
OppiaMobile			X	X	X		
RapidPro	X	X	X	X		X	X

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Platform functionality for FHW supported interventions

C.2

Table 4 reviews the commonly used platforms to evaluate their non-functional capabilities. Ease of use refers to the user experience and user interface for an FHW. Platforms were ranked as high, low or neutral. While the use of a platform does limit the extent of customization as compared to a custom built application, the platforms were evaluated on the ease of customizing workflows, data collection forms, content and generation of reports. They were categorized as high, low and neutral. Information about scale was drawn from the projects reviewed the USAID compendium. Updated information about the project status and scale in terms of number of users was collected by a survey disseminated to the projects that were reviewed. Platforms that were used by fewer than 100 FHW users were categorized as low, between 100 – 1000 users as moderate and over 1000 users as high.

Table 4: Evaluation of non-functional capabilities of commonly used platforms

Technology Platform	Open source	Ease of use[#]	Ease of customization[#]	Scale in mHealth
CommCare	✓	high	high	high
CommCare Supply	✓	high	high	high
DHIS2	✓	high	moderate	high
Frontline SMS		high	high	moderate
iHRIS	✓	high	moderate	moderate
MagPi		high	high	*
Mangologic		*	*	*
MedicMobile	✓	high	moderate	*
ODK	✓	high	high	high
OpenLMIS	✓	neutral	neutral	*
OpenMRS	✓	moderate	moderate	low
OpenSRP	✓	high	high	low
OppiaMobile	✓	neutral	high	high
RapidPro	✓	high	high	high

Subject to reviewers interpretation

*Information not available

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Cost Assessment for ICT-supported FHW interventions

D

Given the limited resources for funding interventions for FHWs and competing priorities within health systems targeted for digital strategies, it is important to look at the costs and evidence of cost-effectiveness in support of mHealth interventions. When determining the cost-effectiveness of solutions, not only the costs of the intervention should be considered compared to the non-mHealth alternative, or status quo, but also the savings generated from improvements in process and health. Typically, innovations in global health are compared by estimating the financial investment required to produce a specific health benefit. ICT innovations have the capacity to not only improve the delivery of interventions (thus improving efficacy), but also to improve the process by reducing inefficiencies inherent to paper-based systems.

The landscape of technologies for FHWs is dynamic, as new technology is developed and software and hardware evolve. There is a need for a systematic understanding of the long-term costs and savings attributable to mHealth interventions. This is a difficult task, given the ever-changing technology environment which makes projecting future costs challenging. Although the signal functions targeted by the systems may remain fairly consistent, the underlying technology layer will almost certainly change over time. This will impact the costs of hardware, airtime and software. If anything, this tends to have a positive effect on the cost-utility / cost-benefit ratio over time. In just the past decade, as an example, the cost of 7"-10" tablets has dropped dramatically from \$500-600 to now just over \$100 in most settings, with a much wider range of offerings at the lower end of the spectrum. The massive market demand continues to drive and keep prices low, particularly for wifi-only tablets, rivaling those of robust smartphones in LMIC settings.

This section provides an overview of costs for mHealth interventions based on a comprehensive review of peer-reviewed literature, as well as grey literature, including reports and program documents. First, we describe the key cost-drivers. That is followed by a review of the literature on mHealth costs to provide an understanding of the challenges around assessing the cost-effectiveness of mHealth interventions, as well as synthesize the evidence that savings from mHealth are possible in the long-term. Then, we will present a framework for mHealth costs and savings that demonstrates increasing cost-effectiveness in the long-term. Finally, we will discuss the implications of the research for scaling mHealth interventions for FHWs.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Costs/Cost Drivers for mHealth projects supporting FHWs

D.1

The key categories of costs of mHealth interventions for FHWs, based a review of the literature are:

- 1) Initial costs, which includes fixed costs,
- 2) Ongoing/operational costs,
- 3) Management and human resources,
- 4) Training, and
- 5) Governance.

For each of these categories, we identify the main costs and the cost drivers that contribute to the total cost of an intervention Appendix B.

The initial costs are the startup costs of the project, which include the development and the deployment of the mHealth software system and intervention, the development of materials and processes for training and technical support, as well as initial training. Reflected in Appendix B, the principal drivers of initial costs include the requirements and specifications of the system (i.e. the level of customization and software development), training, and volume of equipment required. While discrete costing data was not provided, OppiaMobile, an open source mobile learning platform being implemented in 6 countries across Africa and Asia, reported that the project takes into consideration the initial development of the technical platform and content development. It notes that additional implementations of the platform will reduce costs by leveraging the existing technical and content development.

Costs associated with purchasing hardware and equipment depends on the number of phones or other devices needed for the intervention, which could vary significantly depending on whether the intervention will distribute phones to end users or expect them to use their own phones, and the level of technology required, such as smart phone or feature phone. The cost of deployment can also vary based on the state of existing infrastructure, both physical and the level of internet connectivity. Poor internet connectivity may slow down the testing, training, or implementation process, requiring additional work and resources while delaying the deployment. In addition, the required scale of the deployment and the security requirements will drive the costs of getting the system up and running. To support more users, more extensive server system setup and testing requirements may be necessary to ensure the system is sound.

Ongoing, or **operational costs** continue throughout the implementation period and the duration of the intervention. These costs may vary depending on the number of users and time period. As referenced in Appendix B, the cost category of operational costs includes data and communication, hardware maintenance and replacement, server/ software/ hosting management and maintenance, system administration and customer support, as well as project management and human resources.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Costs/Cost Drivers for mHealth projects supporting FHWs

D.1

The costs associated with data, voice, and SMS are driven by the telecommunication plans available (or rates negotiated), and the level of usage, ie number of minutes, volume of text messages, or data usage. Asimwe et al demonstrates the breakdown of operational costs in their cost effectiveness evaluation of an SMS based reporting system for disease surveillance in Uganda. The study accounts for the cost per message, the number of messages per week per user, and the number of users, as well as fees for telecom services, data hosting, and connectivity into its cost analysis. (Asiimwe et al., 2011)

Included in operational costs are hardware maintenance and upgrades, and additional expenditures for damaged, lost or, stolen hardware. The costs drivers are the cost of replacing and maintaining the equipment, and hardware requirements. For example, if end users are expected to use their own phones, the costs will be significantly lower. Also included in operational costs, are costs associated with day-to-day operations such as system administration and customer support, which are necessary for the sustainability of an intervention. The costs are driven by level of support offered, call volume, the frequency of maintenance including system updates, and staff HR turnover. Both the size of the project and usability of the intervention will impact the number of customer support calls. Thus, the number of users, and the level of support being offered will all contribute to the amount of dedicated staff needed for an intervention.

The **human resources and management costs** cover the staff and leadership required to both initiate and maintain the project, including both international and domestic staff and program leadership. Those costs are driven by number of staff, level of technical specialty required, salaries, and travel. A higher level of technical complexity of the software requires a greater degree of technical expertise. Cost will vary based on the location of the staff and their ability to work remotely. Limiting travel and leveraging local expertise reduces costs. The level of staff turnover impacts costs by requiring additional training and transition of knowledge and responsibilities, as well as potentially extending the project timeline.

Training costs are ongoing, but highest at the initiation of an intervention. The initial costs include the development of the training curriculum and any training tools that will be utilized, as well as the delivering the training to FHWs and other end-users. Incorporated into the cost of delivering the training is materials, facility fees, per diems and transportation. The cost depends on the # people being trained, duration of the training, and travel requirements. Ongoing costs include refresher trainings, new-features training, and training new end-users to the project. The training delivery method is another cost driver and varies depending whether the training given in-person, via eLearnings, or a through blended approach. Typically interventions rely on in-person training, but several studies and reports make an argument for the cost-effectiveness of a blended approach of in-person and digital, remote training. (Dalberg Global Development Advisors, 2012; Diedhiou et al., 2015; University Research & Quality Assurance Project Organization(s), 2009)

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Costs/Cost Drivers for mHealth projects supporting FHWs

D.1

Governance costs include any costs associated with decision-making and oversight by the government. It also includes costs associated with policy development, which is particularly relevant when considering costs to scale. The governance costs are driven by the number of meetings, trips, and time allocated by government officials to the intervention. For example, in the costing data provided for the USAID compendium, the Ma Sante project included the formation of a board of directors in its implementation costs.

Challenges in assessing cost-effectiveness of mHealth programs

D.2

Currently, there is no standardization for how costs are reported and which costs are included when demonstrating cost-effectiveness. This presents challenges to understanding cost-effectiveness of mHealth interventions. The first is that it calls into question the reliability of cost analysis of individual mHealth interventions because completeness of the data is unclear. It also limits comparisons between interventions, and inhibits the aggregation of data to provide a macro level understanding of cost-effectiveness.

At the individual project level, it does not appear that any of the studies on cost-effectiveness of mHealth interventions include a fully comprehensive list of all the costs, as reflected in Appendix C. It is possible that some of the costs that are not explicitly included are nested under other listed costs. The problem is that we do not know. Most notably, training costs were only mentioned 3 of the 10 studies, (Asiimwe et al., 2011; Chang et al., 2013; Diedhiou et al., 2015) despite being one of the biggest cost drivers. Meanwhile, development of training materials was only factored into 2 out of the 10 studies. (Asiimwe et al., 2011; Diedhiou et al., 2015) Human resources for design, deployment and implementation were included in only 2 of the 10 studies. (Thriemer et al., 2012; Zurovac, Larson, Sudoi, & Snow, 2012) In certain cases, the study explained why certain costs were excluded. For example, Chang et al. noted that supervisory costs were excluded from the total costs because of the assumption that supervisory costs would vary based on who implemented the intervention. (Chang et al., 2013). The most readily available cost data is on phone service fees and phones, or other devices All relevant include phone service fees which covers the cost of SMS, phone contracts, SIM cards, data, and phone numbers. (Asiimwe et al., 2011; Chang et al., 2013; Diedhiou et al., 2015; Hunchangsith, Barendregt, Vos, & Bertram, 2012; Lemay, Sullivan, Jumbe, & Perry, 2012; Lester et al., 2010; Mahmud, Rodriguez, & Nesbit, 2010; Njuguna et al., 2014; Thriemer et al., 2012; Zurovac et al., 2012) Equipment costs are noted in 9/10 of the studies. (Asiimwe et al., 2011; Chang et al., 2013; Diedhiou et al., 2015; Hunchangsith et al., 2012; Lester et al., 2010; Mahmud et al., 2010; Njuguna et al., 2014; Thriemer et al., 2012; Zurovac et al., 2012)

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Challenges in assessing cost-effectiveness of mHealth programs

D.2

The inconsistency between the costs included in the cost analysis of mHealth interventions for FHWs limits the ability to compare the cost-effectiveness of different interventions. This makes it difficult to compare projects and analyze how cost-effectiveness could be improved. For example, both Njuguna et al and Asiimwe et al. studies include mHealth data collection tools for FHWs. However, the studies include only 3 of the same costs out of the 8 costs reported. (Asiimwe et al., 2011; Njuguna et al., 2014) Consequently, any comparison between the two would be looking at a different set of costs.

Further complicating the ability to compare mHealth interventions is the lack of standardization of cost-effectiveness metrics. The variety of metrics found in the studies includes the cost or savings per FHW, per patient, per facility, per system, per number of visits, per number of reports submitted, and per outcome metrics, such as a DALYs averted or number of cases prevented of future switches to second-line ART. (Asiimwe et al., 2011; Chang et al., 2013; Diedhiou et al., 2015; Hunchangsith et al., 2012; Lemay et al., 2012; Lester et al., 2010; Mahmud et al., 2010; Njuguna et al., 2014; Thriemer et al., 2012; Zurovac et al., 2012) Additional metrics used by the projects in the USAID compendium include per implementation, per pregnant woman, and per project. Because the FHW interventions vary in their design and objectives, metrics cannot be fully standardized. However, the establishment of normative metrics, such as cost per patient, per FHW, or per outcome or impact measure, allow for more effective comparisons between different interventions. It also enables aggregating the outcomes, which is necessary to make an argument for the overall cost-effectiveness of mHealth interventions for FHWs and scaling those interventions. While the results seem promising on an individual basis, further research should be completed that compares and evaluates interventions using a standard set of costs and cost indicators.

High Initial Costs, Cost-Savings in the Long Run

D.3

Some studies have demonstrated that while the initial costs are often higher for mHealth interventions than the non-technical comparators, or the status quo, cost savings are possible in the long-run. (Asiimwe et al., 2011; Diedhiou et al., 2015; Njuguna et al., 2014; Thriemer et al., 2012). The savings can be further increased through opportunities for savings at scale, such as bulk phone purchases and discounted phone and data plans. (Asiimwe et al., 2011; Moore, Long, & Keith, 2014; Qiang, Yamamichi, Hausman, & Altman, 2011) An essential element of costing is its relationship with efficiency. For the purposes of this report, we will use Palmer and Torgerson's break down of efficiency into technical efficiency, productive efficiency, and allocative efficiency. Technical efficiency is the relationship between resources and outcomes. Productive efficiency is the relationship between outcomes and cost. Allocative efficiency looks at the distribution of outcomes across the community, in terms of maximizing the community-wide impact. (Palmer & Torgerson, 1999)

4. Current trends in the use of mobile phones/tablets by FHW (continued)

High Initial Costs, Cost-Savings in the Long Run

D.3

Cost savings in interventions focused on data collection for disease surveillance were demonstrated in studies in Zanzibar (Thriemer et al., 2012) and Kenya (Njuguna et al., 2014). Thriemer et. Al found that direct electronic data collection using PDAs to implement a stepwise approach to disease surveillance not only reduced costs, but also improved efficiency in terms of the timeliness, accuracy, and completeness of data collection. Data entry time per patient decreased by 50%, and turn around time for data input into the central surveillance system decreased from 5-7 days to less than 24 hours, up to an 86% reduction. Errors and data omissions decreased by 6%. The total cost savings of the direct electronic data entry over the 1.5 year study is \$5790 (from \$23,500- \$17,710), or a 25% reduction in cost from the paper system (Thriemer et al., 2012).

In Kenya, Njuguna et al determined that the initial costs for implementing a smart phone-based data collection tool, as compared to the existing paper data collection system for influenza surveillance were higher, 17,500 v. 15,999. However, the yearly operating costs of the smartphone system were less than the paper system, \$16,350 as compared to \$19,001. By the second year, the cost-savings were distributed and the smartphone system cost 7% less than the paper system, taking the initial costs into account. Njuguna et al similarly found improvement in the timeliness, accuracy and completeness of data. Data input into the central system of data collected with smartphones versus paper data collection was 66% faster. The median duration of reporting decreased from 21 to 7 days, reduced errors by 7%, and increased completeness by 10%. (Njuguna et al., 2014).

Cost savings was demonstrated in task shifting and improving communication between providers and CHWs in Malawi in two different studies. The mHealth intervention implemented by Mahmuda et al, which used task-shifting to CHWs to triage and treat patients, created net savings of \$2750 for 77 users including 75 CHW, 1 HBC nurse, 1 TB coordinator, and 1 ART coordinator over 6 months. It also improved technical, productive, and allocative efficiency. A total of 2048 hours were saved in triaging and travel. The coverage of TB patients doubled and the number of ART reports increased from 25-67 per month. (Mahmud et al., 2010) Lemay et al. analyzed the cost-effectiveness of using SMS for CHWs to report events to their supervisors and receive feedback. While the study was unclear about the discrete cost line items that were factored into the cost analysis, it found the SMS is four times less expensive and 134 times more efficient than non-SMS event reporting, ands resulted in more events reported. The average cost per event-reported per SMS report decreased from \$2.70 to \$0.67 for standard reporting methods that require the CHWs to travel to the supervisor site. They also found that the average time was reduced from 1445 minutes to 9 minutes on average per event reported, and that the average number of contacts with the supervisor increased from 4 to 5. (Lemay et al., 2012).

4. Current trends in the use of mobile phones/tablets by FHW (continued)

High Initial Costs, Cost-Savings in the Long Run

D.3

When considering the costs savings, the savings to the patient, health providers, and health system should be incorporated into cost analyses. While the body of literature on mHealth cost-effectiveness is limited, there is substantial research on the outputs and outcomes of mHealth interventions, all of which need to be accounted for when considering the overall savings of mHealth programs. In order to calculate savings, Schweitzer and Synowiec provide a set of indicators that convert outcome measures into monetary units. For example, from the patient or health system perspective, improved adherence to treatment protocols has an impact of QALYs and that can be converted into a monetary value by calculating the “value of a statistical life-year from the value of a statistical life.” (Schweitzer & Synowiec, 2012) Avoided hospital admission can be calculated as the cost per day of hospital admission multiplied by the average duration of a hospital admission. Improved diagnosis and treatment capacity in primary health care decreases the utilization of higher-level health services. The savings can be calculated by calculating the average costs of health services that the patient would have received. (Schweitzer & Synowiec, 2012)

Framework for Costs and Savings of mHealth Interventions for FHWs

D.4

This framework (Figure 8) demonstrates the relationship between costs and savings of mHealth interventions for frontline health workers, and the distribution of costs and savings as the scale an intervention increases. The costs are represented by cost/unit, which could be per patient, per frontline health worker, per provider, or per facility, or per other stakeholder. While the overall costs of mHealth interventions increase as the coverage and utilization of health services increases, the cost per unit decreases. The savings represents the overall savings from the intervention. As the impact of the intervention expands the savings will grow. Savings extend beyond the direct savings, to indirect, and health systems savings as a result of improved outcomes. At each level, the savings are distributed amongst the patients, health providers, and health system. This framework takes into account cost-savings evidence from the mHealth literature on FHW interventions, but also assumes indirect and system-level savings based on an understanding of the economic benefits of improved health systems outcomes.

The cost per unit of the intervention decreases over time because the incremental cost decreases. The higher initial costs, which include fixed costs such as development, deployment, and in this case, training costs, are distributed over each additional unit. Since the initial costs precede the execution of the intervention, there are no savings associated with the initial costs. Ongoing and operational costs may also decrease through partnerships, cost-sharing, and discounts for scale.

