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MOBILE HEALTH AND ITS ROLE IN ADDRESSING MATERNAL HEALTH IN SUB-SAHARAN AFRICA

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ABSTRACT

Background: In the last 10-15 years, mobile health (mHealth) interventions have generated considerable interest as tools for sustainable development in the global health sector as well as to improve access to care for remotely isolated populations in Sub-Saharan Africa. This paper explores existing literature on mHealth for clinical data collection for maternal health, discusses some of its benefits and challenges, and addresses mHealth's limitations, such as 1) inadequate monitoring and evaluation framework; (2) inability for project scalability; and (3) lack of partnerships that are unsustainable and inclusive of all stakeholders. Although the healthcare sector acknowledges the potential benefits of mHealth, there should be further efforts to address these limitations.

Methods: Initially, literature reviews were conducted to gain general knowledge about mHealth in Sub-Saharan Africa. After the literature review, 4 interviews with global health professionals working in global health consulting organizations in Boston were interviewed to gain further insight from those directly involved in mHealth projects.

Results/Findings: Based on the interviews, it was determined that mHealth project scalability, local and external international partnership, and monitoring and evaluation framework are aspects requiring further investigation before integrating mHealth within a larger national healthcare system in a country in Sub-Saharan Africa.

Conclusions: mHealth should be implemented with the intention of incorporating it into existing national health systems rather than as an external supplement. If stakeholders show interest in nationalizing mHealth interventions, project partnership, monitoring and evaluation framework, and project scalability should be give greater attention.

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Introduction

According to UNICEF, a woman in a developed country has a "1 in 16 chance of dying in pregnancy or childbirth, compared to a 1 in 4,000 risk in a developing country – the largest difference between poor and rich countries of any health indicator" (UNICEF). Addressing maternal health disparities could save many women's lives. And, in economic development terms, investing in maternal health is a wise health and economic policy decision because there are spill-over macro-economic benefits from women whose lives are improved by maternal health interventions. Investing in maternal health is a political and social imperative, as well as a cost effective investment in strong health systems. The wellness of society is contingent upon healthy mothers who deliver healthy babies. For this reason Millennium Development Goal (MDG) 5 aimed to reduce by three quarters, between 1990 and 2015, the maternal mortality ratio, along with increasing universal access to reproductive health for women by 2015 (WHO, 2015). The statistical data show that not all countries achieved the targets of MDG 5. For this reason, in the past 10-15 years mHealth applications have been utilized to help narrow health disparities gap and continue improvements in the new Sustainable Development Goals of 2015-2030.

This paper aims to highlight the existing platform of mHealth using literature reviews, discuss the benefits and challenges of mHealth for clinical data collection to improve maternal health conditions in pilot projects across sub-Saharan Africa, and finally address the limitations of mHealth applications for clinical data collection

based on interviews with professionals who have overseen mHealth projects in their particular organizations.

What is mHealth?

As it exists today, mHealth lacks a standardized universal definition, however, it encompasses "the use of portable electronic devices with software applications to provide health services and manage patient information" (Källander et al, 1). mHealth comes in many different forms to serve different purposes in the global health sector. According to United Nations Foundation common uses of mHealth applications are for 1) education and awareness; 2) remote monitoring; 3) communication and training for healthcare workers; 4) disease and epidemic outbreak tracking; and 5) diagnostic and treatment support; 6) remote data collection (United Nations Foundation, 10-14).

- *mHealth for Education and Awareness* – In this application, the mobile user [the patient] receives SMS messages with information about testing, treatment methods, disease management and availability of health services (United Nations Foundation ,10). This method is valuable in areas where health care workers are not present, clinics hospitals are unavailable and people reside in remote areas and are hard to reach (United Nations Foundation, 10).
- *mHealth for Remote Monitoring* – this application of mHealth is used to treat patients usually with chronic conditions like HIV/AIDs, diabetes, tuberculosis in an outpatient setting due to limited availability of hospitals or clinics. This

application is used to help patients to adhere to their medication regimen, provide appointment reminders and monitor health conditions (United Nations Foundation, 12).

