

# Mobile Technology for Monitoring and Evaluation and Health Information Systems in Low- to Middle-Income Countries



Cover photograph, by Stephanie Watson-Grant of MEASURE Evaluation, shows participants taking part in an mHealth training session in Jamaica.

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## INTRODUCTION

In many developing country settings, limited resources constrain the development and expansion of certain technology infrastructures — such as high-speed Internet — that could facilitate more efficient data collection and reporting in the health sector, as well as communication of important health information through other electronic means (Aranda-Jan, Mohutsiwa-Dibe, & Loukanova, 2014).

Mobile technologies, however, may offer an affordable alternative to (or alongside) other electronic health<sup>1</sup> (eHealth) applications in many low-resource settings. The use of mobile technology for health<sup>2</sup> (mHealth) is becoming more widespread in developing countries. This is due, in part, to the fact that global mobile phone consumption is high, with nearly 7 billion cell phone subscriptions and an estimated 96% mobile penetration in the world in 2014 (ITU, 2014). This level of mobile penetration in low-income countries suggests that mobile phone functions and applications can be a promising tool within broader efforts to strengthen infrastructures that enhance the performance of health systems. Monitoring and evaluation (M&E) systems and health information systems (HIS) are such systems that could benefit from mHealth tools.

### *Monitoring and Evaluation Systems*

A functional M&E system should be able to capture data that will help to determine the progress and status of a particular health issue or health program (Peersman & Rugg, 2010). At the programmatic level, organizations need M&E data to know whether their health programs are working and to better prioritize program areas or district-level services. At the country level, M&E data is critical to ministries of health to keep track of epidemics, as well as to document progress on health indicators and health systems performance.

Historically, M&E systems in the health sector relied on data that were collected via paper forms. Raw data collected on paper were usually aggregated by hand or calculator, and then reported onward through the various reporting levels on additional paper forms. Both public and

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<sup>1</sup> Broadly defined, eHealth refers to “the transfer of health resources and health care by electronic means” (WHO, 2014).

<sup>2</sup> The use of mobile technology to improve health, or mHealth, is defined as “medical and public health practice supported by mobile devices” (mHealth Alliance, 2013). Mobile devices can include mobile phones, personal digital assistants (PDAs), tablets or other wireless devices.

private sectors institutions in the developed world now commonly use electronic databases for much of their M&E needs, which automatically aggregate and analyze data, populate reports, and send the reports to responsible parties. However, much of the developing world still heavily relies on paper-based data collection and reporting of health information, an approach with inherent problems related to timeliness and quality. Paper-based data collection and reporting for national health information systems (HIS), including national M&E systems, are complicated because poor infrastructure prevents timely and accurate data flow. The Nigerian Ministry of Health, for example, reported that there are data quality issues with the ministry's paper-based system and that it struggles to produce data for even the "simplest indicators" (Ministry of Health of Nigeria, 2008).

The use of mHealth technology in low-income countries is rapidly expanding, and ranges from the use of text messages reminding patients to adhere to a strict medication protocol to applications on mobile phones for efficient data collection at the facility level. These innovations are, collectively, contributing to important improvements in health service delivery and practice, yet have not yet been adopted systematically in efforts to improve M&E or HIS; in our review of the mHealth literature, we found few studies on the use of mHealth specifically for M&E or HIS. Nevertheless, the rapid expansion of mHealth technology in the health sector and the increased interest in use of electronic medical records (EMR) suggest that mobile data collection and reporting could be used to improve the quality of data collected in M&E components of national health systems.