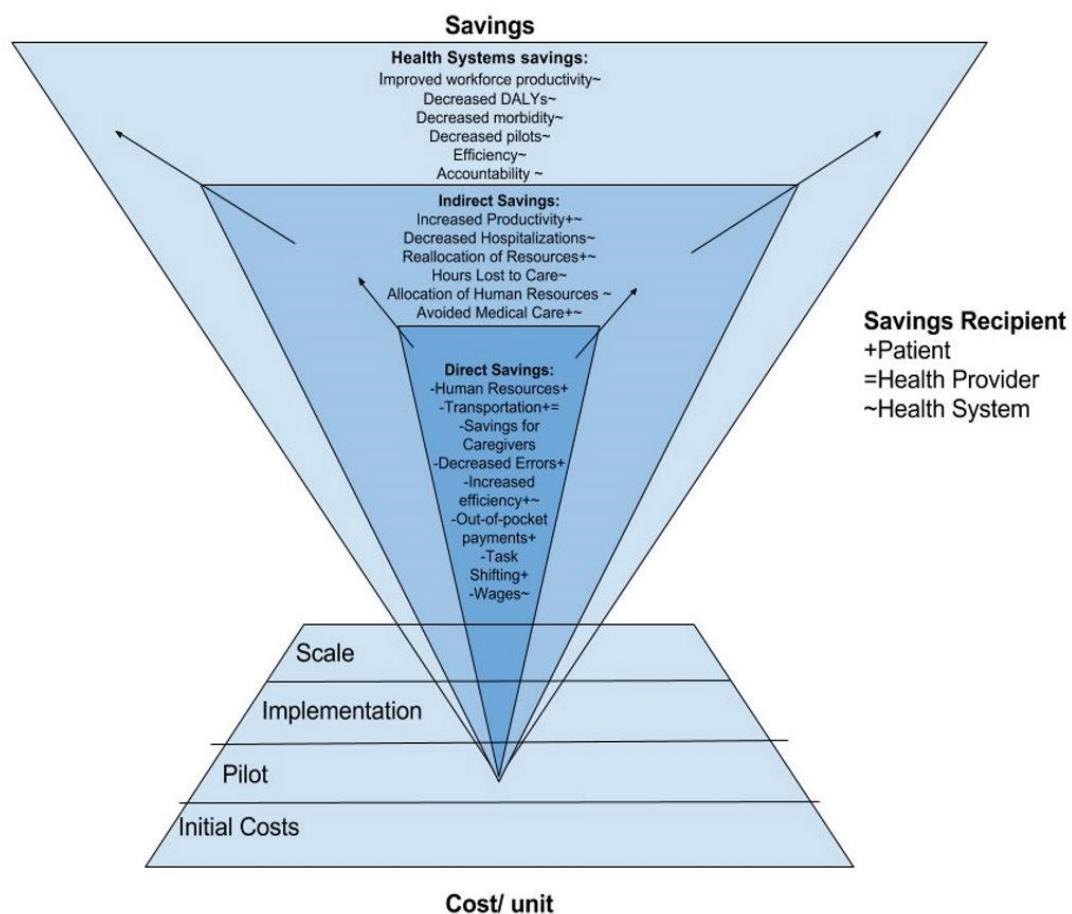
4. Current trends in the use of mobile phones/tablets by FHW (continued)

Framework for Costs and Savings of mHealth Interventions for FHWs

D.4

The magnitude of the savings extends beyond the direct savings, to indirect and ultimately health system savings, like a snowball effect on savings. The direct savings typically include savings from improved process outputs and outcomes such as reduced travel costs, improved efficiency of human resources, and streamlined workflows. The outcomes that result from those process improvements create greater health savings, such as resources saved from fewer hospitalizations, or fewer wages lost for sick days. Greater savings can result from less disease, but also from more effective use of data and greater accountability of health system actors. These savings are extended to the health system on a greater scale, allowing for more expansion of the programs and the redistribution of resources to other health issues.

Figure 8: Framework for costs and savings of mHealth programs for FHWs



4. Current trends in the use of mobile phones/tablets by FHW (continued)

Cost of scaling programs

D.5

Opportunities for Cost Savings

Discounts for Bulk Purchases of Equipment & Phone Services (Minutes, SMS, Phone Plan, Data Plan)

Government & Private Sector Partnerships

Cost-Sharing between donors, NGOs, government, and private enterprise

Interoperability

Open Source content

Utilizing existing tech platforms

Utilizing existing content

Standardization of content

Open Source technology platforms

There have not been many studies around the costs of going to scale. The cost analysis of an intervention at scale requires different cost considerations than a research study. Oftentimes, the assumption is made that if a study is cost-effective, then the costing numbers can be multiplied by the number of additional users or patients to demonstrate the cost-effectiveness on a larger scale. However, additional requirements are necessary to support interventions at scale such as infrastructure and maintenance, all of which generate additional costs. While the cost analysis literature reviewed does not provide evidence for scaling mHealth interventions for FHWs, it does provide projections for scaling interventions and suggests opportunities for improving the cost-effectiveness for interventions at scale through public-private partnerships, collaboration between donor and government agencies, as well as standardizing and leveraging existing content and technology.

When evaluating the cost-effectiveness of an mHealth intervention at scale, consideration should be given to the additional costs that are necessary to support an intervention from a technical and programmatic perspective, as the coverage of the intervention expands. Primarily, those costs include additional hardware, support and maintenance, training, and human resources. From a technical perspective additional hardware and server systems infrastructure is needed to support the increased volume of users and security measures. The technical maintenance of the system requires technicians, as well as support system for issues reporting and management. Training program expansion may be necessary to account for new user training, staff turnover, and refresher training for existing users, as well as the dissemination of information about updates and upgrades. Additional oversight, technical and programmatic support, and software development may also expand the need for additional human resources.

One way to reduce costs is by developing partnerships between the governments, donors, NGOs, and private enterprise, as opposed to relying on exclusively donor-funding. (Qiang et al., 2011) Partnerships offer opportunities for cost-sharing between multiple beneficiaries for one project. (Qiang et al., 2011) For example, public-private partnerships, especially with telecommunications companies, create opportunities to generate revenues through advertising and information management. (Moore et al., 2014) The government also has better access to certain kinds of data that could benefit the mHealth interventions for FHWs. Zurovac et al projected that a partnership with the Ministry of Health would reduce implementation costs by 20%, the cost associated with collecting CHW phone numbers, since the government maintains records of those phone numbers. (Zurovac et al., 2012) A greater level of government involvement and ownership could contribute to decreasing costs through the development of policies and guidelines that promote the dissemination of mHealth interventions and increasing access to affordable mobile services. (Schweitzer & Synowiec, 2012) For example, in the case of Kenya, 90% of the costs of mHealth interventions go to the telecommunication companies. The government introduced policies that limit spending and promote the sustainability of mHealth interventions. (Qiang et al., 2011)

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Cost of scaling programs

D.5

Collaboration and standardization between different mHealth interventions and the mHealth platforms that support those interventions creates an opportunity to decrease costs associated with technical and content development. The utilization of OpenSource software platforms saves costs on software development by leveraging existing technical development and facilitates interoperability. (Qiang et al., 2011) Improving the interoperability between mHealth platforms and other information management platforms decreases costs associated with system and information management. (Moore et al., 2014) While the initial cost of integrating the software is higher, (Moore et al., 2014) savings stem from the decreasing duplicate data collection, data entry, and content creation, by introducing opportunities for data and information sharing. Meanwhile, collaboration between interventions on content creation and content sharing as well as the standardization of content for similar interventions decreases the need to reproduce content for every intervention. (Dalberg Global Development Advisors, 2012) Dalberg projected that at digital content creation and content sharing could decrease the cost for training 1,000,000 CHWs, across 41 countries in Sub-Saharan Africa from \$65 to \$15 per CHW. However, it is important to note that this estimation is based on a number of assumptions and does not take into account equipment, training, materials, or per diems into account. (Dalberg Global Development Advisors, 2012)

Below: A kiosk where health workers can exchange mobile money incentives



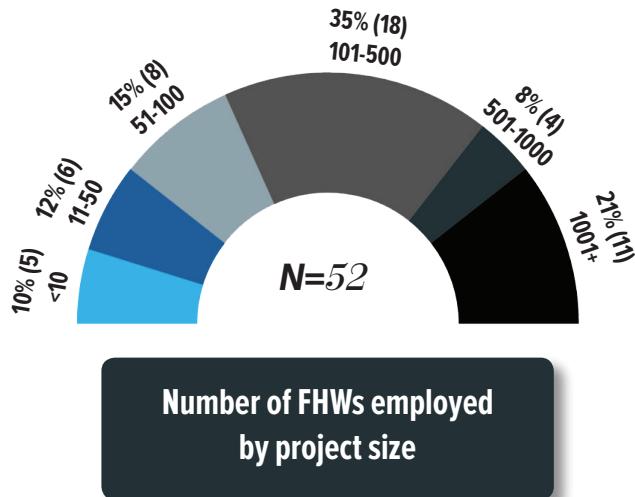
4. Current trends in the use of mobile phones/tablets by FHW (continued)

Scale and Complexity of Current FHW projects

E

Scale was measured based on the number of FHW's who are actively using mobile devices for healthcare delivery. It must be noted that we did not have information on scale for nearly two-thirds of the project sample. From the projects for which information on number of users was available, about 35% (N=19) of the projects had less than 100 active FHWs using mobile tools to deliver services, suggesting these projects are fairly early pilot stages (Figure 9a). Another 35% (N=18) projects reported employing between 100-500 FHW. 17 of these projects are based in Africa, with maximum concentration in Kenya. About 28% projects (N=15) currently have 500 or more FHWs actively using mobile devices. 10 of these projects are based in Africa and 4 are based in Asia.

Figure 9a: Scale of mHealth Programs



4. Current trends in the use of mobile phones/tablets by FHW (continued)

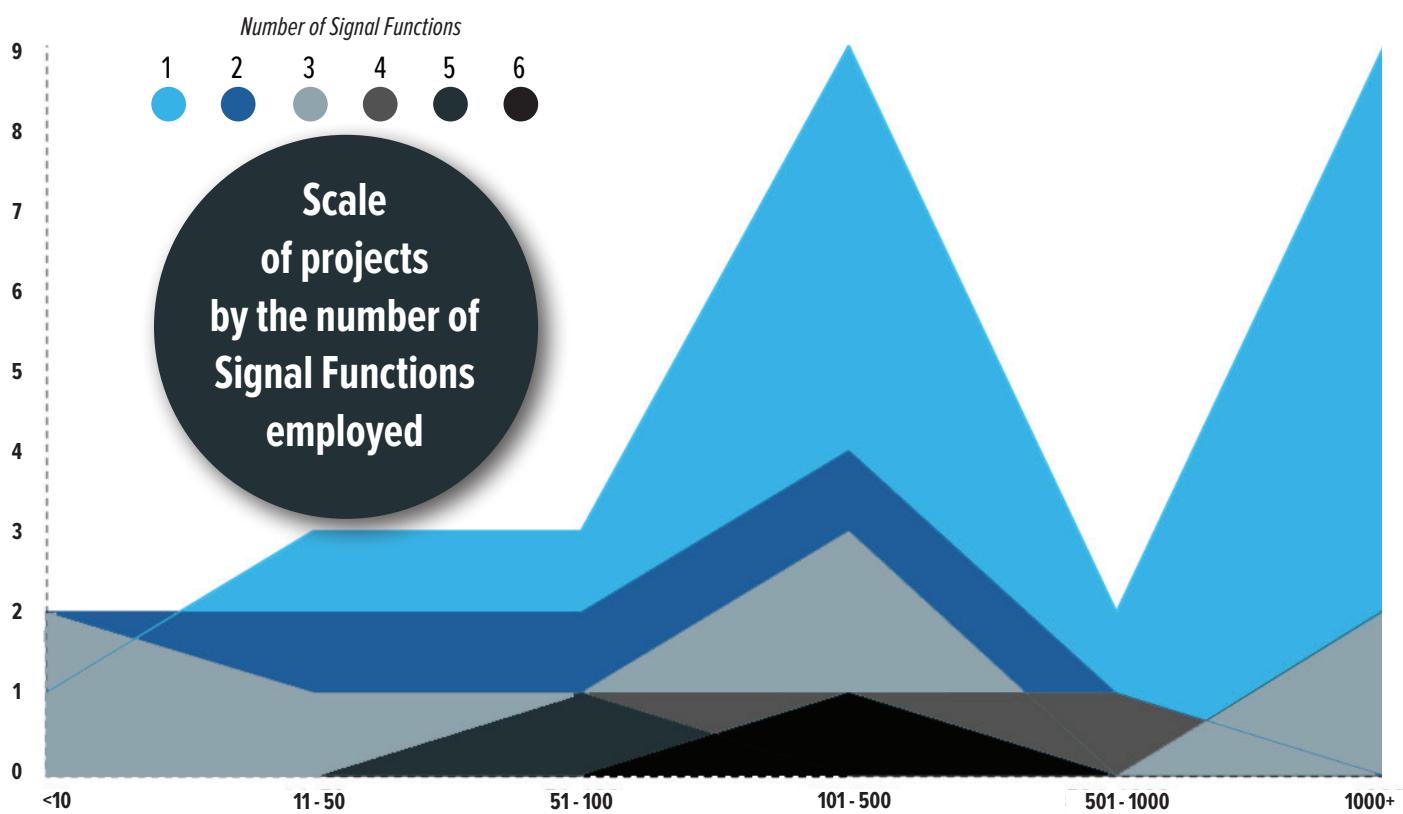
Scale and Complexity of Current FHW projects

E

In analyzing the projects by degree of scale, it becomes rapidly apparent that the majority of FHW-centric projects at substantial scale are simple, single-function strategies with data collection as the most frequently used function (Figure 9b). The more complex, multi-function projects are limited to small-scale pilots or deployments with fewer than 100 users. As projects grow in size, there seems to be a clear tendency towards parsimony of purpose. Interestingly, few projects (N=3) were reported in the 501-1000 user category, suggesting that there may be a transitional challenge involved in moving from the sub-500 user level to the 1000+ user level. This has been posited by others to be a “tipping” point between pilots and programs at “scale”, where costs begin to escalate dramatically, or where the technology/program faces challenges in absorbing a larger number of users.

For projects in the 101-500 category, the most commonly used signal functions were electronic decision support (N=11), client education and behavior chance communication (7), and data collection (5). For users in the 501-1000 category, data collection (N=4), and electronic decision support (N=2) were most used functions. Lastly, in the >1000 category, the most used functions were electronic decision support (N=3), supply chain management (N=3), and data collection (N=3).

Figure 9b: How does scale change with number of functions addressed?



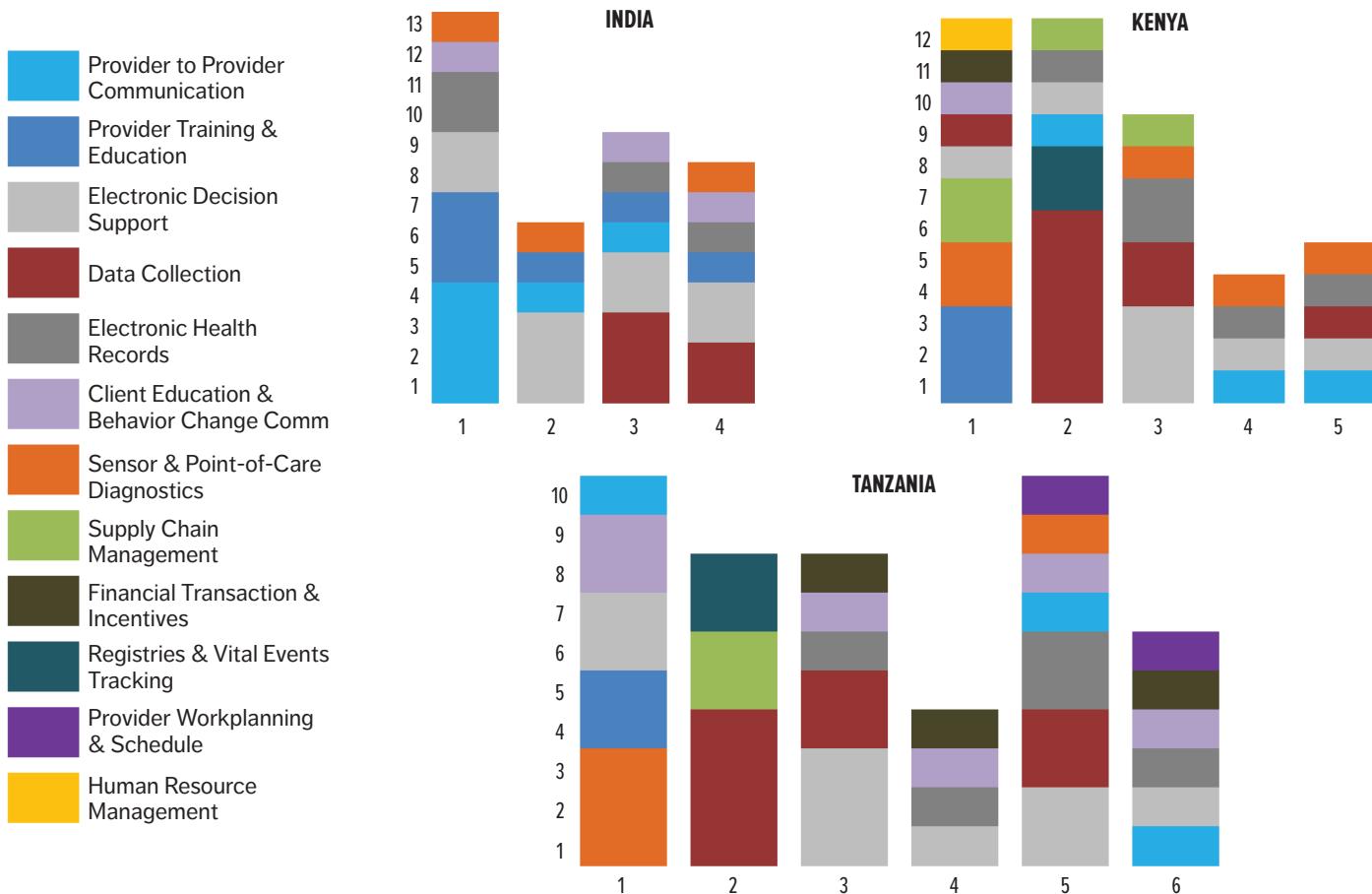
4. Current trends in the use of mobile phones/tablets by FHW (continued)

Profiles: India, Kenya, Tanzania and Scaled Programs

F

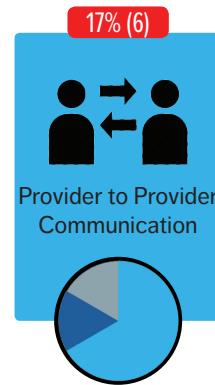
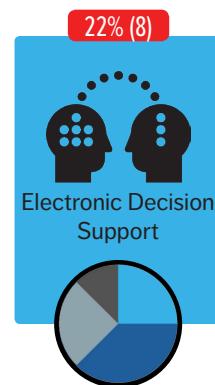
This section provides a trends in the applications and use of mobile phones for FHWs in the three countries with the maximum number of reported mHealth programs: India, Kenya and Tanzania. In addition, we also present details of projects that reported as having greater than 1000 active FHWs.