- *mHealth for Communication and Training of Health Workers* – Because of the shortage of health professionals in the Sub-Saharan region, this application trains new community health workers to help fill that gap as well as simultaneously maintaining communication between different health units (United Nations Foundation ,13).
- *Disease and Epidemic Outbreak Tracking* – this mHealth application helps monitor disease incidence by capturing and transmitting data in order to design preventative and containment measures (United Nations Foundation, 13).
- *Diagnostic and Treatment Support* – In this application, the mHealth application connects community health workers with medical staff or a medical information database in order to prevent ramifications of wrongful diagnosis of health conditions. The mobile phone allows the community health care worker to enter the symptoms of the patient, which allows the medical staff to diagnosis the illness and recommend treatment. This saves the patient travel time and increases the patient's ability to access care (United Nations Foundation 14).

- *mHealth for Clinical Data Collection* – Rather than using paper-based survey collection methods, the mHealth application allows data to be entered manually into the mobile phone in order to collect patient's information and clinical data. Remote data collection for clinical purposes is crucial for the overall establishment of health policies and merging the central health database of district, regional and national level health information systems. This permits patient's information to be easily and readily available to health providers regardless of geographical location (United Nations Foundation, 11).

The specific mHealth application that will be discussed in this paper focuses on clinical data collection in which a community health worker (s) receives and sends text messages for follow-up appointments and data gathering and submissions through the use of a mobile device

mHealth Clinical Data Collection Process

According to the interviews conducted with working professionals for mHealth applications for this paper, community health workers are used to intervene at the primary health care level using the mobile health applications. This data collection process goes as follows, an African internal project team will reach out to the US-based external project team requesting a particular project intervention, in this case, an intervention to address the specific maternal health outcome to focus on. The US-based project team will design the intervention project either using a free open-source mHealth software application or one that is privately owned and costs

money. With the needs and requests in mind, the US-based team will then hire a software engineer and simultaneously work with health consultants to design the intervention. Simultaneously, most US-based teams will or should cultivate both private and public partnership in the country with NGOs, local and national governments, local and regional hospitals, cell networks providers and other stakeholders. After the software is designed, usually the health consultants and software engineer will travel to the African country to work with the local telephone network provider to incorporate the mHealth application into the mobile phone. Once that process is completed, the US-based team will conduct in-person training for a few hours or weeks to community health workers on how to use the mHealth application. This process is depicted in the picture below.

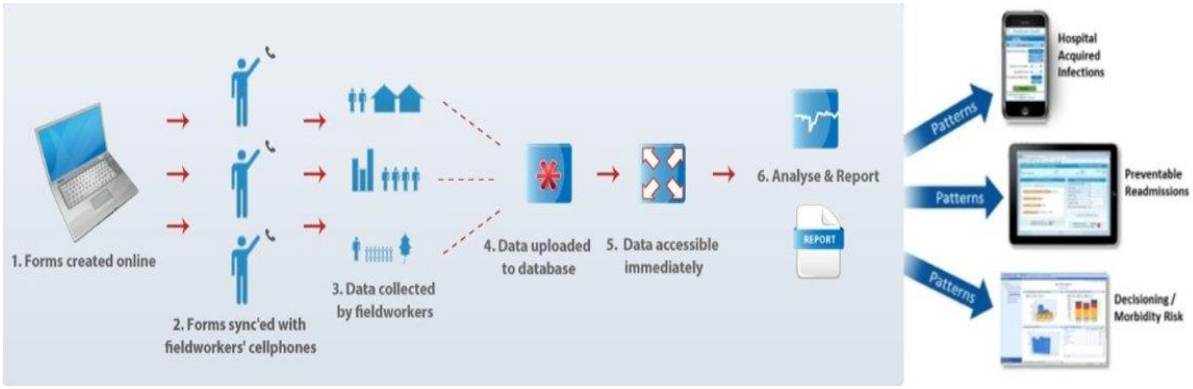

Figure 1: mHealth Data Collection Process

Prior to the intervention, the health center (district, state, or regional hospital/clinic) will have demographic information about the community health workers, where in the village or area the community health worker(s) will be located,

and how many community health workers are in the village. After that, depending on the project, whether it is a regional or local mHealth intervention, the community health worker will have a supervisor who acts as the liaison between the community health worker (s) and the primary health care facility. The supervisor oversees the work of the community health worker and make sure home visits are being conducted by the community health worker and patient's pregnancy status and informational data is being recorded. Once the community health worker enters the patient's pregnancy related information manually into the mobile phone, that information is then transmitted from the mobile phone into the health database of the district, state, or regional hospital or clinic. Using mobile health for data collection will help community health workers meet their technical need for maternal health using mHealth applications as well as collect clinical assessment data that can be transmitted to the district health office, referral hospitals and clinics in a more timely fashion so that clinical data can be used to guide treatment decisions and prenatal care.