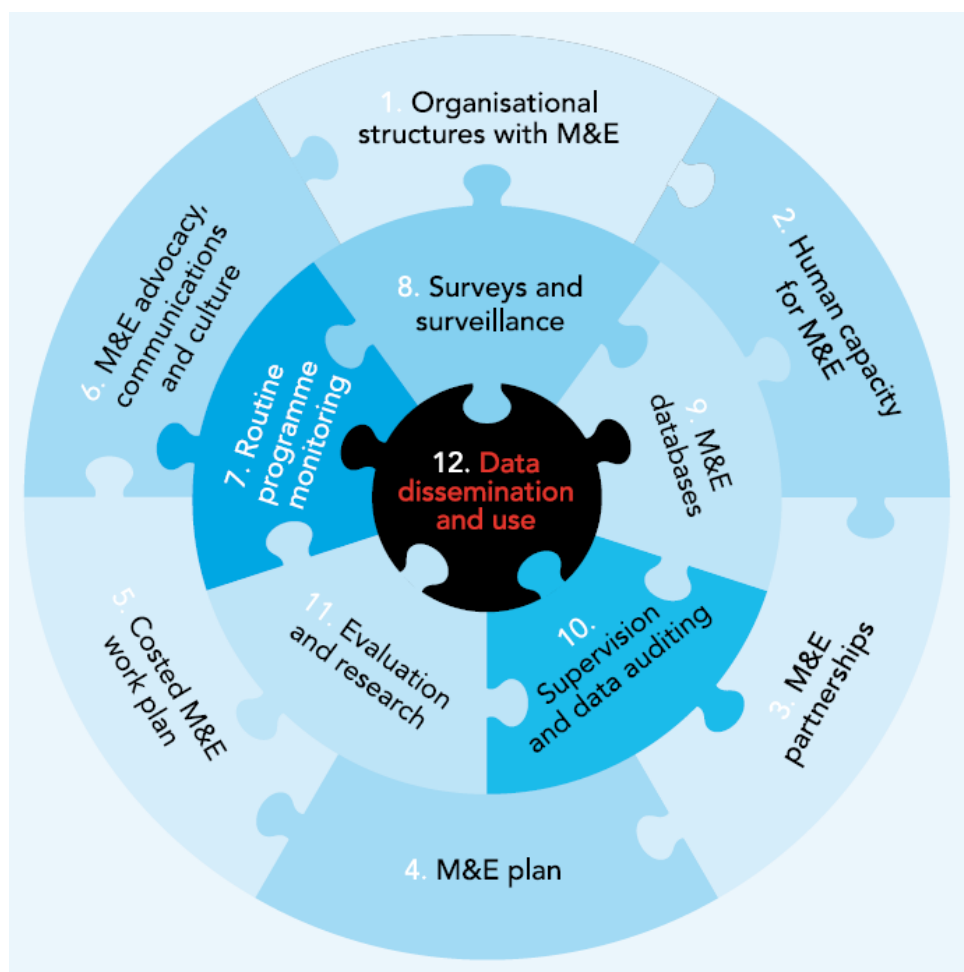
In this paper, we describe the current primary uses of mHealth in the developing world and discuss how these approaches can be applied to improve national M&E systems. We also discuss some common mHealth themes found in the literature and the lessons learned from mHealth activities undertaken by the MEASURE Evaluation project, which is funded by the U.S. Agency for International Development (USAID). Lastly, we suggest guidelines on the use of mobile technology for M&E purposes.

We intend the evidence synthesized in this analysis to guide public health researchers, ministries of health, international donors, and other health stakeholders at the country level working to

integrate or adopt mobile technologies when developing or to improve national HIV M&E systems.

### *Twelve Components of a Functional HIV M&E System*

The Joint United Nation’s Programme on AIDS/HIV (UNAIDS)’s framework for a functional HIV M&E system, commonly referred to as “the 12 Components,” is widely used by the international community to develop, assess, and improve national HIV M&E systems (UNAIDS, 2009). The 12 components framework provides an important starting point to guide decision makers attempting to incorporate mHealth into national M&E systems (see Figure 1).



**Figure 1. The 12 components of a functional national HIV M&E system (adapted from UNAIDS, 2009).**

The first six components (the outer ring in figure 1) make up the organizational structures that are needed to facilitate the technical elements of an M&E system. These components are commonly called the “people, partnerships and planning” or the “PPP” elements. The middle ring includes the technical elements, (also known as the “collecting, verifying and analyzing Data” ring) which are components seven through 11. Component 12 is placed at the center of the diagram to emphasize that all M&E systems should provide quality data for dissemination and use.

## **METHODS**

### *Literature Review*

We conducted a review of the existing literature on use of or integration of mobile technology in healthcare, and focused on mHealth in developing countries. We defined our research parameters to prioritize the mHealth literature that would be most useful in the context of mHealth for M&E purposes. Our search parameters included the following key words and relationships in the PubMed database:

- mHealth
- mHealth and monitoring and evaluation (or M&E)
- mHealth and health information systems

We also searched these terms in Google Scholar to capture any grey literature that might have been missed by PubMed. Websites of organizations that were known to promote mHealth were also scanned for additional grey literature. These included the websites of the National Institutes of Health (NIH), Catholic Relief Services (CRS), UNAIDS, the World Health Organization (WHO), and the Knowledge for Health project’s mHealth Working Group.