NUMBER OF PROJECTS BY PROGRAM COMPLEXITY



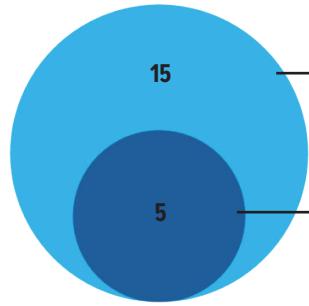


Number of concurrent Signal Functions when “*this*” Signal Function is employed



Ranges not represented did not have any current reported projects.

TYPE OF FHW

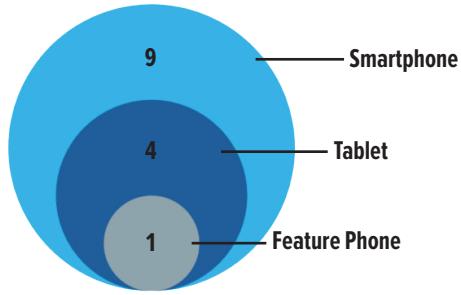


CHWs (includes ASHA, CHEWs & other variations of CHWs)

5

Health Facility Staff (includes doctors, nurses, first respondents & other hospital staff)

TYPE OF PHONE



Smartphone

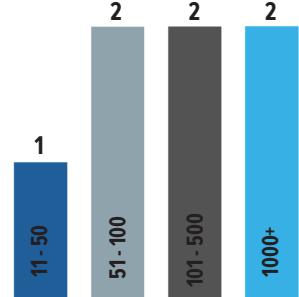
4

Tablet

1

Feature Phone

SCALE OF PROJECTS



India - Featured Projects

Projects at scale

In addition to the projects captured through the systematic surveys, India has a number of projects that are currently being scaled:

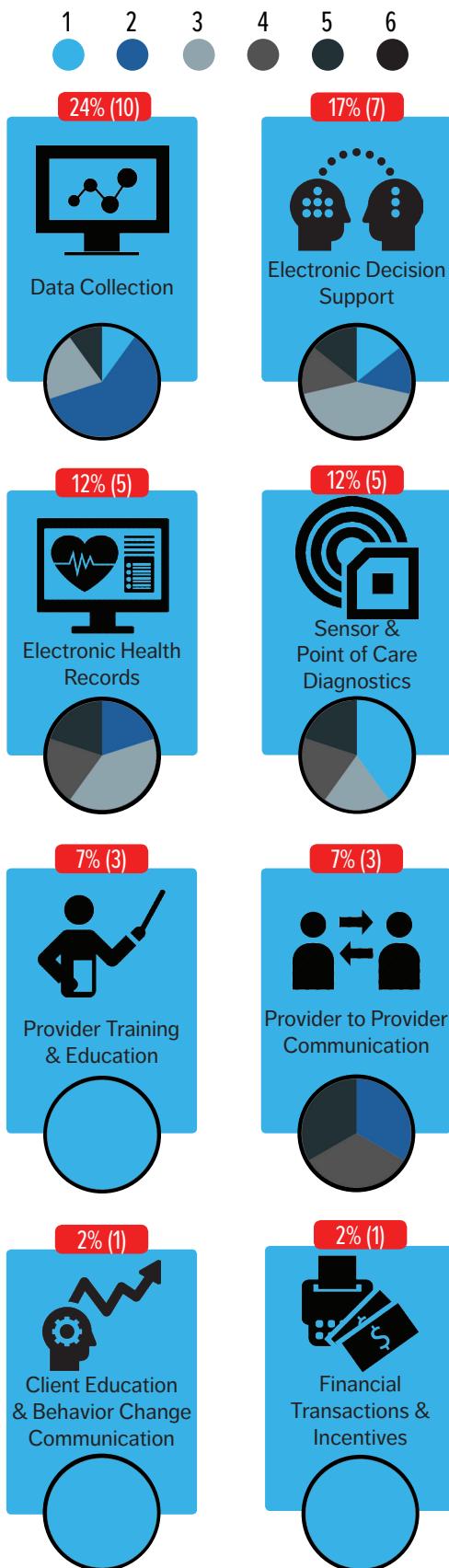
Mobile Academy is an IVR-based training course for Accredited Social Health Activist (ASHA) designed to refresh their knowledge of life-saving preventative maternal and child health behaviors and to improve their interpersonal communications skills. The program is live in Bihar, Odisha, Jharkhand, Madhya Pradesh, Rajasthan, Uttarakhand and Uttar Pradesh- 145,764 ASHAs have begun the course, and 72,339 have successfully graduated.

Mobile Kunji is an audio-visual job aid, involving a printed deck of illustrated cards on a ring, each with a unique shortcode printed at the bottom, which the ASHA can call to play related audio content. The job aid is also focused on live-saving preventative health behaviours. 46,523 ASHAs are using Mobile Kunji across three states (Bihar, Odisha and UP) every month. Both Mobile Kunji, and Mobile Academy are built on the MOTECH platform and are led by BBC Media Action.

The Society for the Elimination of Rural Poverty (SERP) based in Telengana, currently has 2,650 health activists using feature phones to coordinate and improve nutrition services for pregnant women and children under-five. SERP uses a proprietary software application.

mSehat is currently being rolled-out in all sixty-five blocks of the five Districts of Uttar Pradesh (Mirzapur, Faizabad, Sitapur, Bareilly, and Kannauj) covering a total of 10,500 ASHAs and 2,000 Auxiliary nurse Midwives (ANM's). ASHAs are given smartphones and ANMs are provided with tablets to effectively plan, manage and perform their day-to-day work, with the aim to improve maternal and child health service delivery. mSEHAT uses a proprietary software application and is implemented by the State Innovation in Family Planning Services Project Agency (SIFPSA) of the Government of Uttar Pradesh.

Number of concurrent Signal Functions when "this" Signal Function is employed

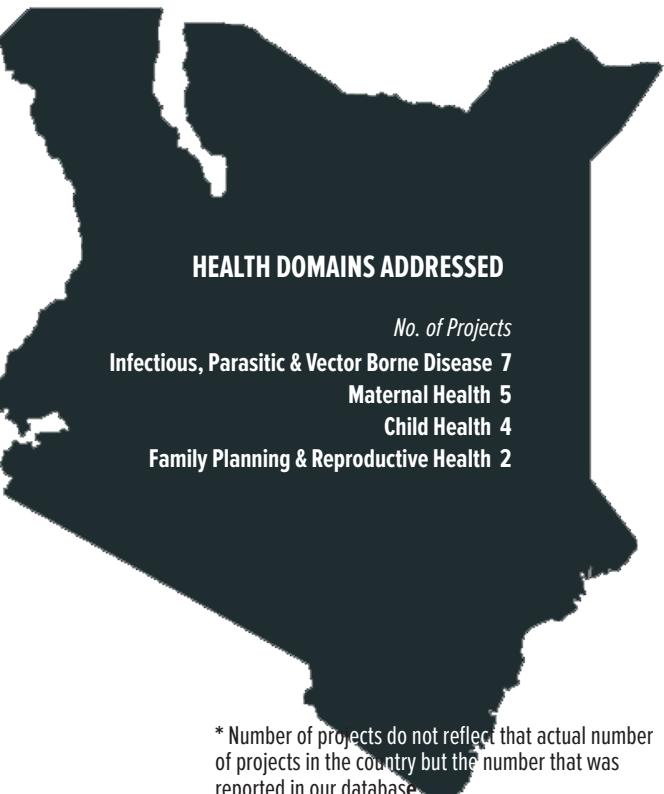


KENYA

COUNTRY OVERVIEW

23 PROJECTS*

F.2



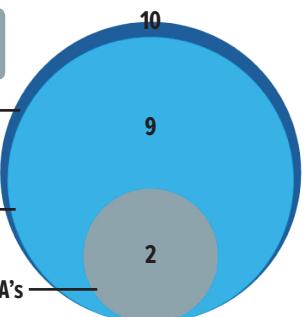
* Number of projects do not reflect the actual number of projects in the country but the number that was reported in our database.

TYPE OF FHW

Health Facility Staff (includes doctors, nurses, first respondents & other hospital staff)

CHWs (includes ASHA, CHEWs & other variations of CHWs)

Midwives/TBA's

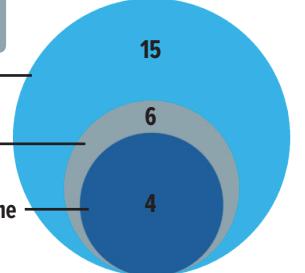


TYPE OF PHONE

Smartphone

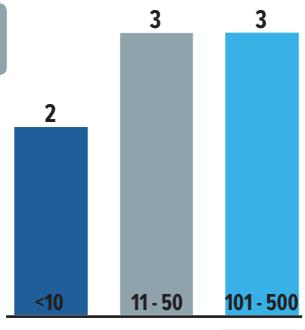
Tablet

Any Phone



SCALE OF PROJECTS

Ranges not represented did not have any current reported projects.

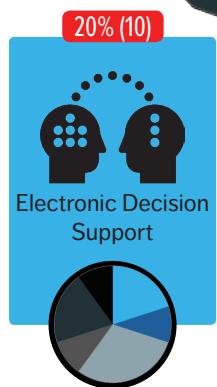
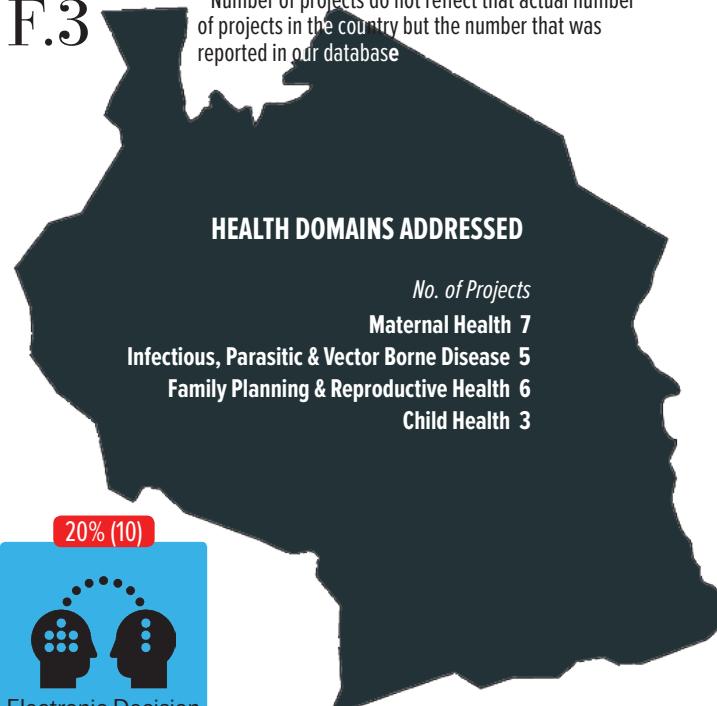


TANZANIA

COUNTRY OVERVIEW - 22 PROJECTS*

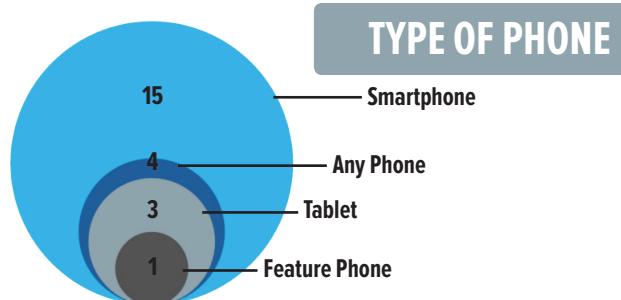
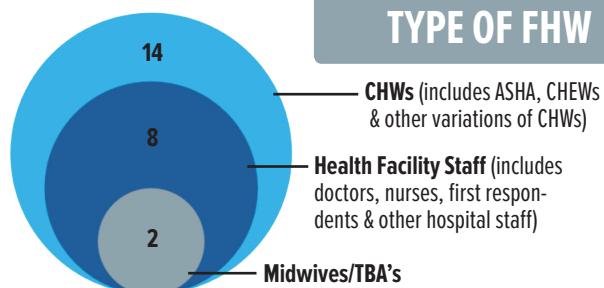
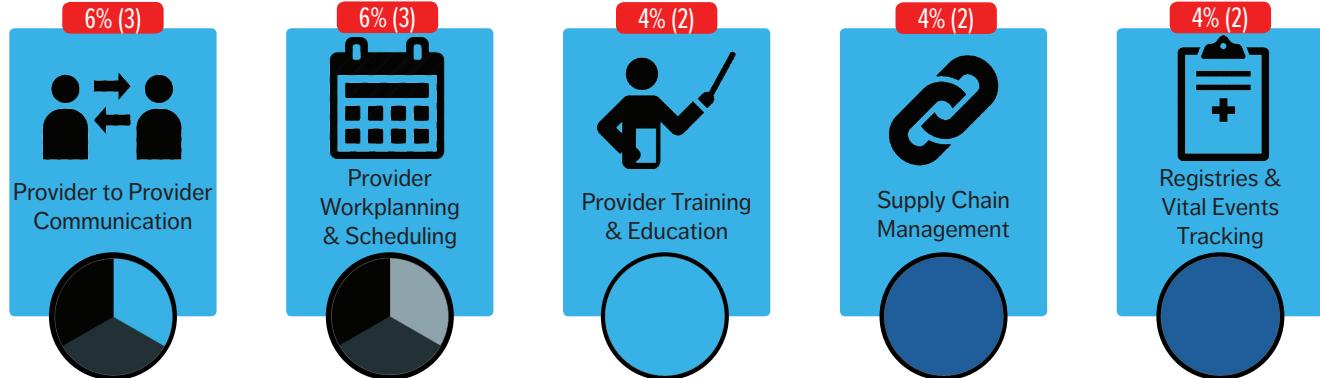
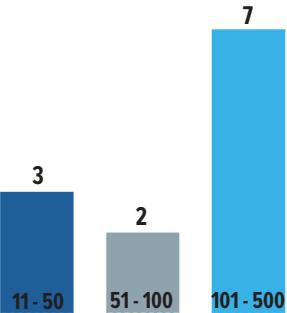
F.3

* Number of projects do not reflect that actual number of projects in the country but the number that was reported in our database



Number of concurrent Signal Functions when "this" Signal Function is employed

1 2 3 4 5 6



SCALE OF PROJECTS

Ranges not represented did not have any current reported projects.

PROJECTS AT SCALE

(1001+ users) F.4

MomConnect

Country: South Africa

Year Started: 2014

Platform: MAMA/Vumi

Type of Health Worker: Health Facility Staff

Health Domain: Maternal & Child Health

MomConnect has three main objectives: 1) Register each pregnancy at a government health facility; 2) Send stagebased, personalized short message service (SMS) texts to each mom in the registry; and 3) Allow women to engage with the health system through help desk tools and feedback services. The services are free to the user, and messages are currently available in six languages and will shortly be available in all 11 official South African languages.

mHealth for Integrated Community Case Management

Country: Malawi

Year Started: 2012

Platform: Not Specified

Type of Health Worker: HSAs, Nurses

Health Domain: Maternal & Child Health

?

Improving the quality of child health care at the primary level through integrated decision-support tools. These tools include clinical protocols for infant care, registration of eligible children and treatment management, supervision tools to gather KPIs for HSA performance, tool for improved logistics management to improve the availability of needed drugs at the rural clinics where HSAs see patients.



Client Education & Behavior Change Communication



Data Collection



Supply Chain Management



Electronic Decision Support



Provider to Provider Communication



Registries & Vital Events Tracking

Hang Up & Track

Country: Democratic Republic of the Congo

Year Started: 2014

Platform: ODK

Type of Health Worker: Any CHW

Health Domain: Infectious, Parasitic &

Vector-borne Disease



Community health workers (CHWs) do not just distribute LLINs, they also installed and hung them up in each household. They then recorded household registration data using smart phones, took GPS coordinates, and took a photo of the installed mosquito net to ensure accountability and accuracy.

Early Warning System

Country: Ghana

Year Started: 2011

Platform: CommTrack/CommCare Supply

Type of Health Worker: Health Facility Staff

Health Domain: Open to all domains



Early Warning System (EWS) involves the use of mobile phones by health facility staff to report stock levels of 27 tracer commodities (HIV, malaria, and family planning) via SMS to a dedicated short code on a weekly basis. By logging in to the EWS website through the Internet, Regional Medical Stores are also able to input their stock levels for the 27 tracer commodities. Data is then processed and immediately made available to all relevant participants on a website accessible to all program managers and participating providers.