We looked at all literature in the past 30 years; but with exception of three, all of the articles had been published within the last four years.

The titles of the articles generated in the searches were skimmed for relevance. Those articles that did not have a title relating to mHealth were discarded. Titles that indicated a narrow use of mHealth that would not be relevant or useful to M&E were also discarded. Abstracts of the

remaining articles were read to ensure relevance. Our criteria for exclusion of publications captured in the review of the remaining abstracts included the following:

- The article briefly mentioned mHealth, but the content was not valuable or applicable to any M&E context.
- The mHealth study would not be relevant in developing countries.
- The article was about eHealth, not mHealth.
- The article addressed technology providers and programmers and was not useful for the purposes of applied research.
- The mobile technology discussed required high-tech hardware technology that would be difficult to afford or maintain in a low-income country context (e.g., a mobile glucometer and Bluetooth adapter to automatically transfer readings of glucose levels).
- The article discussed mHealth in a narrow context or setting (e.g., the Haiti earthquake disaster) rather than a national-level system.

Each publication that remained after the abstract selection was read carefully, and relevant findings were recorded in a Microsoft Excel database. Thematic uses of mHealth were identified qualitatively from the relevant findings. Table 1 is a summary of literature review process.

**Table 1. Results of Literature Review Process**

Source	Number of Articles at Initial Search	Number Remaining after Screening Titles	Number Remaining after Screening Abstracts
PubMed search	230	92	33
Grey literature	62	50	31
<b>Total</b>	<b>292</b>	<b>142</b>	<b>64</b>

Of the 64 relevant articles, there were seven randomized controlled trials (RCTs), although five of the RCT studies had small sample sizes. There were 10 program or process evaluations and 10 cross-sectional studies. The majority of the studies were qualitative in nature. The studies that were quantitative did not go far beyond descriptive statistics. The majority of the articles (30) were opinion or position papers; or review articles that suggested mHealth guidelines, identified gaps, or summarized mHealth results based on the authors' own literature reviews.

Because the implementation of mHealth technology specifically for M&E systems in the developing world is relatively new, it was difficult to find literature that was directly related to the use of mHealth for M&E. In our review, we therefore identified and listed themes and different uses of mHealth technology in developing countries that contributed evidence, lessons learned, or suggested guidelines that might be helpful to groups incorporating mHealth into M&E systems.

## **RESULTS**

Our analysis identified four themes that were mentioned in the majority of articles that met our inclusion criteria for review: use of text messages; mobile data collection; cost analysis; and supportive environments for mHealth.

### *Use of Text Messages*

The majority of mHealth activities in developing countries involved text messaging or short message services (SMS)-based functions. Text messages were often used to disseminate HIV prevention messages at reasonable cost (Chib et al., 2012; Cornelius et al., 2012; Coomes et al., 2012; Juzang et al., 2011; Lemay et al., 2012; Mitchell et al., 2011; and Person et al., 2011), promote adherence to HIV/sexually transmitted infections (STI) or malaria treatments (Horvath et al., 2012; Kunutsor et al., 2010; Lester et al., 2010; Shet et al., 2010; Sidney et al., 2012; Tran and Houston, 2012; and Zurovac et al., 2011), or disseminate family planning and maternal and child health information (Evans et al., 2012 and Parker et al., 2012). These uses of text messages were all intended to “push out” information to participants, with little or no opportunity to collect behavioral or health information from the participants. Text messages were also used by community health workers to bridge the communication gap between patients and healthcare professionals (Mahmud et al., 2010).

Most of the studies that examined use of text messages/SMS were pilot-phase studies and independently reported positive outcomes. For example, Chang and colleagues (Chang et al., 2011) reported that the SMS-based mHealth intervention used by community health workers in Uganda improved overall patient care. Another study in Uganda showed that adherence to clinic visits improved after an mHealth intervention (Kunutsor et al., 2010). A randomized trial in

Kenya found that HIV patients who received weekly adherence reminders via text messages self-reported better adherence and viral suppression than those who did not (Lester et al., 2010). In western Kenya, a text messaging mobile technology platform was used to register children under 5 years of age and follow their nutritional status by keeping track of their mid-upper arm circumference (Wariero et al., 2010). The study reported that the text messaging strategy was able to reach about 95% of the intended target population. Finally, the use of text messages to report flu symptoms in Madagascar indicated that public health professionals can detect the spread of the influenza virus in developing countries (Rajatonirina et al., 2012).

Despite the successful implementation and positive results from these SMS-based pilot studies, there was little evidence that these pilots were replicated or brought to scale. Such lack of scalability has been widely acknowledged; two papers encouraged researchers to prioritize sustainability and scalability in mHealth interventions (Nilsen et al., 2012 and Sherry & Ratzan, 2012).

We found it difficult to compare these text-based mHealth interventions to determine relevant best practices because study designs and interventions varied. The number of text messages sent throughout the study period, the timing of the messages, supplementary care such as counseling, objectives of the messages, and target populations all varied across the different mHealth interventions. This made it difficult to apply a general evaluation methodology to determine best practices. Most studies also indicated that it was relatively easy to introduce the new technology into existing health structures and work flows or that the users were able to learn and use the technology quickly (Wariero et al., 2010; Kunutsor et al., 2010; Cohn & Xiong, 2012). Text-messaging interventions were generally well accepted by local users and will likely continue to be a popular communication tool for public health professionals.

### *Mobile Data Collection*

Some earlier examples of mobile data collection used voice call functions to call and interview respondents for information (Bradley et al., 2012 and Chang et al., 2011). In one intervention, voice calls were used to monitor the daily sexual activities of female sex workers and the study reported a high participation rate (Bradley et al., 2012), indicating that voice calls were an acceptable form of data collection for studies that involve sensitive topics or vulnerable

populations. In Malawi, community health workers were provided phones so they could communicate information to health facilities (Lemay, Sullivant, Jumbe & Perry, 2012). The study found that those community health workers equipped with a mobile phones called to report important health data to facility-based supervisors within approximately nine minutes, as opposed to non-equipped community health workers who averaged 24 hours to report the information; the community health workers without cell phones had to use public transportation to visit the facility and report the information in person.

Other examples of early innovative data collection methods include the use of personal digital assistants (PDAs). Mosoriot Rural Health Center in Kosirai Division of Kenya piloted the use of PDAs to monitor HIV-positive patients in between clinic visits (Wools-Kaloustian et al., 2009). The study revealed that the PDA technology intervention was well accepted by the clinic and was a feasible strategy to address the lack of healthcare professionals. Most importantly, this study reported that the community health workers (CHWs) were able to gather information that clinicians were not, such as insight into patients' psychological issues and obstacles to treatment adherence. However, the study did not reveal if the health information collected by the PDA and CHWs during home visits was used at the clinic visits or how this collection of information might have helped to inform clinical decisions. In an M&E context, real-time use of data collected at the community level would be essential.

There are other studies that used PDAs for mobile data collection but most of them were conducted in the developed world. For example, Oliver and colleagues (Oliver et al., 2013) published results from a study conducted in 2008 and 2009 on the use PDAs to record daily dietary and physical activity of obese adolescents in Spain. The authors reported that the PDAs compiled more complete data than paper-based registers. This study provided early evidence that mobile data collection could improve the quality of data being collected for M&E efforts.

Despite the high acceptability and feasibility of PDAs as a research tool in the low- to middle-income countries (Curioso & Kurth, 2007), smart phones quickly infiltrated the mobile market and replaced PDAs.

We found that the most common use of mobile phones in international public health was to disseminate health messages, often through text messages or SMS. However, evidence suggests that the mHealth environment is now starting to focus on using SMS functions to collect health data as well. For example, Pact, a U.S.-based humanitarian organization that works in developing countries, recently published *Mobile Technology Handbook* (Bruce et al., 2014) to help guide implementing partners incorporating mobile technology into their development work. The handbook lists basic phones, feature phones, smart phones, and tablets as possible mobile data collection devices. According to the USAID-funded Knowledge for Health (K4H) project at Johns Hopkins Bloomberg School of Public Health, there are hundreds of mHealth projects worldwide that are currently utilizing mobile phones or tables in different mobile data collection methods (the project's descriptions are available at [www.mhealthevidence.org](http://www.mhealthevidence.org)). Importantly, the lack of literature providing evidence for effective mobile data collection methods suggests that studies of these applications are still in progress. Nevertheless, the common applications that are used on mobile phones and tablets to collect survey-type data include OpenData Kit, Magpi, EpiCollect, and CommCare Mobile.