SIJARIEMAS

The Referral Exchange System

Country: Indonesia

Year Started: 2011

Platform: Not Specified

Type of Health Worker: Midwives

Health Domain: Open to all domains



System was developed to address challenges of the current referral system by facilitating timely communication and improved coordination within an agreed upon referral network (public and private facilities and health providers) using SMS, internet and phone calls.

cStock Supply Chains for Community Case Management

Country: Malawi

Year Started: 2011

Platform: N/A

Type of Health Worker: HSAs

Health Domain: Maternal & Child Health &

Infectious, Parasitic & Vector-borne Disease



cStock uses mobile technology to increase community access to life-saving medicines needed to treat all three targeted childhood illnesses (malaria, pneumonia, and diarrhea) for improved community case management to reduce U5 mortality. cStock was introduced as an integral component of two broader intervention strategies – Enhanced Management (EM) and Efficient Product Transport (EPT).

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Performance of Existing Programs

G

As highlighted in Section 2 of this report, evidence on the performance of these FHW programs continues to be limited. Section 2 summarizes the evidence based on a review of peer-reviewed literature. However, it should be noted that most projects reported on in the peer-reviewed literature operated at a small scale under “efficacy” (i.e. ideal) settings. A number of projects reported on in the peer reviewed literature ceased to operate once the study ended, or after the funding cycle ended. To capture the performance of current projects, several of which are operational at a larger scale, we reached out to the implementing organizations to share any available data on performance, which may not have been available in published form. Evidence on the performance of these projects is summarized below based on the primary function served by the programs. Please note that specific references for most of the data presented below was through personal communication with the project leadership.

Supply-chain management: Zidi, a health management information system, reported that its implementing clinics experienced a 40-70% increase in revenues within the first month of use, possibly due to reduced pilferage of medicine. A different approach to Zidi, Sightsavers used SMS for Life to collect weekly data on drugs for neglected tropical diseases (NTDs) in Cameroon. The project reports that districts where mobile reporting was implemented had 90% data availability, compared to 40% data availability in comparison districts. The number of treatments for NTDs increased by 10.5% in intervention districts compared to a 3.5% increase in comparison districts. A RCT, in partnership with Tulane University, is underway to assess the impact of data monitoring for supply chain management. eLMIS in Bangladesh facilitates mobile reporting of family planning commodities and stock-outs. Improved visibility of logistics data has reduced stock-outs at the facility level from 69% in 2009 to 0.7% in 2014. cStock, currently being scaled in Malawi, aims to reduce stock-outs of life saving medicines for treating childhood illnesses (malaria, pneumonia, diarrhea). cStock was introduced as an integral component of two strategies- Enhanced Management, and Efficient Product Transport (EPT). The program reports that EM was significantly more effective than EPT in reducing stock-outs, and had a mean drug resupply duration of 12.8 days compared to 26.4 days for EPT. These findings suggest that the implementation of a mobile-based intervention to reduce stock-outs is more effective with an accountable management structure.(Shieshia et al., 2014)

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Performance of Existing Programs

G

Improved coverage of interventions: Coverage of interventions might improve if the mobile intervention is helping to improve the demand for the service (e.g. through education), supporting continued use of the service (e.g. through reminders), creating incentives for improved use of services (e.g. financial reimbursements) or resulting in improved quality of health-care delivery. Wired Mothers sends pregnant women appointment reminders, educational information, and a mobile phone voucher which can be used to contact their provider in case of emergencies. The project reported improved and sustained use of antenatal care was observed in the intervention group, and that 60% women who were receiving this intervention versus 47% in the control group delivered with a skilled attendant (OR- 5.73, 95% CI -1.51-21.81). No significant difference was observed in the outcomes among rural women. mCare in Bangladesh used a multi-functional approach with community-level pregnancies and birth registration, follow up with pregnant clients, and facilitation of referrals for mother and newborns. Pilot data suggest that the intervention resulted in tripling number of antenatal visits, and doubling postnatal visits in the intervention groups as compared to the control groups.

TulaSalud in Guatemala trained 125 community facilitators (CFs) to use mobile phones to consult with medical staff, call for emergency transfer of pregnant women with a complication, capture data on pregnant and post-partum women in real-time, and receive continuous training on promotional and prevention activities through teleconferences. The study reported that over the 5-year implementation period, the CFs conducted 116,275 medical consultations, monitored 6,783 pregnant women, and coordinated 2,014 emergency transfers.(Martinez-Fernandez, Lobos-Medina, Diaz-Molina, Chen-Cruz, & Prieto-Egido, 2015) The project claims a significant decline on maternal and infant mortality attributable to the intervention, however the study methods used are inadequate and this claim is not well substantiated in data. A recent impact evaluation, compared the effectiveness of a mobile phone based intervention added onto an existing maternal and child health program in Bihar, with the core program.(Borkum et al., 2015) The Ananya program in Bihar aims to improve maternal and infant health outcomes through a series of FHW interventions at the community level. The Information and Communication Technology (ICT) Continuum of Care Services (CCS) intervention provided ASHA's and Aganwadi workers (AWWs) with mobile phones to aid with pregnancy registration, schedule home visits, and use guided audiovisual job-aids for counselling clients. Auxiliary midwives (ANMs) and lady supervisors (LSs) were provided ICT-enabled phones to improve oversight and supervision of ASHA's and AWW's. Though technical and logistical challenges were reported by the project, it has a significant 2-year impact on several coverage indicators. The intervention significantly improved the frequency of FHW- client interactions especially during the final trimester. 50% of the women in the ICT-CS group had atleast 3 antenatal care visits, compared to 29% women in the comparison group.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Performance of Existing Programs

G

Similar improvements were seen for immediate breastfeeding (76 percent in treatment group versus 62 percent in the comparison group), introduction of complementary feeding (41 percent versus 32 percent, and introduction of solid/semi-solid foods for children over 6 months (64 percent versus 55 percent). No significant improvements were seen on measures of birth preparedness, and facility deliveries.

Retention of clients in care: Ongoing retention of clients in care is important to the success of a number of chronic disease management programs, including HIV/AIDS programs. TXT-Alert in South Africa reported that sending HIV-positive pregnant women reminders about upcoming appointments, and their CD4 count test results by SMS, helped reduce drop-out rates. TXT-Alert has less than 10 active users currently. It should be noted that there is no evidence on the effect of mobile reminders on long-term (>1 year) retention in care in developing countries.

Training of FHW: Training of FHW using mobile devices was reported a one of the most common program goals, often built in as sub-component of a more comprehensive intervention. The Safe Delivery App, which can be downloaded free of charge, is designed to train traditional birth attendants in the management of normal and complicated deliveries. The program reported (based on a cluster randomized trial) that the intervention health workers skill scores increased significantly compared to control at both 6 months (mean 6·04 (4·26-7·82)) and 12 months from baseline (mean 8·79 (7·14-10·45)). Knowledge scores also improved more in the intervention compared to the control group; 1·67 (1·02-2·32) at 6 months, and 1·54 (0·98-2·09) at 12 months. This resulted in a lower (but not statistically significant) perinatal mortality in interventions groups (14 per 1,000 births) compared to 23 per 1,000 births in control clusters (OR 0·76, 95% CI 0·32-1·81).

BBC Media Action piloted Mobile Academy, a program to reinforce health worker's knowledge about pregnancy and aid in counselling. mSAKHI, also in India, aims to support CHWs (i.e. ASHA in India) through an interactive audio-visual app that guides the CHWs in conducting activities across the MNCH continuum. Some qualitative evidence to suggest that the CHWs perceived this to be useful has been reported. No studies on the effectiveness of these programs were identified.

Provider-to-provider communication is another feature that is typically built into a broader programs. The direct benefits of facilitating direct communication between providers is challenging to quantify. The mHero platform allows rapid communication via SMS, IVR and direct calls among health workers, government authorities, and other stakeholders to strengthen communication among health authorities. It was widely adopted and used by agencies to improve coordinated response to the Ebola epidemic.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Performance of Existing Programs

G

Sensors and diagnostics: Specific mobile apps and clip-on hardware that serve a range of diagnostic functions are being tested for use by FHWs in the community. A study to assess the effectiveness of training CHWs to use a mobile phone cardiovascular disease (CVD) risk assessment application to screen clients for CVD reported that the mean screening time using a paper based system was 36 minutes, compared to 21 minutes using the mobile phone application.(Surka et al., 2014) The study also reported that the paper-based system resulted in significantly more incorrect calculations for blood pressure and basal metabolic rate. "PIERS on the Move" integrates the miniPIERS (Pre-eclampsia Integrated Estimate of RiSk) predictive model, which can accurately stratify pregnant women into risk categories up to one week before complications arise and without laboratory tests with a Phone Oximeter, a cellphone based pulse oximeter (a non-invasive device which can measure blood oxygen saturation levels). The mobile phone application assists community health workers to provide local, rapid and accurate risk assessment, referral, and treatment advice for pre-eclampsia, and transmits information to referral centers for coordination of triage, transportation and treatment. Some data on coverage of this service is available, but no information on the accuracy and effective is available. Another mobile app for android phones called Peek Vision, can run a range of tests, including visualization of the back of the eye. The test has shown to have a sensitivity of >80% and specificity of >90% for detecting retinopathies. The acuity was shown to be comparable to the gold-standard.(Bastawrous et al., 2015) A mobile phone microscope has been evaluated in Tanzania, had 69% sensitivity and 62% specificity in detecting soil transmitted parasitic infections, with robust results in peer-review publications.(Ephraim et al., 2015) DekiReader, a mobile-based invitro diagnostic device interprets commercially available rapid diagnostic tests for malaria, HIV, syphilis, hepatitis, and dengue. Quality issues are still being addressed and data on effectiveness is unavailable.

Real-time data capture and monitoring: Mobile data collection for a variety of healthcare domains was reported as one of the most commonly functions. In some cases, mobile data collection may be a standalone activity for real time monitoring of health data. In programs targeted at reaching clients for ongoing engagement with healthcare, FHWs may be involved with activities to register clients. For example, MomConnect in South Africa employs CHWs to register pregnant women in health facilities to receive pregnancy-related information on their mobile phones. The service covers nearly 86% of the government facilities in the country, and evaluation studies are underway. Ma Sante in Mali and Senegal uses mobile phones for data collection on malaria and other critical child health indicators, and subsequently, improves communication and response to addresses problems. The project reports that rapid detection of suspected malaria cases increased house calls by CHWs by 20%, and resulted in a 25% increase in the number of children receiving malaria treatment within 24 hours. No comparison group was reported.

4. Current trends in the use of mobile phones/tablets by FHW (continued)

Performance of Existing Programs

G

Electronic decision support system and EHRs: Decision support tools have been used to serve a number of critical health functions. The mHealth for Safe Deliveries project in Zanzibar has developed a clinical algorithm that takes TBA's step-by-step through the process of screening pregnant women, counselling them, identifying danger signs, and contacting the emergency driver, if needed. Some primary data on impact is currently in publication. The program reports that over 200 TBAs and CHWs have registered over 7000 women using the tool. The intervention areas report a high rate of facility deliveries (75%), compared to the 35% rate in Zanzibar. A similar mobile application based decision support system in Tanzania guides CHWs to systematically guide clients through their contraceptive choices based on their fertility intentions. The mobile application includes reminders to CHWs to follow up on their clients for contraceptive refills and to confirm completion of referral to the health facility for long acting contraceptives. Pathfinder implemented a pre/post study to assess the effect of using a decision support system for ANC by CHEWs on quality of ANC, in Abuja. 150 CHEWs were trained in the use of the application, and 266 clients were counselled using it. Quality was assessed based on 25 indicators covering technical and counselling elements of ANC. The study reports that the quality score improved from 13.3 at baseline to 17.2 at endline.(Mcnabb, Chukwu, Ojo, & Shekhar, 2015)

Below: Mother and child arrive for check-up appointment



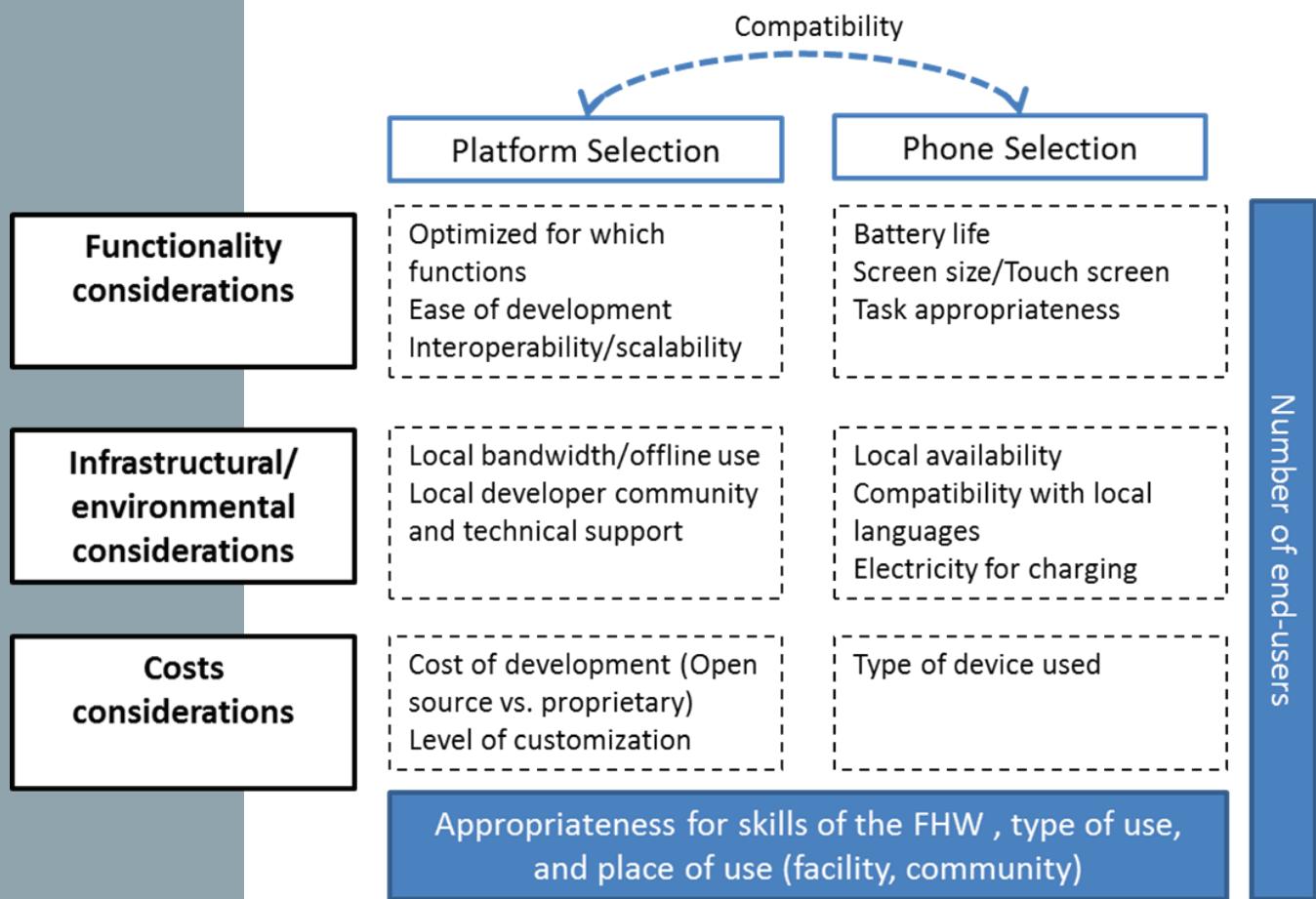
5. Summary of Findings and Future Directions

Framework based on findings

A

We note that few programs have achieved scale- section 4E shows how the number of reported projects drops sharply at 500 users. This might suggest that a number of programs that are operating at a smaller scale do not have the built-in capacity to scale beyond a certain point due to infrastructural, managerial, organizational, political and technical limitations. Figure 10 presents a framework to highlight some critical considerations for FHW-supported mHealth programs to move beyond the pilot stage. We posit that several functional, infrastructural/environmental, and cost considerations must be considered when selecting a platform and phone for developing programs to support activities of FHWs. Appropriateness of the chosen intervention approaches to the skills and context of the FHW is foundational to the success of the program. As the number of users increases, the fine balance between platform selection, phone selection and cost becomes even more critical.

Figure 10: Considerations for scaling mHealth programs for FHW



5. Summary of Findings and Future Directions

(continued)

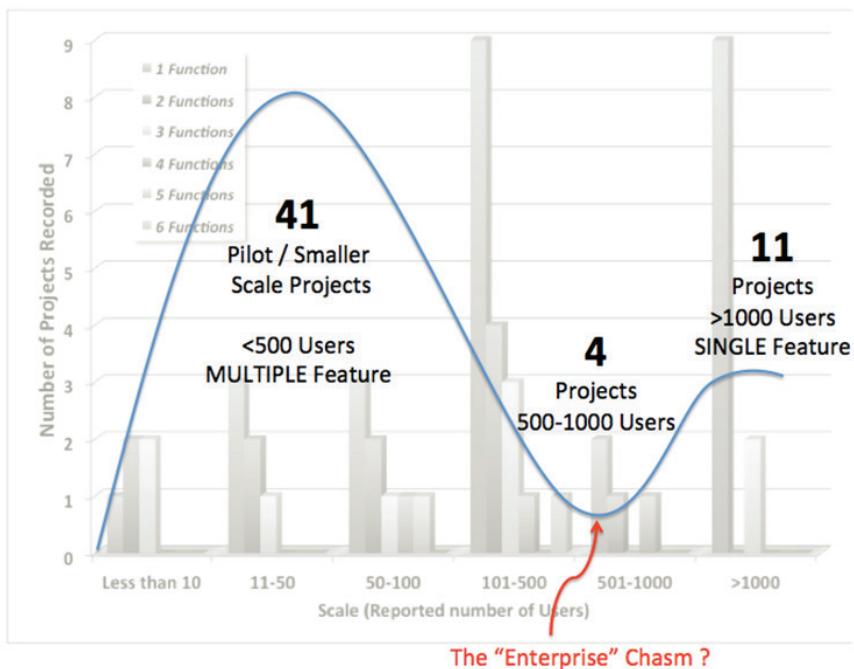
Framework based on findings

A

Insight: The "Enterprise Chasm"?

One interesting observation with the above distribution of projects brings to mind a distribution much like the well-known Gartner Hype Cycle for technologies (Figure 9c). On the left hand side, we have 41 projects with fewer than 500 users, in the middle only 4 projects with 500-1000 users, and at the extreme level of "scale", a mere 11 projects with over 1000 users. Of course, a number of caveats prevent definitive conclusions to be drawn from this dataset with any degree of certainty, but a few interesting hypotheses may be proposed. A major differentiator between projects on the left and right sides of this possible "Enterprise Chasm" is complexity. Digital FHW projects that have emerged as leaders in scale surprisingly are parsimonious, with primarily a single function (usually decision support).

One might speculate that a combination of both intrinsic and external factors contribute to challenges in making it across this Chasm, not least being the necessary ecosystem required to support programs with over 1000 users. At smaller scale, with under 500 users, a limited number of technical support personnel may be able to support operational and technical issues which arise in the implementation of the project. However, the need for human resources, technical supply chains and system redundancy planning becomes more pronounced at larger scale. Funding and institutionalization may also play a contributory role to the chasm. Smaller mHealth projects can be designed and implemented within the confines of a five-year project. In order to grow larger, they often have to make the leap from the project-life cycle into a new funding mechanism. This is a complex undertaking, requiring that the mHealth project had achieved enough success and institutional buy-in before the end of the umbrella project that it was able to interest other funders and partners. This process has been unique to each of the larger deployments.



5. Summary of Findings and Future Directions

(continued)

Framework based on findings

A

Interestingly, when technology solutions are deployed at 1000+ users, implying their being a requisite part of the FHW's workflow, there must be a certain guarantee of functional redundancy in the event of a system failure. One can imagine how intolerant a health system would be of a defective or dysfunctional device preventing a FHW from performing her daily work. Also intriguing is the apparent simplicity of systems which make it across the Chasm, into large scale deployment – perhaps a combination of technical functionality and stability and political acceptability of simpler systems. It remains unclear, given the present state of available data, which precise intrinsic and external factors may be contributing to limiting the number of projects which we have documented operating at scale. Further implementation science research is required to better characterize the technical, social, political and enabling ecosystem components which are needed to allow digital FHW projects to scale. It is also unclear in this early stage of mHealth system evolution whether complexity can increase once projects integrate themselves successfully into the health system at a larger scale. This is also an opportunity to emphasize a global sea change in the mHealth landscape away from complex monolithic systems towards an encouragement of parsimonious systems which are interoperable with others, especially integrating with larger national health information systems.

Limitations in Identifying Credible Data and Findings

B

This report highlights the need for more accurate documentation of the implementation, challenges and effectiveness of mHealth. Given the recent explosion of support for mHealth programs, there is a large amount of churn- where programs operate for a small period of time only. Reporting, and updating of data on programs can be very useful in decision-making. As reported in Section 3 of the report, 45% of the programs (who responded to our surveys) recorded in the USAID compendia are no longer operational. We provide a description of these projects in Appendix D . An additional 35% of the programs did not respond to our requests for follow-up. The information available on the operations, implementation and effectiveness of such programs in the public domain is limited. Most programs, including those operating at scale, have limited data on the effectiveness of their approaches. The fact that these programs have scaled, represents the enthusiasm of the stakeholders and intuitive perceived benefits of such programs.

The results of this report help push the envelope beyond what is known about the trends and effectiveness of mHealth programs from peer-reviewed literature. We draw on multiple sources of information from mHealth databases, organizations doing mHealth work, peer-review literature and mHealth experts. The database developed to report these findings is a unique contribution to the space, and possibly the only current database that compiles this information. It however, has several limitations. First- results from the analysis of the database should be cautiously interpreted as the sample of included projects is self-selective.

5. Summary of Findings and Future Directions

(continued)

Limitations in Identifying Credible Data and Findings

B

We recognize that we may have missed projects, especially those in non-English speaking locales, led by non-English-speaking managers, or programs that are not connected to the mHealth community in any way. Second- the quality of information collected for the database is of variable quality, with several missing items. For example, less than 50% of the respondents had any information on the number of users. We hypothesize that these programs are likely to be operating at a small scale resulting in some systematic errors in our conclusions. We individually contacted every project in the USAID compendia, but when some projects did not respond to repeated requests for follow-up we were not able to include them in this review. We were not able to conduct the same type of follow up for the projects in the CHMI compendia so it is likely that some of this information is outdated. In seeking to ensure that we conducted our data collection in a systematic way, we had to strike a balance between trying to ensure that any project we included came through our data collection channels, while not ignoring projects we know to be substantial but which are not properly captured even in the grey literature.

To encourage participation, our surveys had room for free text. While attempts were made to code this text accurately, sometimes the information was incoherent, and we had to use our best judgement in coding it.

Gaps and Way Forward

C

In addition to identifying gaps and directions for future progress based on the finding of our research, we also present additional insights from leaders in the field (Lesley Anne Long, Sara Chamberlain, and Marc Mitchell) in boxes below. For complete transparency, the initials of the expert are listed after each quote.

Mobile technology based interventions have benefited from the enthusiastic, and often unquestioning support of implementing and governmental agencies, corporates, and donors. However, there has also been a recent recognition of the lack of evidence to support the blanket use of such technologies. The emergent landscape of multiple small scale programs with different applications of existing and proprietary platforms, and types of phones to varied healthcare functions, has thrown decision-makers for a loop about ways to move forward constructively. This report helps to shed light on some of the emergent trends and summarizes knowledge and insights from practitioners; however it is still limited in its recommendations moving forward due to the limitations in evidence on what works. Two factors that should be simultaneously taken into account when supporting a specific mobile-based intervention approach- 1.) What function does the intervention serve?; 2.) What level of evidence (and quality of evidence) is needed to support the intervention?

5. Summary of Findings and Future Directions

(continued)

Gaps and Way Forward



It is critical to note that not all interventions need the same amount and quality of evidence in order to be supported. For example, several options alternate to the use of mobile phones might be available to train FHW in the delivery of healthcare. In order to support the use of mobile phones instead of an alternative, we need to answer questions such as- Is training FHWs using mobile phones more effective than an alternate strategy ? Is this impact sustained over time? Is it more cost-effective than an alternate strategy? Interventions that directly influence delivery of services and outcomes need this robust level of evidence that is based on comparison with alternate strategies, in order to have enough support for their continuation. However, interventions that are targeted at improving the process in some way may not need as robust evidence. For example, using mobile tools for data collection has benefits that are more intuitive, and may need evidence on best practices to make it work to move forward.

Expert opinion: What kinds of challenges are we all facing?

- Reporting: Lack of feedback and data entry duplication

Reporting systems are too top-down - data gets sent up to district/region/ministry level, but FLHWs don't get to realize/are not told about the value of decisions based on the data they send...FLHWs don't feel engaged in the data (or don't see its relation to their day to day jobs) this probably impacts on the quality and integrity of the data. (LA)

Most technology innovations for FLHWs (esp. with data and visit recording) have been small scale (perhaps not comprehensive across even a small district), so HWs are still required to complete paper records/reports. This adds a burden to their workload as they essentially need to report the same data twice. (LA)

- Electricity and charging

"Feedback from the recent HEW workshops in Ethiopia was that power/electricity access is the very top item on the health workers' list of barriers/challenges in mHealth interventions (especially those using smartphones, with shorter battery life). Solar chargers etc. can help with this issue, but the very small/personal solar devices aren't really a good substitute over mains/grid supply for regular/consistent recharging (larger solar/wind systems may be but these come with their own technical maintenance challenges)." (LA)

5. Summary of Findings and Future Directions

(continued)

Gaps and Way Forward



Most technical platforms have not been deployed and tested at scale and there is little evidence to suggest how they may function at scale. The paucity of complex, multi-faceted systems which are operating at scale suggests either that the current state of the ecosystem is still in its early growth phase, or that in these early days of mHealth Systems at large scale, parsimonious systems are easier to expand. This may be attributable to a combination of technical, human and political factors. More complex systems architecture are challenging to oversee and manage, requiring dedicated staff and resources to ensure functionality and constant debugging / troubleshooting. Groups like Dimagi (responsible for CommCare), although clearly successful in the ‘scale-by-replication’ model have admittedly found it difficult to keep pace, from a technical support perspective, with the rapid expansion of projects using its platform. Like with any complex system, the more moving parts, the greater the innate risk of the system malfunctioning or breaking down, especially when the number of users reaches a certain threshold.

Similarly, the support network required to troubleshoot, repair and replace hardware when the population of users meets a certain level is substantial. In our experience, one supervisor can usually manage a team of 20-35 individuals most efficiently. When this ratio is extended by an order of magnitude (200-350), a reflection of the technical support end user ratio in many mHealth deployments, if not less, the dependability of these systems for daily function is compromised. Systems required for everyday FHW functions must therefore integrate multiple layers of redundancy (hardware and software) to avoid crippling fieldwork due to technical dysfunction. This is especially true during the early stages of a project implementation, when user expectations are high and the risk of disenchantment equally so.

Finally, from a political perspective, our experience and those of colleagues leading platforms included in this report suggests that the first response to the expansion of digital tools for FHWs by large NGOs or governments to be either skepticism or cautious enthusiasm. In this context, parsimonious systems with clear functions that fit cleanly into existing workflows may face less resistance. Uncertainties around the true cost of scaling and sustaining these systems have also been reported as barriers to scale-up.

Important gaps still persist in our understanding of the ecosystem, support infrastructure and human capacity required to introduce, scale and sustain digital tools for FHWs. There are ample technical systems which can be mapped to the core signal functions of FHWs in most settings. From basic enumeration and surveillance, to communications and protocol adherence – commercial and open-source systems have emerged and have demonstrated stability with a large number of users. A clear trend suggests simplicity of purpose to be associated with scalability – although it is not clear whether this is, in fact, a causal association. There is limited information on data security protocols and compliance with national regulations. Most countries where these projects are operational may not have any national regulations on data security imposed. However, as community data are integrated with facility base patient records, this will need to be addressed. Our results suggest that demand is high for systems that are compatible with low bandwidth and intermittent connectivity environments, however, limited options exist for users in such environments.

5. Summary of Findings and Future Directions

(continued)

Gaps and Way Forward



Globally, there is increased discussion around interoperability – developing systems which can share information and leverage specific functions to improve efficiencies. “Backbone” services, such as shared health records and unique individual identifiers, are required essential investments before large-scale interoperability can truly be harnessed. Once in place, though, such frameworks may allow simple FHW-targeted systems to work together on a common platform (eg. like multiple, interconnected “apps” on a mobile device), as well as contribute to national health information systems like DHIS2 or clinical systems like OpenMRS. Data on the degree to which the systems described in this report adhere to standards is limited, as recognition of the importance of data standards and common data dictionaries is just emerging. Most of the materials available / repositories searched did not include any reporting of data architecture or data standards used by the programs.

Although the existing evidence for the cost-effectiveness of mHealth interventions for FHWs looks promising, there is insufficient evidence because of the limited research done on the topic. The literature reviewed provides an analysis of the cost-effectiveness of specific interventions, but the lack of a clear representation of which costs are included in different cost categories, and whether the costs evaluated are all-inclusive, both inhibits a clear understanding of the cost effectiveness of individual interventions and the aggregate cost-effectiveness of mHealth interventions for FHWs. In addition, the discrepancy needs to be made between research and intervention costs when considering the sustainability of an intervention.

Expert opinion: Why is it so much easier to talk about scale than it is to accomplish it?

- “... NGOs and open source software providers are unproductively competing against each other and governments are overwhelmed by too many competitive choices. And often it’s the same donor funding multiple pieces of software that do basically the same thing and then through their competition, which involves different government folks competing for resources, nothing gets scaled...” (SC)
- “Tech programs can be myopic - programs are deemed a success when they do well on a specific indicator. Yet often these programs don’t address the complexity of disease or human interactions or the multifaceted environment in which health workers work. NGOs all seem to want a specific app – despite the fact that about 99% of what most organizations want for a program can already be done by existing code/apps. So NGOs are essentially creating new apps for the 1%...These are issues related to mHealth implementers and planners rather than on the direct use by FLHWs. And because they focus on specific indicators, they are unlikely to go to scale once the funding for the program ends. (LA)
- “...the most neglected area, which requires the most attention, is focusing on scale and what happens after the scale up - not in terms of software (although support is key), but in terms of everything else - procurement, distribution, training, support, financial management, monitoring, supervision, incentives etc.” (SC)

5. Summary of Findings and Future Directions (continued)

Gaps and Way Forward



Further research should explicitly include a comprehensive list of costs included in all of the relevant cost categories; and then be evaluated and compared using a standard set of cost-effectiveness indicators.

Expert Opinion: What are key areas to focus on as we move forward?

- From a programs perspective, a comprehensive approach (including interoperability in systems as well as coordination in programs), user-centeredness, and willingness to improve on an existing technology rather than starting from scratch seem to be common sticking points – basically programs should be based on and only funded if they can demonstrate they have used the principles for digital development in their design/implementation plans.
- "...some of the program areas that most stand to benefit from mobile technology are communication, reporting, and learning:

Communication - FLHWs, especially in remote areas, need better access to on-demand information, someone to answer questions, a way to communicate their needs for resources (transport, supplies, etc), and a functioning referral system (one of the aspects of HELP that the community health volunteers rated the highest satisfaction was not the learning aspects of the program but the fact they could talk to each other and their supervisors using the free closed calling system)

Reporting - mHealth has not comprehensively solved the problem that reporting systems are often slow, inaccurate, and extremely time consuming for FLHWs; and in many cases an mHealth solution is run alongside the existing print based solution so adds to the health worker's tasks;

Learning - This includes training, but also broader areas including tech literacy, access to new information, and peer learning. One big issue here is integration of mobile tech into curricula, and training that is useful to the user (considering language, pedagogy, relevance, etc)." (LA)

5. Summary of Findings and Future Directions (continued)

Gaps and Way Forward



To get a complete understanding of the cost-effectiveness of mHealth interventions for FHWs, the total savings should not only include the direct savings, but also the indirect and health systems savings resulting from the outputs and improved outcomes. Since the research indicates that initial costs are typically higher for mHealth interventions as opposed non-technical interventions, to make an argument for the mHealth interventions, it is important to understand the net-savings generated from their implementation by converting improved outcomes into monetary values.

Expert Opinion: What are key areas to focus on as we move forward? (cont)

- “Scaling distance learning/self-learning tools – as per our Mobile Academy – this is critical because standardized, high quality face to face training is so challenging and expensive to provide.” (SC)
- Scaling job aids to support their support FLWs in their critical outreach and health education work – as per our Mobile Kunji – again helps ensure facilitated, standardized, high quality counselling to families” (SC)
- “Scaling software that enables FLWs to create, access and update electronic medical records for women in their catchment area, and generate workplans/schedules with reminders for themselves is a critical next step – as per Dimagi/Motech/D-Tree/Cell-life and many more” (SC)
- Supply chain management for FLWs – so they can log shortages of supplies (meds, contraceptive, supplements etc) and track shipments coming to their [primary health center].” (SC)
- On quality of care:

“The use of decision support in the hands of health workers has shown time and time again to improve diagnostic and treatment accuracy and lead to more trust in the system by patients....The question, then is what is needed? First, we need to focus more on quality of care which in this case means getting the right diagnosis and treatment. It also means communicating with the patient or client in a way that can be heard. Using video and other novel ways to communicate rather than relying solely on the provider to talk with the client. We need ways to measure quality that measures if treatments are correct and if patients who are sick get well. Do clients feel they were well treated? Would they go back again? Would they recommend it too their friends?” (MM)

5. Summary of Findings and Future Directions (continued)

Gaps and Way Forward



Finally, while projections exist for both the cost-effectiveness of scaling mHealth interventions for FHWs, and opportunities to improve cost-effectiveness, the research is very limited. Further research should be completed on mHealth interventions for FHWs that are either currently at scale, or are scaling up, to analyze the cost-effectiveness, but also to gain a better understanding of what are the additional costs, costing challenge, and opportunities to improve cost-effectiveness. This will help inform the decision-making and design of mHealth interventions for FHWs with the objective of being implemented at scale.

Expert Opinion: What can government do to help?