### *Cost Analysis*

There is general agreement that mHealth can be a cost-saving method to collect health data and widely disseminate health information to increase health knowledge and promote healthy behaviors. However, very few studies we reviewed included a cost analysis or a financial evaluation of any kind to confirm this assumption. In fact, a retrospective analysis of telemedicine projects noticed this gap, and concluded that cost analysis of future mobile technology interventions for health must be prioritized for better decision making (Kahn, Yang & Kahn, 2010). Later studies and meta-analyses have affirmed the importance of cost analysis of mhealth interventions (Aranda-Jan et al., 2014; Eysenbach, 2011; Mbuagbaw, 2011; Mechael et al., 2012; Schweitzer and Synowiec, 2012; Zolfo et al., 2010). Still, few studies on mHealth have incorporated an extensive cost analysis, likely because most of the studies have not moved beyond the pilot phase.

## *Supportive Environments for mHealth*

A supportive environment for mHealth technology is important for the successful implementation of mHealth interventions. Understanding a supportive mHealth environment is especially important when considering the sustainability and scalability of mHealth interventions. External factors that make up the mHealth environment can include the following: mHealth policies (Michael et al., 2010), opportunities for private-public partnerships (Michael et al., 2012), local capacity (Bruce et al., 2014), technology infrastructure (Aranda-Jan et al., 2014), local mobile market penetration (Bruce et al., 2014), gender roles (Rounseville, 2012), and current health systems and management structures (Aranda-Jan et al., 2014).

The majority of mHealth interventions have not been brought to scale (Tomlinson et al., 2013), partially because the uptake of mHealth strategies is not well understood. This is an important area of mHealth that currently lacks evidence. Tomlinson and colleagues (Tomlinson et al., 2013) argued that there is a lack of “foundation that would permit evidence-based scale-up.” Like Tomlinson, our review also demonstrated a lack of evidence that could be used to identify elements of a supportive mHealth environment; we found no studies that provided evidence on this topic. However, several opinion and policy papers urged researchers to study the external factors (aside from the mHealth technology itself) that impact an mHealth intervention. Akter and Ray (2010) were early voices that expressed the need for more research around factors that contribute to enabling policies and an operational environment for mHealth. The mHealth Alliance, a nonprofit organization that focuses on advancing mHealth technology in global health care, also published a policy paper in 2010 stating that the “limited knowledge of what works and how it works” in the context of limited “policies, strategies and guidelines” greatly prevented the scale-up of mHealth projects (Michael et al., 2010).

While there is no evidence to support the benefits of an open-source architecture of mHealth application, mHealth implementers and researchers agree that there is a need for open-source platforms. Estrin and Sim (2011) have advocated for an open-source environment so that data and mobile applications can be easily available and shared to reduce costs. Ministries of health that have developed (or are developing) a health information technology division are prioritizing open-source solutions.

## LESSONS LEARNED

As previously noted, the majority of M&E systems in low-income countries are still using paper-based data collection and reporting systems that are prone to data quality problems related to accuracy, completeness, and timeliness. Ministries of health often express the need to move from a paper-based M&E system to an electronic M&E system, but lack the resources to effect this transition. Expansion of computer networks and high-speed internet infrastructure have proved prohibitively costly or inaccessible.

There are indications that mHealth is currently being used for M&E purposes, even though our literature review did not reveal much evidence on the use of mHealth for M&E. However, there are several small studies that MEASURE Evaluation has implemented or evaluated mHealth activities in Jamaica, Mali (de la Torre & Unfried, 2014) and Mozambique (do Nascimento & de Jesus Joao, 2013). In Jamaica, a mobile data collection and reporting system was implemented to determine whether mHealth technology can improve the quality of HIV M&E data that is collected in the community and reported up to the national HIV M&E unit. Formative research was conducted in Mozambique to help guide an anticipated mHealth intervention in Nhamatanda. In Mali, the use of an SMS-based mobile technology, aimed at improving the timeliness, completeness and use of data for the routine reporting of malaria data was developed and evaluated.