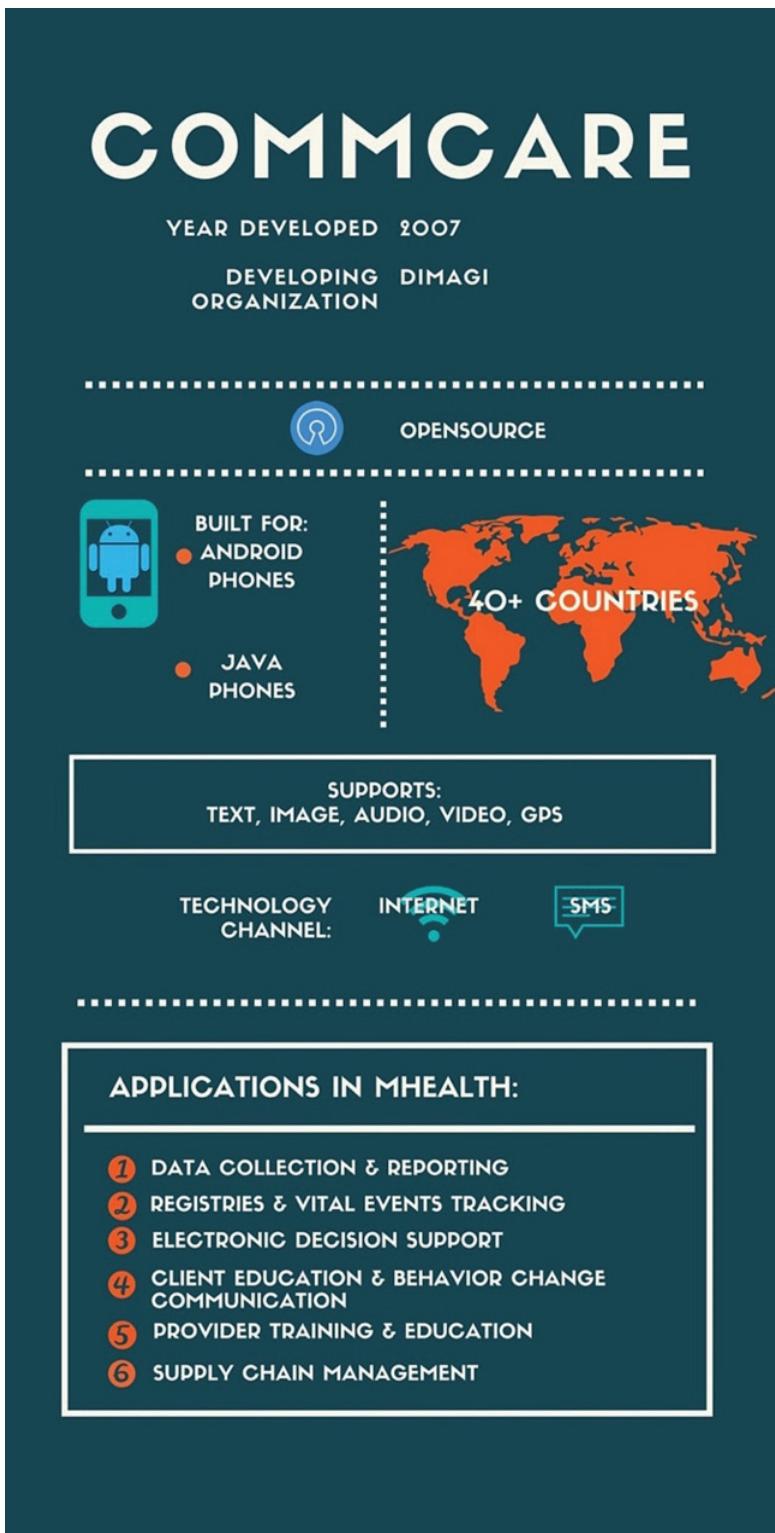
- “A major step forward would simply be the provision of Closed User Group (CUG) SIM plans by government to allow FLWS to speak to each other for free.” SC
- “Digital training would be the next step – i.e. how to use a feature phone for anything other than voice calls.” SC
- “Provision of feature phones by government would be the next step (smart phones are obviously more useful – but battery life is a major issue) + SIM with data pack.” SC

Expert Opinion: What can donors do to help?

- 1) Support (not financially – but strategically and logically) governments in not just the procurement of phones and SIM plans, but in figuring out how to support/repair/replace phones at scale on an ongoing basis. No one has really cracked this yet, and there seems to be little understanding of the economics of scaling and managing smart phone services.
- 2) Fund digital skills development among FLWs
- 3) Recognize that it's as important to figure out ongoing management, monitoring, supervision and support at scale as it is to fund software development – this isn't about funding parallel government – it's about figuring out strategies/methods/logistics and testing them, as much as testing software.
- 4) Fund localized content - and recognize that high quality content is as important as high quality software.
- 5) Stop funding so many competitive pilots and so much repetitive software.

Platforms Case study 1: CommCare (Part of MOTECH Suite)

CommCare is a mobile platform for case management allowing frontline health workers for tracking and managing care for their beneficiaries. It allows implementers to rapidly create and deploy mobile applications without the need for any background in programming or software development. CommCare has over 300 active programs in over 50 countries, and 9,000 active users.



CommCare has two components:

1. CommCare Mobile: This is the mobile application that is typically used by the frontline health worker for data entry using a mobile phone or tablet. It can run on Android as well as basic feature phones.
2. CommCare HQ: This is the web application that allows users, typically implementers or project managers, to create, edit and deploy applications without any programming. It allows users to create and manage frontline health workers (the users of CommCare Mobile) as well as for management of data, creation of reports and data analysis (CommCare, n.d.-b).

CommCare has been used for a number of mHealth application areas such as data collection and reporting, electronic decision support, supply chain management, client education and behavior change communication. One of the basic core functionalities of CommCare is in the ability to register and track clients for longitudinal care management. This allows FLWs to create a client record, manage visits and collect information at follow-up from the client.

Forms for data collection can be easily created on CommCareHQ with embedded logic for decision support. Decision support tools could be checklists, electronic protocols, algorithms for decision screening and supporting diagnostic tools (Chatfield et al., 2014). CommCare supports the inclusion of multimedia content - text, images, audio and video - and hence has been used for client counseling and education as well as for FLW training and learning. CommCare Mobile supports SMS and Internet as channels of communication for submitting data collected to a remote server. It can work in an internet disconnected environment, storing forms locally on the device and syncing in the presence of an internet connection.

Platforms Case study 1: CommCare

(continued)

CommCare is open source and is also offered in a Software-as-a-Service (SaaS) model. Users can create an account on CommCareHQ and use their cloud hosted application to create mobile tools for FLWs. Its SaaS model has five software plans priced based on number of users and features provided, the basic “community” plan is free. Projects using CommCare pay more for advanced features and for more number of users. The software plans are not customizable and cannot be adjusted. Dimagi provides additional implementation support at added cost. Projects using CommCare can use the free online tools on CommCareHQ, though large scale applications typically use additional support from Dimagi. Dimagi has developed a Total Cost of Ownership (TCO) model that allows projects to estimate the total cost of adoption of CommCare over a five year period (CommCare, n.d.-a).

CommCare mobile has an easy to use interface for FLWs allowing FLWs to swipe through screens and input data, show videos and photos, record findings, tag locations, capture photos, etc. The application can be developed in different languages. CommCareHQ allows implementers to develop applications through an easy-to-use user interface for application building and testing. It allows for easy customization of complex workflows, creation of multiple types of users and defining different roles for users in the system. The ability to create sophisticated, custom reports and dashboards is somewhat limited in CommCareHQ.

CommCare Supply (formerly known as CommTrack) is a specialized CommCare application developed for logistics and supply chain management. It supports FLWs for stock and inventory management. Some projects using CommCare Supply are the Informed Push Model in Senegal, the Early Warning System in Ghana and cStock in Malawi.

Project focus: Innovations at Scale for Community Access and Lasting Effects (inScale)

Year started: 2013

Country: Mozambique

Organization(s): Malaria Consortium, Dimagi, Inhambane provincial health directorate, Mozambique Ministry of Health, London School of Hygiene & Tropical Medicine, University College of London (Implementation partners); Bill & Melinda Gates Foundation (Funder).

Health domain: Maternal, newborn and child health

FLW Users: Agentes Polivalentes Elementares (APEs), who are locally trained community workers for health promotion and education.

No. of users: 132 APEs, 47 supervisors and 6 district co-ordinators.

Deployments: Six districts in Inhambane province in southern Mozambique. Currently being scaled up to the provincial level by the MOH, UNICEF and Malaria Consortium.

The inSCALE project uses a mobile application for APEs developed using CommCare to provide decision support to APEs. It allows them to assess, classify, treat and refer patients to health facilities using decision support tools such as,

- Symptoms checklist of mild and severe signs to provide treatment guidance
- Pneumonia detection using a built in respiratory timer

The application also allows APEs to collect case based information and also monitor drug stock levels at facilities. The data from APEs is aggregated on the CommCareHQ server which allows supervisors at the facility and district level to monitor health care workers, provide support, communicate over SMS, manage stock, create district level statistics and reports (Mendoza et al, 2014).

Platforms Case study 2: DHIS2

DHIS 2 (District Health Information System) is a comprehensive HIS solution for reporting and analysis of health data. It is a platform for mobile data collection, analysis and visualization of aggregate healthcare statistical data, primarily used for (but not limited to) management of health information at a regional or national level.

The infographic provides an overview of DHIS 2, developed in 2008 by the Health Information Systems Program (HISP). It is an open-source system built for Java phones and Android phones, currently in use in over 47 countries. The system supports text and GPS data entry. It uses the Internet or SMS as technology channels. Applications include data collection & reporting, registries & vital events tracking, human resource management, provider workplanning & scheduling, and client education & behavior change communication.

YEAR DEVELOPED 2008*

DEVELOPING ORGANIZATION HEALTH INFORMATION SYSTEMS PROGRAM (HISP)

BUILT FOR:

- JAVA PHONES
- ANDROID PHONES

OPEN SOURCE

47+ COUNTRIES

SUPPORTS:
TEXT, GPS

TECHNOLOGY CHANNEL:

- INTERNET
- SMS

APPLICATIONS IN MHEALTH:

- 1 DATA COLLECTION & REPORTING
- 2 REGISTRIES & VITAL EVENTS TRACKING
- 3 HUMAN RESOURCE MANAGEMENT**
- 4 PROVIDER WORKPLANNING & SCHEDULING**
- 5 CLIENT EDUCATION & BEHAVIOR CHANGE COMMUNICATION**

* EVOLVED FROM DHIS 1 DEVELOPED IN 1996
** THESE APPLICATIONS INVOLVED THE USE OF OTHER PLATFORMS THAT INTERFACED WITH DHIS 2

Currently in use in over 47 countries, DHIS 2 is being used as the national level health information system for 16 countries ("DHIS2 Deployments," n.d.) including Kenya, Tanzania, Uganda, Rwanda, Ghana, Liberia, and Bangladesh ("What is DHIS2?," n.d.).

DHIS Mobile is a mobile application supporting one-time data capture as well as case-based data capture and tracking. It has been developed for low-end Java phones and collect data even in an offline environment. Collected data is submitted to a cloud based DHIS 2 server over SMS and internet. In addition, it also has a web-browser based mobile client to support data collection using higher end smartphones.

The DHIS 2 web server is a cloud hosted server application with robust data management and data warehousing capabilities. DHIS 2's strongest feature is its ability to manage data at the aggregate level, use data analytics, create dashboards and generate reports using its easy-to-use web UI. This along with its high degree of scalability makes it a strong HIS for patient data management.

Key features of DHIS 2 include ("Key Features and purpose of DHIS 2," n.d.):

- Management of data using robust data warehousing principles
- Customization using a user interface, with no programming background required
- Tools to enable easy data entry through forms, lists and tables
- Case-based data collection to enable tracking of patients
- Data collection can occur in offline environment
- Tools for data validation to ensure data quality
- Easy visualization of aggregate data
- Ability to easily create sophisticated reports and summaries
- Modules for data analysis
- Dashboards of monitoring of important indicators for health surveillance
- Mobile based data collection solutions using SMS or web browser
- Extensibility through modular structure
- Integration with other software applications through the Web-API
- Highly scalable

Platforms Case study 2: DHIS2 (continued)

A review of projects using DHIS 2 from the USAID compendia all utilized DHIS 2 in combination with other platforms, where DHIS 2 served the purpose of a data warehouse. These projects include SMS for Life: Sightsavers in Cameroon (platforms used – Mango, DHIS 2) (Levine et al., 2015), mCARE in Bangladesh (platforms used – OpenSRP, OpenMRS, DHIS 2) (Mendoza et al., 2013) and mHero in Liberia (platforms used – RapidPro, iHRIS, DHIS 2) (Levine et al., 2015).

Project focus: DHIS2 in Kenya

Year started: 2011

Country: Kenya

Organization(s): Ministry of Health (MOH)

Health domain: N/A

Users: Health workers at district health level, data entry personnel, data managers.

No. of users: 9402 registered users as of September 2013 (Karuri et al. , 2014)

In September 2011, Kenya deployed a cloud based national HIS system becoming the first country in Sub-Saharan Africa to do so. Implementing a national level HIS system has been a part of Kenya's national health strategy to improve health quality, healthcare service delivery, and collect meaningful information at the health facility level for data-driven decision making. The adoption of DHIS2 as its national HIS was notably due to its functional abilities of health facility level data reporting, data analysis, reporting and dashboards and GIS mapping (Manya et al., 2012).

The customized DHIS 2 software was initially tested in three districts: Machakos, Nyamira and Kisumu East and then piloted on a larger scale in the Coast province (Manya et al., 2012). The proper development of ICT infrastructure, setting up a central national level server, collecting stakeholder feedback and ensuring stakeholder buy-in through meetings, proper training to users followed by supervision and support contributed to the overall success of the pilot. National level roll-out required a significant focus on training and assessment of readiness. Data import from other software systems being used by the MOH such as iHRIS was performed using WHO's Statistical Data and Metadata Exchange for Health Domain (SDMX-HD) (Manya et al., 2012) ensuring interoperability between systems.

As of September 2013, the system had 9402 registered users and 2262 active users (users who had logged on to the system in the last 30 days) (Karuri et al., 2014). In order to meet the need for offline data entry due to fluctuation of internet connectivity, DHIS 2 used the offline capabilities of HTML 5 to save the data locally on the web browser and upload when the data connection was established. The system recorded 1,254,993 data points for deriving 688 indicators in the 30-day period from Aug-Sep 2013 (Karuri et al., 2014). User feedback was positive and the most popular tools reported were the standards reports and data visualizer (Manya et al., 2012). The adoption of DHIS 2 has significantly contributed to achieving Kenya's Vision 2030 and improving health information reporting.

Platforms Case study 2: DHIS2

(continued)

Project focus: mHero

Year started: 2014

Country: Liberia

Organization(s): IntraHealth International, UNICEF, Jembu Health Systems, Thoughtworks, HISP, mPowering Frontline Health workers (Implementation Partners); UNICEF, USAID, Johnson & Johnson (Donors)

Users: Community Health Workers

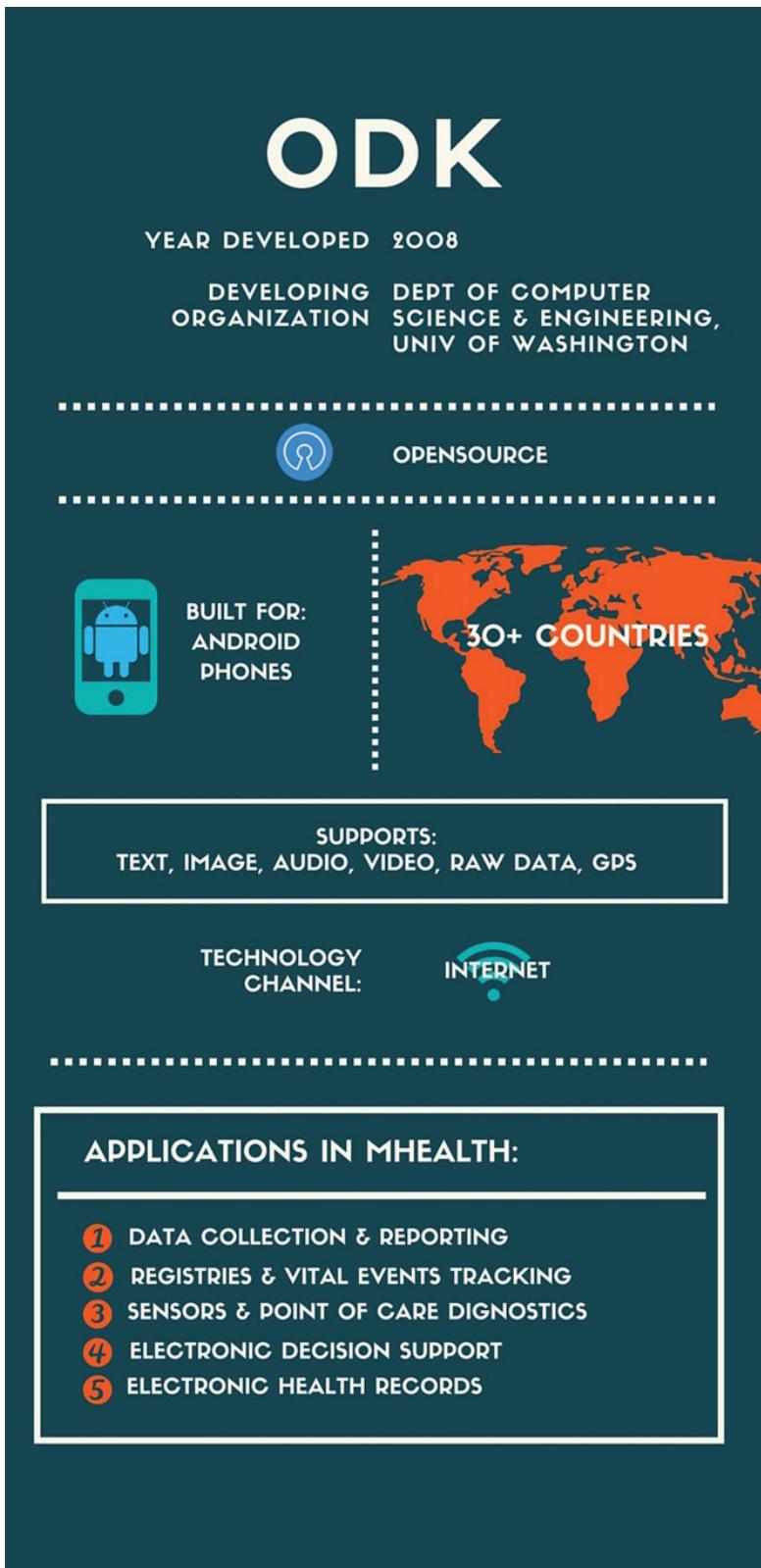
No. of users: 500 – 1000 CHWs, 30 Other users

mHero (Health worker Electronic Response and Outreach) connects and empowers frontline health workers by enabling communication between health workers, supervisors, government officials and other stakeholders using SMS messaging for communication. The project originated among the Ebola outbreak in West Africa to address the need to rapidly disseminate actionable information to health workers and empower them with two-way communication tools (“The mHero Story: Adapting mobile technology to support health systems strengthening amid the Ebola Outbreak,” n.d.). It allows for data collection of key health indicators, manage the workforce and its continued professional development. Currently in pilot scale in Liberia, it is scheduled to scale up to the national level in Liberia with plans to expand to Guinea where it will be used to support health workers in maternal and child health.

mHero was built on top of existing platforms being used by the Ministry of Health and Social Welfare in Liberia - iHRIS and DHIS 2 and UNICEF’s RapidPro platform. Information about health workers and facilities in iHRIS and DHIS 2 is drawn and used to locate and connect healthcare workers. For this project, DHIS 2 and iHRIS acts as information systems for data management of data about health care workers and facilities. RapidPro is UNICEF’s interactive messaging system, which was already in use at the time of the Ebola outbreak. RapidPro serves as the messaging platform to disseminate information to groups of health workers and enable two-way communication between groups. This project leverages the interoperability of iHRIS and DHIS2 with RapidPro using the OpenHIE architecture (Levine et al., 2015).

Platforms Case study 3: Open Data Kit (ODK)

ODK is an open source platform for building mobile data collection solutions. It allows users to build applications to enable easy collection of data, author forms and view aggregate data. An extensive survey of the ODK user and developer community conducted revealed up to 55 deployments of ODK in over 30 countries (Brunette et al., 2013); the actual number of active deployments of the ODK platform in mHealth may be different.



- ODK consists of tools for authoring forms, deploying applications for data collection based on these forms on Android devices and server-side tools for aggregating and viewing the collected data.
- ODK Build (drag and drop tool for building forms) and XLSForm (allows for creation of more complex forms by creation in Excel): Tools for creating forms based on the XForms standard
- ODK Collect: It is a smart phone client for data collection that renders forms and content and can be deployed on an Android phone.
- ODK Aggregate: An easy to deploy server application implemented on Google's App Engine to which data is submitted by ODK Collect and is used to view the collected data. It can be hosted on the cloud, a virtual machine or private server. It has basic tools for data visualization and extraction such as spreadsheets, queries and maps (Anokwa et al., 2009). Data can be exported to other formats such as csv, kml or json (Hartung et al., 2010).

ODK is supported by a large developer community, uses open standards and is open source [2]. ODK has an easy to use interface to author forms, though it can be harder to create forms with more complex logic. The Android application has a simple user interface allowing the user swipe through screens to collect data points. In addition, the specialized applications of ODK greatly enhance the functionality, usability and flexibility of the ODK platform.

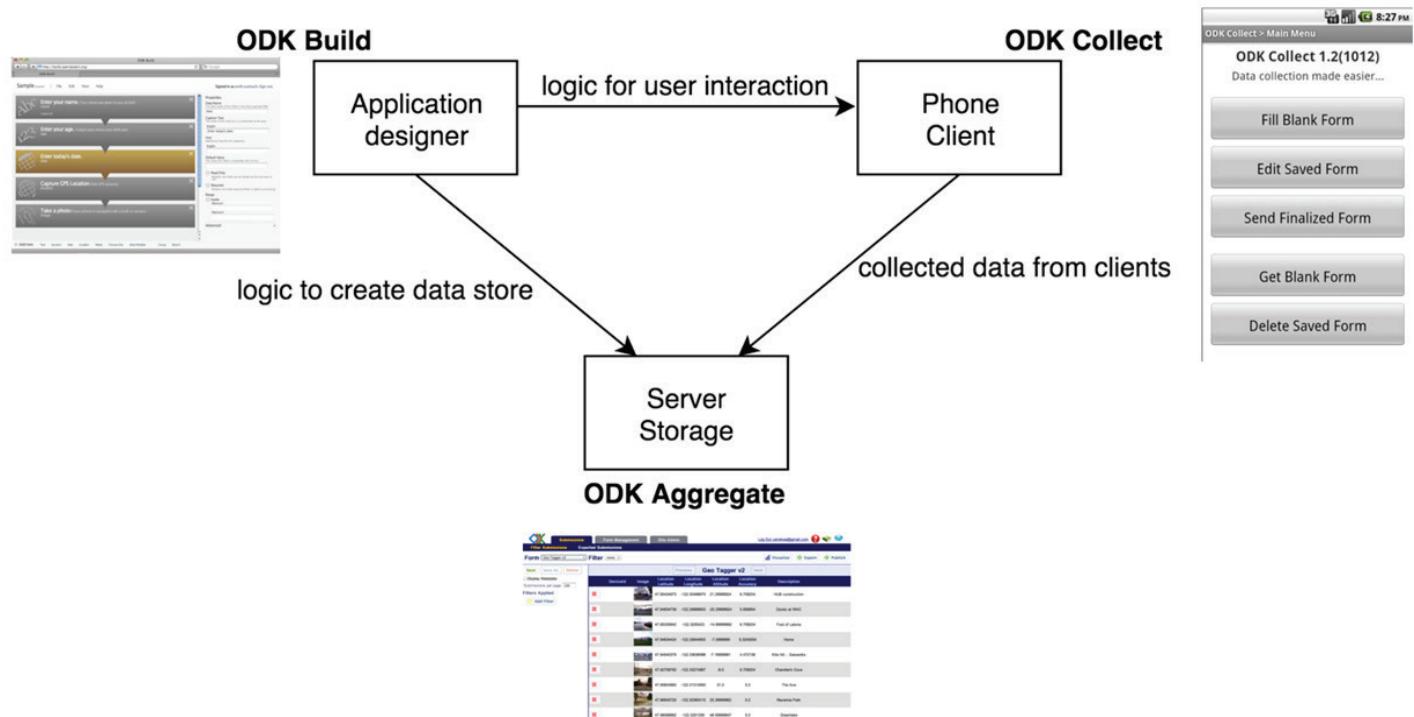
- Sensors: connects external sensors to devices (Brunette et al., 2013)
 - Scan: translate paper form to digital data (Brunette et al., 2013)
- Other specialized applications include Briefcase (transfer data from Collect and Aggregate), Clinic (Access/update medical records), Tables (update/curate previously collected data) (Brunette et al., 2013) and Diagnostics (reads rapid diagnostic tests) (Dell et al., 2013). ODK is free to download and use, however, configuring and customizing ODK will vary based on implementation and requires additional expenditure for developer time. Other cost components would include server hosting, cost of internet connection, data, etc (Datadyne, n.d.)

Platforms Case study 3: Open Data Kit (ODK)

(continued)

Figure 1: Structure of the ODK platform with its various components and how they interact with each other.

Modified from Fig.1. Hartung C, Lerer A, Anokwa Y, Tseng C, Brunette W, Borriello G. Open data kit: tools to build information services for developing regions. InProceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development 2010 Dec 13 (p. 18). ACM.



Basic features:

- Easily create and author forms based on the XForms standard
- Easily digitize data collected using paper forms using ODK Scan
- Can easily and rapidly create an end-to-end data collection system
- Set up server using Google App Engine
- Data collected on devices is stored locally
- Data collection can occur in an offline environment; forms can be sent to the server once an internet connection is established
- Multiple languages are supported
- Active developer community and technical support available
- Can be easily customized

Platforms Case study 3: Open Data Kit (ODK)

(continued)

Project focus: Hang Up and Track

Year started: 2014

Country: Democratic Republic of Congo

Organization(s): IMA World Health (implementation partner), Against Malaria Foundation, UKAID (donors)

Health domain: Malaria prevention

Users: Community Health Worker (CHWs), Supervisors

No. of users: 1000+ CHWs, 22 Supervisors

Deployments: Eight health zones in western Kasai-Occidental province: Kitangwa, Mutena, Kamonia, Kamuesha, Banga Lubaka, Kanzala, Tshikapa and Kalonda. Expanding to Nord Ubangi province in 2016.

To increase malaria prevention in the Democratic Republic of Congo, IMA World Health implemented a mass long-lasting insecticidal net (LLIN) distribution campaign in which CHWs installed and hung up the nets in the household instead of simply distributing them to beneficiaries. In order to ensure accountability, accuracy and collect pertinent information related to the disease, the CHWs also registered the household, took a picture of the installed bed net, geo-tagged the location and collected socioeconomic data and data regarding malaria perception and malaria treatment using the ODK Collect application installed on their phones. This ensured full transparency and accountability through the use of the GPS data and images. It also allowed for easy visualization of the distribution activity visually through GIS using ODK Aggregate. Using the Hang Up and Track (HUT) strategy it was observed that coverage of households in the eight distribution areas was 93-99% (Levine et al., 2015). Recently, HUT has added an educational video for behavior change communication to the ODK survey that demonstrates how to hang up and take care of a net that is available in two local tribal languages.

Project focus: MP3Youth

Year started: 2014

Country: Kenya

Organization(s): New York University, University of Nairobi, Impact Research and Development Organization (implementation partners); National Institute of Health/National Institute of Allergy and Infectious Diseases (Donor)

Health domain: HIV

Users: Field study staff

No. of users: 11-50 study staff, 600 Patients/clients

This is a pilot study assessing the impact of gender-specific packages for HIV prevention in high-burden settings. Patients are enrolled using tablets with ODK Collect using biometric identifiers which also simply patient tracking and follow up. A fingerprint scanner captures biometric data which is sent to ODK Collect. Behavioral data is also collected. Participants follow up occurs through the use of USSD and SMS to document behaviors and adherence to the selected intervention (Levine et al., 2015).

Appendix A: Descriptions of platforms most frequently reported as being used to support FHW programs

No.	Technology Platform	Description
1	Case.io	Software for secure exchange of medical information with colleagues through transfer of files or images
3	CommCare	Platform for quick development of mobile apps for longitudinal case management with minimal coding requirements.
4	CommCare Supply	Platform for supply chain management, customized version of CommCare, formerly known as CommTrack
5	DataWinners	Survey tool for digitizing paper forms for rapid data collection and visualization of data
6	DHIS2	Web based health data management information system to collect, manage, visualize and explore data with mobile client for data reporting. Commonly used at the national level for data reporting.
7	eMocha	A mobile health platform for data capture, training and education and communication
8	Enketo	Opensource, Saas, tool for creating web forms. Enketo Smart paper
9	FreeSwitch	Opensource communications software for creation of voice and messaging products
10	Frontline SMS	Mobile messaging platform to send and receive data over SMS
11	GuideView	A platform for creating and delivering healthcare content, such as clinical guidelines and advice, with multimedia that requires no programming.
12	iFormBuilder	A platform for mobile data collection
13	iHRIS	Opensource platform for managing health workforce
14	MagPi	A platform for mobile data collection
15	Mango mobile Application Platform (Greenmash)	Platform for mobile data collection, remote surveillance, monitoring and evaluation
16	Mangologic	System for creating and deploying certain kinds of mobile apps, without programming. It is suited to the development of apps that need to run complex logic such as for clinical decision support.
17	MDConsults	Customizable platform for teleconsultations
18	MedicMobile	A platform for mobile data collection
19	Mezzanine Helium	Platform for developing mHealth solutions that has been used for case management, stock management, managing patient records and data and decision support to name a few.
20	Mobenzi - Outreach	Built on top of Mobenzi research, it is a case management platform for CHWs

Appendix A: Descriptions of platforms most frequently reported as being used to support FHW programs

No.	Technology Platform	Description
21	Mobenzi - Research	Platform for field research and data collection
22	Moodle	Opensource software for online learning allowing teachers to create and deliver online courses and also manage them
23	MOTECH	Suite of services focusing on behaviour change and increasing demand, managing patient data, improving worker performance, last-mile supply chain, patient adherence
24	mSupply	COTS solution for pharmaceutical management, tracking inventory, stock and distribution
25	ODK	Opensource platform to create and manage mobile data collection solutions
26	ONA	SaaS platform for data collection and reporting
27	OpenEMR	Opensource EHR platform - not a mobile platform
28	OpenLMIS	Open source platform for logistics and supply chain management
29	OpenMRS	Opensource electronic health record system
30	Open SRP	Opensource platform that replaces paper registers with mobile registers allowing for patient tracking, appointment scheduling and management of health workers.
31	OpenXData	Opensource platform for mobile data collection
32	OppiaMobile	Opensource platform for delivering mobile learning content
33	Poimapper	Platform for mobile data collection and data management
34	RapidPro	Build interactive messaging systems using an easy visual interface, evolved from RapidSMS
35	txtAlert	Mobile messaging platform for sending bulk messages, broadcasts
36	Verboice	Platform for creating IVR applications
37	Voto	Platform for developing messaging and IVR based surveys
38	Vumi	Opensource mobile messaging platform
*	mPESA	Mobile phone based money transfer, financing and microfinancing service for Vodafone

Appendix B: Key costs and cost drivers of mHealth programs

Adapted from Planning an Information Systems Project- A Toolkit for Public Health Managers
http://www.path.org/publications/files/TS_opt_ict_toolkit.pdf

Cost Category: Development (Initial Cost)

Software Development

Main Costs

- Initial Software development (if new)
- Environment Configuration (all environments)
- Customization
- Interface development
- Software licensing

Cost Drivers

- "Number of user requirements"
- "Licensing each environment (production, test, training)"
- "Licensing costs per user"
- Number of interfaces and complexity
- Level of customization

Cost Category: Deployment (Initial Cost)

Hardware & Software

Main Costs

- Computers, printers, scanners
- Phones/ mobile devices- New or old?
- Servers
- Testing
- Technical Support
- System Security and Operating Capacity

Cost Drivers

- # phones, printers, scanners, computers
- Cost and availability of power and connectivity, for setup
- Physical environment modifications to house hardware
- Existing technical infrastructure
- Accessibility of hardware
- Number of users
- Level of security needed
- Availability of PHI

Cost Category: Ongoing/Operations

Data & Communications

Main Costs

- Voice, data, and SMS services

Cost Drivers

- Internet Connectivity
- Mobile SMS and Data plans
- Data/Minutes/SMS usage
- Telecommunications partnerships

Appendix B: Key costs and cost drivers of mHealth programs (continued)

Cost Category: Ongoing/Operations	Hardware Maintenance & Replacement	
	Main Costs <ul style="list-style-type: none"> • Equipment upgrades • Equipment maintenance • Lost/stolen/damaged hardware 	Cost Drivers <ul style="list-style-type: none"> • # Devices/Computers • Maintenance and Replacement Rate/Cost
	Server/Software/Hosting Management & Maintenance	
	Main Costs <ul style="list-style-type: none"> • Software updates and upgrades • Server management • Hosting • System security maintenance/updates 	Cost Drivers <ul style="list-style-type: none"> • Hosting (server or cloud) • Data center setup • Existing hardware and software infrastructure • Service levels • Software and Hardware maintenance fees • Internal vs. External Support
System Administration and Customer Support		
Main Costs <ul style="list-style-type: none"> • Day to day operations including system configuration/modification • Administrator training • Customer support 	Cost Drivers <ul style="list-style-type: none"> • Expected call volume • Hours of operation • Additional support staff needed for scale (National and subnational level) • Equipment replacement/ new installations rate • Staff turnover 	
Cost Category: Management and Human Resources		
Main Costs <ul style="list-style-type: none"> • Trainers • Implementers • Technical support • Content Specialists • Management • Other 	Cost Drivers <ul style="list-style-type: none"> • # Staff • Salaries • Travel • "Mix of local and international technical assistance" • Mix of onsite and remote work • Staff turnover 	

Appendix B: Key costs and cost drivers of mHealth programs (continued)

Cost Category: Training

Main Costs

- Develop training
- Deliver training - Initial, New User, Software Updates
- Refresher training
- Per diems for attendees
- Transportation for attendees
- Facility costs

Cost Drivers

- # Users
- Days of training
- Days refresher training
- Training delivery method
In person, digital, hybrid

Cost Category: Governance

Main Costs

- Oversight
- Policy Development
- Trips
- Meetings

Cost Drivers

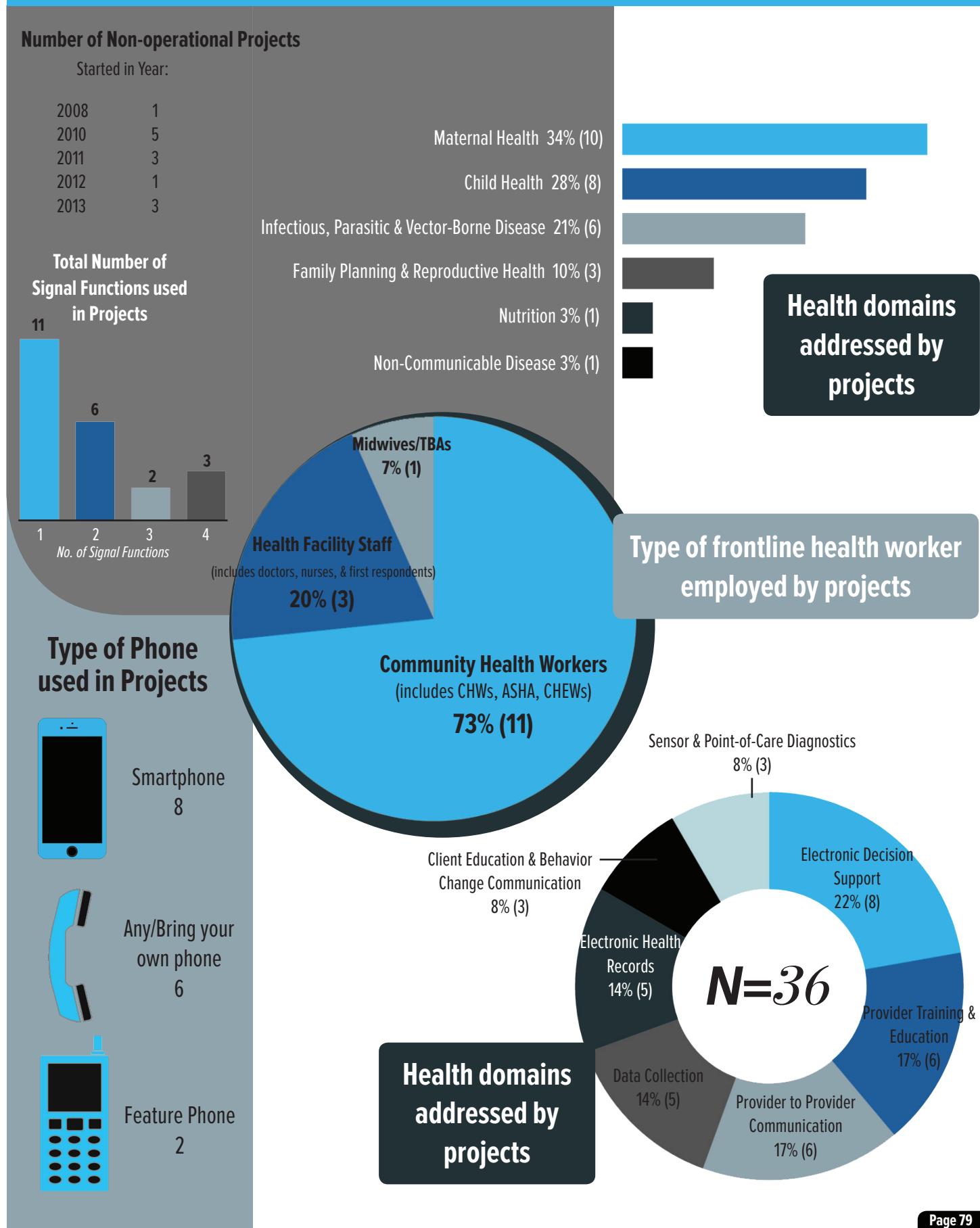
- # Trips
- # Meetings
- Policy requirements