The surge of mobile phone penetration in low-income countries has allowed a unique opportunity to introduce an electronic data capture and reporting M&E system. For example, mobile technology was used in other MEASURE Evaluation activities as a data collection method for specific studies; the mHealth element was not a priority area of interest for these activities, but rather, used for efficiency and/or convenience. For example, Android tablets were used to collect data for a Priorities for Local AIDS Control Efforts (PLACE) study in the Dominican Republic. The use of the tablets provided an opportunity to collect sensitive information about sexual risk behaviors and to use global positioning system (GPS) tools to map venues where people meet sex partners within real-time. In Liberia, tablets were used with the Lot Quality Assurance Sampling (LQAS) methodology for monitoring health outcome of maternal and child health programs.

We believe the transition from a paper-based M&E system to an electronic system should be carefully guided, using relevant evidence from literature. The following are some lessons learned from the mHealth activities at MEASURE Evaluation, which we believe can be useful for future uses of mHealth for M&E/HIS.

***There is low proficiency with smart phones, despite high mobile penetration in developing countries.***

The literature we reviewed suggests that high mobile penetration in developing countries is reason enough to adopt mobile platforms that would require a relatively high proficiency with mobile phones. However, we found that high mobile phone penetration did not mean that there was high proficiency with using more complicated mobile phones. In Jamaica, where community workers were trained to use an application on a smart phone to collect and report HIV M&E data, the community workers self-reported low proficiency with complicated mobile applications. Despite the self-reported low proficiency with smart phones, the community workers were able to quickly learn and use the mHealth technology. The self-reported low proficiency was not a barrier to the mHealth intervention. However, they felt that it this wrong assumption was noteworthy, indicating that more sensitivity to low proficiency with smart phones was needed.

In Mali, where a more simplified SMS-based technology was applied than in Jamaica, the staff reported that mobile data entry was easy. The formative research in Mozambique concluded that while 85% of the community workers interviewed used phones on a daily basis, voice calls were still the most common uses of mobile phones and text messages were the second most used function of a phone.

Similarly, the PLACE study in the Dominican Republic found that while all the data collectors were comfortable with mobile phones, many of them were not familiar with using tablets. Data collectors (typically 30 years of age or older) had a difficult time learning how to use the devices and were resistant to using them. Eventually all data collectors became comfortable with the tablets and were able to use the tablets accurately for data collection. Required practice with the devices during training was an important factor that contributed to increased levels of comfort. The training was very hands-on, to encourage maximum use of the tablets.

***Protocols for the supervision and management of data collection need to be adjusted when introducing mobile technology.***

Both studies in Jamaica and Mali found that existing supervision structures were not sufficient to ensure accurate uploads of data by the data collectors. This also contributed to untimely upload of data in Jamaica. In Jamaica, the paper-based system required community workers to fill out data collection forms after an intervention. Because the forms were submitted at the end of the month; there was no accountability for when the forms were actually completed, as long as they were submitted by the end of the month. An added value to the mHealth platform was that data were available in real time, requiring the community workers to upload M&E data immediately after the intervention. A new supervision strategy was developed to encourage the community workers to upload on a daily basis, which contributed to data accuracy and the real time availability of the data. Adequate supervision was also found to be one of the limitations of the SMS reporting system in Mali. The study concluded that supervision would need to be improved, specifically to encourage better data quality and use of the data that is collected with the mobile phones.

This element of human supervision and management was not mentioned in any of the literature. From the MEASURE Evaluation activities, we conclude that while the mHealth technology is a great tool to capture M&E data efficiently, the human inputs are still essential to ensure data accuracy and meaningful uses of the data that is reported through the system. This finding strengthens UNAIDS's emphasis on organizational structures with M&E functions, human capacity for M&E and M&E advocacy, communications, and culture.