Appendix C: Summary of key costs considered by costing studies

Cost	Lemay et al.	Lester et al	Chang et al.	Zurovac et al	Threimer et al	Mahmuda	Njuguna	Asiimwe	Hunchangsith	Diedhioua
Initial Costs										
Software		n/a		X			x	x		X
Training Development								x		X
Training			x					x		X
Hardware (Servers, Computers, Modems)				x	X		x	x		
Equipment (Phones, Tablets, Chargers, Batteries)	x	x	x	X	x	x	x	x	x	X
Human Resources (Engineers, Implementation, Content Specialists, Trainers, Technical Support)				x	X			x	x	
Ongoing Costs										
Phone Service Fees (SMS, Contracts, Sim Cards, Data, Phone Number)	x	x	x	X	n/a	x	x	X	n/a	x
Hosting				n/a				x		
Customer Support*					?			x		x
Backup System*								x		
Technical Support					?			x		
System and Software Maintenance				n/a				x		
Program oversight					x				x	
Refresher Training*										
Monitoring tools*					x					
Account for damage/ theft (Equipment, Hardware, Insurance)							x			

* - Necessary for scale if there is a software component

Appendix D: Inactive USAID Compendia projects overview



Appendix E: Expert survey questions

1. Do you consent to your data being used and reported anonymously as part of this research process?
2. In what role do you primarily work with ICT-based health interventions ?
 - a. Software Programmer
 - b. Project Implementer
 - c. Researcher
 - d. Policymaker / Government
 - e. Other _____
3. What countries is your organization currently using mobile phones to support frontline health workers?
4. How have ICTs been used to support FHWs in your programs
 - a. Client Education and behavior change communication
 - b. Sensor and point-of-care diagnostics
 - c. Registries and Vital events tracking
 - d. Electronic health records
 - e. Electronic decision support
 - f. Provider to provider communication
 - g. Provider workplanning and scheduling
 - h. Provider training and education
 - i. Human resource management
 - j. Supply chain management
 - k. Financial transaction and incentives
 - l. Other
5. In your programs, do FHWs use their own devices or are these devices provided to them by the project
 1. FHW use their own device
 2. Device is provided to them
6. Approximately what is the size of your project, in terms of numbers of FHW directly interacting with the system?
7. Name up to three technical platforms that you/your organization have used to support the activities of frontline healthcare workers. (E.g. Commcare, Mangologic, OpenSRP, etc...)
8. What were the THREE key considerations in your selection of this platform? (E.g. open source, SMS functionality etc.)
9. If you/your organization has used ICTs to support CHW/FHW activities, which type of device did you use?
 - a. Simple phone (e.g. SMS and call functions only)
 - b. Feature Phone (e.g. can run simple java apps, etc.)
 - c. Smart Phone (Android/iOS/Symbian)
 - d. Tablet (Screen larger than 7")
 - e. Laptop (Connected to a network)
10. What were THREE of the main considerations in the selection of this (these) devices? (E.g. screen size, connectivity, battery life, cost, local availability etc.)
11. Name THREE global health programs employing ICTs for CHWs/FHWs that have reached maturity, in your opinion. These do not need to be programs run by your organization, but can include any programs using ICTs that you have heard about and feel are important 'leaders' in this space.
12. Are you willing to be contacted for further information? If yes, please share your contact email address.

References

- Agarwal, S., Perry, H. B., Long, L.-A., & Labrique, A. B. (2015). Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: systematic review. *Tropical Medicine & International Health*, 20(8), 1003–1014. <http://doi.org/10.1111/tmi.12525>
- Anokwa, Y., Hartung, C., & Brunette, W. (2009). Open Source Data Collection in the Developing World. *Computer*, 42(10), 97–99. <http://doi.org/10.1109/MC.2009.328>
- Asiimwe C, Gelvin D, Lee E, Ben Amor Y, Quinto E, Katureebe C, et al. Use of an innovative, affordable, and open-source short message service-based tool to monitor malaria in remote areas of Uganda. *Am J Trop Med Hyg* [Internet]. 2011;85(1):26–33. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3122339/>&tool=pmc&rendertype=abstract
- Baker, B. K., Benton, D., Friedman, E., & Russell, A. (2007). Systems support for task shifting to community health workers, 1–5.
- Braun, R., Catalani, C., Wimbush, J., & Israelski, D. (2013). Community Health Workers and Mobile Technology: A Systematic Review of the Literature. *PLoS ONE*, 8(6), e65772. <http://doi.org/10.1371/journal.pone.0065772>
- Brunette, W., Sundt, M., & Dell, N. (2013). Open data kit 2.0: expanding and refining information services for developing regions. *Proceedings of the 14th ...* <http://doi.org/10.1145/2444776.2444790>
- Callaghan, M., Ford, N., & Schneider, H. (2010). A systematic review of task- shifting for HIV treatment and care in Africa. *Human Resources for Health*, 8, 8. <http://doi.org/10.1186/1478-4491-8-8>
- Chatfield, A., Javetski, G., Fletcher, A., & Lesh, N. (2014). CommCare Evidence Base.
- Chang LW, Kagaayi J, Nakigozi G, Serwada D, Quinn TC, Gray RH, et al. Cost analyses of peer health worker and mHealth support interventions for improving AIDS care in Rakai, Uganda. *AIDS Care* [Internet]. 2013;25(5):652–6. <http://www.tandfonline.com/doi/abs/10.1080/09540121.2012.722600>
- CommCare. (2014a). Budgeting for a project - CommCare Total Cost of Ownership (TCO) Model. Retrieved January 12, 2016, from <https://confluence.dimagi.com/display/commcarepublic/Budgeting+for+a+Project>
- CommCare. (2014b). CommCare Fundamentals.
- Dalberg Global Development Advisors. Preparing the next generation of community health workers : The power of technology for training. 2012;(May).
- Datadyne. (n.d.). Mobile Phone Based Data Collection Systems Comparison Table. Retrieved January 12, 2016, from <https://docs.google.com/spreadsheets/d/1HB8bESHOTpYd09q-SHnh3OKEID5M9TyZ4IXUF-ZjdJw/edit?hl=en-US#gid=0>
- Dell, N., & Borriello, G. (2013). Mobile tools for point-of-care diagnostics in the developing world. In *Proceedings of the 3rd ACM Symposium on Computing for Development - ACM DEV '13* (p. 1). New York, New York, USA: ACM Press. Retrieved from <http://dl.acm.org/citation.cfm?id=2442882.2442894>
- DeRenzi, B., Sims, C., Jackson, J., Borriello, G., & Lesh, N. (2011). A Framework for Case-Based Community Health Information Systems. *2011 IEEE Global Humanitarian Technology Conference*, 8, 377–382. <http://doi.org/10.1109/GHTC.2011.59>
- DHIS2. (n.d.). DHIS2 Deployments. Retrieved January 12, 2016, from <https://www.dhis2.org/deployments>
- DHIS2 Documentation Team. (2016a). Key Features and purpose of DHIS 2. Retrieved January 12, 2016, from <http://dhis2.github.io/dhis2-docs/master/en/user/html/cho1so2.html>

References

- DHIS2 Documentation Team. (2016b). What is DHIS2? Retrieved January 12, 2016, from <http://dhis2.github.io/dhis2-docs/master/en/user/html/ch01.html>
- Diedhiou A, Gilroy K, Cox CM, Duncan L, Koumingue D, Pacque-Margolis S, et al. Successful mLearning Pilot in Senegal: Delivering Family. *Glob Heal Sci Pract.* 2015;3(2):305–21.
- Dussault, G., & Franceschini, M. C. (2006). Not enough there, too many here: understanding geographical imbalances in the distribution of the health workforce. *Human Resources for Health*, 4(1), 12.<http://doi.org/10.1186/1478-4491-4-12>
- Every Mother Counts. (n.d.). The Healthcare Worker Shortage. Retrieved January 1, 2015, from http://issuu.com/everymothercounts/docs/the-hr-shortage-study-guide_0
- Free, C., Phillips, G., Watson, L., Galli, L., Felix, L., Edwards, P., ... Haines, a. (2013). The Effectiveness of Mobile-Health Technologies to Improve Health Care Service Delivery Processes: A Systematic Review and Meta-Analysis. *PLoS Medicine*, 10(1), e1001363. <http://doi.org/10.1371/journal.pmed.1001363>
- Frontline Health Workers Coalition. (n.d.). Who They Are. Retrieved January 1, 2015, from <http://www.frontlinehealthworkers.org/frontline-health-workers/who-they-are/>
- GSMA. (2013). The Mobile Economy India 2013.
- Grevendonk, J., & Brigden, D. (2013). Planning an information systems project.
- Hartung, C., Anokwa, Y., Brunette, W., Lerer, A., Tseng, C., & Borriello, G. (2010). Open Data Kit: Tools to Build Information Services for Developing Regions. Proceedings of the International Conference on Information and Communication Technologies and Development, 1–11.<http://doi.org/10.1145/2369220.2369236>
- Hunchangsit P, Barendregt JJ, Vos T, Bertram M. Cost-Effectiveness of Various Tuberculosis Control Strategies in Thailand. *Value Heal [Internet]*. Elsevier Inc.; 2012;15(1):S50–5. <http://linkinghub.elsevier.com/retrieve/pii/S1098301511035431>
- IntraHealth International. (2015). The mHero Story: Adapting mobile technology to support health systems strengthening amid the Ebola Outbreak. Retrieved January 20, 2016, from <http://usaidlearninglab.org/lab-notes/mhero-story-adapting-mobile-technology-support-health-systems-strengthening-amid-ebola>
- Inventory, A., & Review, A. (2014). mHealth Support Tools for Improving the Performance of Frontline Health Workers; (March).
- Karuri, J., Waiganjo, P., Orwa, D., & Manya, A. (2014). DHIS2: The Tool to Improve Health Data Demand and Use in Kenya. *Journal of Health Informatics in Developing Countries*, 8(1), 38–60. Retrieved from <http://www.jhidc.org/index.php/jhidc/article/view/113>
- Källander, K., Tibenderana, J. K., Akpogheneta, O. J., Strachan, D. L., Hill, Z., ten Asbroek, A. H. A., ... Meek, S. R. (2013). Mobile Health (mHealth) Approaches and Lessons for Increased Performance and Retention of Community Health Workers in Low- and Middle-Income Countries: A Review. *Journal of Medical Internet Research*, 15(1), e17. <http://doi.org/10.2196/jmir.2130>
- Kho, A., Henderson, L. E., Dressler, D. D., & Kripalani, S. (2006). Use of handheld computers in medical education. *Journal of General Internal Medicine*, 21(5), 531–537. <http://doi.org/10.1111/j.1525-1497.2006.00444.x>
- Krishna, S., Austin Boren, S., & Balas, E. A. (2009). Healthcare via Cell Phones : Telemedicine and E-Health, 15(3), 231–240. <http://doi.org/10.1089/tmj.2008.0099>

References

- Labrique, A. B., Vasudevan, L., Kochi, E., Fabricant, R., & Mehl, G. (2013). mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. *Global Health, Science and Practice*, 1(2), 160–71. <http://doi.org/10.9745/GHSP-D-13-00031>
- Lehman, U., & Sanders, D. (2007). Community Health Workers: What do we know about them?
- Lehmann, U., Dieleman, M., & Martineau, T. (2008). Staffing remote rural areas in middle- and low-income countries: a literature review of attraction and retention. *BMC Health Services Research*, 8(1), 19. <http://doi.org/10.1186/1472-6963-8-19>
- Lemay NV, Sullivan T, Jumbe B, Perry CP. Reaching Remote Health Workers in Malawi: Baseline Assessment of a Pilot mHealth Intervention. *J Health Commun.* 2012;17(sup1):105–17.
- Lester RT, Ritvo P, Mills EJ, Kariri A, Karanja S, Chung MH, et al. Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WelTel Kenya1): a randomised trial. *Lancet* [Internet]. Elsevier Ltd; 2010;376(9755):1838–45. <http://www.ncbi.nlm.nih.gov/pubmed/21071074>
- Levine, R., Corbacio, A., Konopka, S., Saya, U., Gilmartin, C., Paradis, J., & Haas, S. (2015). mHealth Compendium, Volume Five (Vol. 5).
- Mahmud N, Rodriguez J, Nesbit J. A text message - Based intervention to bridge the healthcare communication gap in the rural developing world. *Technol Heal Care.* 2010;18(2):137–44.
- Manya, A., Braa, J., Overland, L., Titlestad, O., Mumo, J., & Nzioka, C. (2012). National Roll Out of District Health Information Software (DHIS 2) in Kenya, 2011–Central Server and Cloud Based Infrastructure. *IST-Africa 2012* ..., 1–9. Retrieved from [http://www.researchgate.net/publication/230559375_National_Roll_out_of_District_Health_Information_Software_\(DHIS_2\)_in_Kenya_2011__Central_Server_and_Cloud_based_Infrastructure/file/9fcfd501777a933fe0.pdf](http://www.researchgate.net/publication/230559375_National_Roll_out_of_District_Health_Information_Software_(DHIS_2)_in_Kenya_2011__Central_Server_and_Cloud_based_Infrastructure/file/9fcfd501777a933fe0.pdf)
- Mendoza, G., Levine, R., Kibuka, T., & Okoko, L. (2014). mHealth Compendium, Volume Four.
- Mendoza, G., Okoko, G., Morgan, G., & Konopka, S. (2013). mHealth Compendium, Volume Two (Vol. 2). mHealth Evidence Taxonomy. (2013).
- Moore C, Long L-A, Keith K. mHealth Solutions- What's the Cost? Washington, DC; 2014.
- Njuguna HN, Caselton DL, Arunga GO, Emukule GO, Kinyanjui DK, Kalani RM, et al. A comparison of smartphones to paper-based questionnaires for routine influenza sentinel surveillance, Kenya, 2011–2012. *BMC Med Inform Decis Mak* [Internet]. 2014;14(1):107. <http://www.biomedcentral.com/1472-6947/14/107>
- One Million Community Health Workers: Technical Taskforce Report. (n.d.).
- OpenMRS. (2011). OpenMRS guide.
- Palmer, S., & Torgerson, D. J. (1999). Economic notes: definitions of efficiency. *BMJ (Clinical Research Ed.)*, 318(7191), 1136. doi:10.1136/bmj.318.7191.1136
- Perry, H., & Zulliger, R. (2012). How effective are community health workers?, 1–84.
- Principles for digital development. (2008). doi:10.1598/RRQ.40.2.6 Qiang, C. Z., Yamamichi, M., Hausman, V., & Altman, D. (2011). Worldbank report: Mobile Applications for the Health Sector, (December), 101

References

- Rednick, C., Dini, H., & Long, L.-A. (2014). The Current State of CHW Training Programs in Sub-Saharan Africa and South Asia : What We Know , What We Don ' t Know , and What We Need to Do. One Million Community Health Workers Campaign, (January).
- Schweitzer, J., & Synowiec, C. (2012). The Economics of eHealth and mHealth. *Journal of Health Communication*, 17(sup1), 73–81. doi:10.1080/10810730.2011.649158
- Shieshia, M., Noel, M., Andersson, S., Felling, B., Alva, S., Agarwal, S., ... Chandani, Y. (2014). Strengthening community health supply chain performance through an integrated approach: Using mHealth technology and multilevel teams in Malawi. *Journal of Global Health*, 4(2), 020406. doi:10.7189/jogh.04.020406
- Surka, S., Edirippulige, S., Steyn, K., Gaziano, T., Puoane, T., & Levitt, N. (2014). Evaluating the use of mobile phone technology to enhance cardiovascular disease screening by community health workers. *International Journal of Medical Informatics*, 83(9), 648–654. doi:10.1016/j.isjm.2006.10.010.
- Thriemer, K., Ley, B., Ame, S. M., Puri, M. K., Hashim, R., Chang, N., ... Ali, M. (2012). Replacing paper data collection forms with electronic data entry in the field: findings from a study of community-acquired bloodstream infections in Pemba, Zanzibar. *BMC Research Notes*, 5(1), 113. doi:10.1186/1756-0500-5-113
- UNICEF. (2006). Addressing the health worker shortage : A critical action for, 2006.
- University Research, & Quality Assurance Project Organization(s). (2009). Evaluation of an IMCI computer-based training course in Kenya | USAID ASSIST Project, (August). Retrieved from <https://www.usaidassist.org/resources/evaluation-imci-computer-based-training-course-kenya>
- Who. (2007). Task shifting to tackle health worker shortages. Geneva: WHO, (June 2006), 1–12. [http://doi.org/10.1016/S0033-3506\(01\)00422-X](http://doi.org/10.1016/S0033-3506(01)00422-X)
- WHO. (2008). Treat, Train, Retain: Task Shifting Global Recomendations and Guidelines. World Health Organization, 96. <http://doi.org/10.1080/17441692.2011.552067>
- WHO. (2013). WHO Global health workforce shortage to reach 12.9 million in coming decades. World Health Organization. (2010). Increasing access to health workers in remote and rural areas through improved retention: Global policy recommendations, (February), 2 – 4.
- Zurovac D, Larson BA, Sudoi RK, Snow RW. Costs and Cost-Effectiveness of a Mobile Phone Text-Message Reminder Programmes to Improve Health Workers' Adherence to Malaria Guidelines in Kenya. *PLoS One* [Internet]. 2012;7(12):e52045. Available from:<http://dx.plos.org/10.1371/journal.pone.0052045>