***Cost of implementing and maintaining mHealth platforms for M&E/RHIS will continue to be a challenge.***

The startup costs for the mHealth platform in two regions in Jamaica was approximately \$23,000. This included mobile network services for one year. While \$23,000 may not seem expensive when compared to the startup costs of other technology-based applications, these new costs are often beyond the means of health ministries with limited budgets. These startup costs do not include the time and effort for the planning and development process of the mHealth platform by researchers, testing of the mHealth platform, or the resources required for training staff to use the mobile technology, refresher trainings, and training new staff when there is

turnover. There are also recurring costs. Units get damaged, lost, or stolen; or need upgrading. Indicators are added or dropped from M&E systems and their definitions change, or new reporting units need to be added. These changes to the M&E system would require programming adjustments to the automated system. Technology glitches invariably arise, and information technology (IT) support is needed to resolve these concerns. In Mali, airtime was a recurring cost that needed to be considered; and newly-formed health facilities needed to be added and programmed into the reporting system.

On the contrary, the Liberia and Dominican Republic experiences with incorporating mobile data collection methods solely for data collection found that incorporating mobile technology was relatively inexpensive and easy. OpenData Kit, Magpi and other mobile data collection applications are easy platforms to learn and data collection forms can be programmed into those applications without extensive effort. The Jamaican experience involved more complicated integration of the mHealth platform into the existing M&E system, which required additional programming to merge the collected data into reports that the Jamaica Ministry of Health could use, which can dramatically increase the cost.

***Open source platforms can be more expensive than proprietary platforms.***

Open source mHealth platforms were given priority during the development phase of the mHealth technology for the Jamaica intervention. Many free open source platforms were capable of fulfilling the data collection requirements, but it would be expensive to hire programmers to develop customized reports that would automatically aggregate the uploaded data in real time into a format that is ideal to a health ministry. Many open source options were explored; a proprietary platform ended up being the cheapest option. We suspect that most national HIV M&E systems will require some level of automatic aggregation and programmed reports, which significantly increases the initial cost of developing a mobile application for a national M&E system. Often, this high cost would be enough to prohibit the use of mobile technology for data collection and reporting.

***Private-public partnerships are important for a sustainable mHealth platform, but are difficult to establish.***

There were few examples where country governments or national mHealth initiatives were able to secure a strong private-public partnership with network providers for mHealth activities. The project in Mali was not able to secure such a partnership. The project in Jamaica was only able to secure a minor discount for the phones and data services.

One major gap in the mHealth intervention in Jamaica was poor network coverage and insufficient support from the network provider. Generally, network coverage was not as available as researchers believed and mobile phones did not operate optimally. More importantly, support from the network provider did not address the issues that were encountered in the field. Discussions with the network provider after the study revealed that the phone and network issues could have been resolved if network provider representatives would have taken additional steps to identify the source of the issues (e.g., potentially weak antennae on the mobile phones or locating geographic spots with weak coverage). If a stronger partnership with the network provider had existed during the study, network providers would have been more responsive to the phone and network issues that were encountered in the field. This will be even more important as Jamaica considers mHealth activities in the future at a national scale.

Unreliable connectivity was also an issue for the mHealth intervention in Mali, although it did not list connectivity as a major impediment. Despite it not being a major obstacle to the system in Mali, it is clear that a strong partnership with a network provider will be important for a scalable solution at the national level.

## **GOING FORWARD — MHEALTH FOR M&E**

Based on our literature review, and analysis of lessons learned from MEASURE Evaluation activities, we suggest the following guidelines for incorporating mHealth into national M&E systems. These guidelines encourage a systems approach and are based on UNAIDS's 12 components of a functional system (figure 1). The guidelines are organized into two groups, in accordance with the outer and middle rings of the 12 components.

Suggested guidelines for incorporating mHealth into an M&E system involving people, partnerships, and planning (components 1-6) are the following:

- **Develop an internal mHealth policy that addresses data security issues and user agreements.** Internal mHealth policies are important to ensure that all users have a common understanding of individual responsibilities to ensure the safety and quality of the mobile technology and the M&E information that it captures. Data security policies should include instructions to password-protect mobile devices, restrict the users from sharing the mobile units with friends and family members, and provide a plan of action for lost or stolen phones. If possible, applications that can remotely delete all data from the phones should be installed, in the event that a phone is lost or stolen and contains sensitive information.
- **Establish healthy internal collaborations and private-public partnerships with mHealth application developers and network providers.** National M&E systems are complex and require the collaboration of many internal departments and other external partnerships to be functional. The human, systemic, and financial resources that are required are extensive. The process to acquire mutually beneficial private-public partnerships is not well documented. Only a few initiatives have successfully accomplished successful private-public partnerships, including the Mobile Alliance for Maternal Action (MAMA). Despite it not being well documented, mHealth implementers advocate for private-public partnerships for sustainable mHealth solutions. Partnerships are often difficult because private companies and health ministries may have conflicting objectives. Nevertheless, health ministries should initiate conversations with network providers. Many private companies may be willing to consider free or reduced-price services to help address overall social gains.
- **Build local mHealth capacity, with specific attention to technical mHealth skills and management/supervision processes that are needed for a technology-based data collection and reporting.** Recent studies show that text-messaging features and other data collection features are well accepted by personnel in the health sector. There is also general agreement that mHealth users are able to quickly learn and utilize new data collection technology. Despite the ease of use of mobile technologies, health ministries should develop local “experts” to handle complicated technology-related issues that are

encountered by users. Local capacity to maintain software and hardware should also be considered. This might include programming, application development, and data management needs. In addition, technical capacity, management, and supervision processes for a technology-based system need to be well thought out and individuals properly trained to manage teams that will effectively and properly use the technology. For example, field data collectors with supervisory roles might need to be trained on basic technical support. Supervisors also need to be trained to identify individuals that are struggling with the technology and provide resources to assist as needed. All are essential for timely and accurate data collection and reporting.

- **Develop a strong communication system between data collectors and supervisors.** It is important to establish open communication between data collectors and supervisors and between the different levels of the reporting system (i.e., regional level to national level). Previous studies have shown that text messages were highly accepted by healthcare workers as a communication tool for work purposes. Based on the literature, it would also be relatively easy to introduce text messages as a formal communication tool. Text messages can be used to send mass reminders to data collectors to ensure timely uploads of monitoring data. Equally important, open communication between supervisors and data collectors encourages accurate and timely uploads or reporting of data.
- **Budget mHealth costs into national M&E budgets, including data costs, software upgrades or development costs, and maintenance costs.** There are few cost analyses of mHealth interventions. However, it is still possible for program managers to obtain price lists and anticipate costs, based on local rates of voice/texts/data packages. The cost of mobile units and the maintenance of the hardware should also be considered and included in the budget. Some mHealth applications for data collection require monthly or annual subscriptions, although it is advisable to use open-source solutions.

Suggested guidelines for incorporating mHealth into an M&E system collecting, verifying, and analyzing data (components 7-11) are the following:

- **Standardize all data collection forms and aggregation steps by using mHealth platforms to collect and report M&E data.** Data errors occur during data collection and reporting

because individuals misinterpret the definitions of specific indicators, or misunderstand the instructions to aggregate data. Time schedules should also be standardized.

- **Establish a supervision strategy to ensure that data is being entered accurately and uploaded in a timely manner.** Supervisors should be able to access the electronic database and be trained to identify when data is discrepant, late, or missing. The supervision strategy should instruct a supervisor on how to follow up with late and/or discrepant data.
- **Program feedback mechanisms into the mHealth technology to ensure data collectors receive timely and constructive feedback.** With text messages, it is possible to communicate feedback to data collectors at a low cost. Automated reports can also be generated and emailed or texted through the mobile phones. For example, a monthly report that summarizes the uploaded data can be generated and sent back to the data collector, so he or she can confirm whether targets are being met and know how to adjust the following month's work schedule if needed. Feedback loops can also facilitate data use at the sub-national levels.

## CONCLUSION

The use of mHealth tools and the transition from paper to electronic M&E systems is marching onward. We believe the guidelines proposed in this paper will help governments to incorporate mobile technology into their M&E systems more effectively. These guidelines, derived from an extensive literature review and lessons learned from mHealth activities at MEASURE Evaluation and guided by UNAIDS's 12 components of a functioning M&E system, encourage strategic actions at the organizational and technical levels. At the organizational level, our guidelines encourage governments to develop mHealth policies, pursue private-public partnerships, build local mHealth capacity, develop strong communication systems between data collectors and supervisors and include mHealth costs into the national M&E budget. At the technical level, our guidelines encourage the standardization of data collection forms and aggregations steps using mHealth tools, a supervision strategy that ensures accurate and timely data uploads of data collected by mHealth tools and the programming of feedback mechanisms into the mHealth technology.

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## ADDITIONAL RESOURCES

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