Background

Scope of Africa's Health Challenges

The African continent, particularly the Sub-Saharan region faces multiple health challenges, such as high rates of HIV/AIDS, malaria, tuberculosis, and maternal mortality. For example, communicable diseases like HIV/AIDS in the African continent makes up 66% of the existing global HIV/AIDS pandemic and the continent carries 60% of the global burden of malaria (Unit, Economist Intelligence, 8-9).

Additionally, according to the World Health Organization, “almost all maternal deaths (99%) occur in developing countries [and] than half of these deaths occur in sub-Saharan Africa” (WHO, 2015). Women most affected by this statistic are those who cannot access care and services to doctors and nurses during pregnancy as a result of “poverty, distance from hospital or clinic, inadequate services and cultural practices” (WHO, 2015). Such circumstances have led to maternal deaths as a result of complications during pregnancy such as “severe bleeding (mostly bleeding after childbirth), infections (usually after childbirth), high blood pressure during pregnancy (pre-eclampsia and eclampsia), complications from delivery and unsafe abortion” (WHO, 2015).

Greater health systems deficits are impacting the region and are straining the resources and finances for health services. Resource constraints encompass shortages of skilled health workers for a number of reasons like, “low pay and poor living conditions, [which can] contribute to a continuous brain-drain of health professionals to the developed world and make it difficult to recruit and retain skilled staff, particularly in more remote regions where the need is often greatest” especially nursing and midwifery personal, which can impede the development of an extensive primary health care system (Unit, Economist Intelligence, 11). Additionally, the health systems in the region face financial deficits. Despite containing 11% of the world’s population and making up 24% of the global disease burden Sub-Saharan Africa only accesses about 1% of general government health expenditure (Unit, Economist Intelligence, 13).

General African Health Systems Layout

Generally, the health systems in Sub-Saharan Africa are organized into three levels of care: primary, secondary and tertiary. The primary level of care is the first point of contact between patients and their providers and often where interventions for prevention are initiated. At the secondary care level, health services come from general hospitals and some specialist physicians. Finally, the tertiary level of care comprises care provided by specialist physicians and specialized hospitals (Sambo, Louis Gomes). As it stands, the primary healthcare level is equipped to handle acute, short-term treatment of diseases. However as treatment of chronic diseases and prevention of non-communicable diseases remain a concern, there is a call to transition from curative to preventative care in the region. According to Economist, there are two main healthcare transition methods in Africa's future. The first method calls for the inclusion of nonprofessionals like community health workers at the primary healthcare level in order to remove the burden from the already overstretch health system and exhausted nurses and doctors in hospitals and clinics (Unit, Economist Intelligence, 18). The second method is to rely more on technology to expand access to primary care services, especially for those located in remote places and cannot engage with hospitals and (Unit, Economist Intelligence, 21). The mHealth application for data collection uses both community health workers and mobile phone simultaneously to address maternal health issues.

METHODS

There were two types of sources incorporated for this paper. The first step required review of literature to help understand and build knowledge about mHealth in Sub-Saharan Africa. The second step incorporated interviews with development professionals working in global health consulting organization who have maternal health mHealth projects based in a Sub-Saharan African country.

Following IRB approval of this research, interviewees were identified through word of mouth and found through online research. Once they were identified, they were given a synopsis of the research project and asked to provide consent if they were interested in being interviewed. Once they gave consent, they were asked a set of 7-10 interview questions about the nature of mHealth projects in their particular program. Such questions were aimed at addressing mHealth design, implementation, benefits, and challenges. The interview was audio recorded in case the interviewer wanted to use direct quotes from the interview. A total of 4 interviews were conducted and 3 interviews were used for this paper, each lasting 30-45 minutes. Only 3 out of the 4 interviews were used because of redundant information in the 4th interview.

Despite the findings this paper may present, there are some limitations to the study that must be taken into consideration. First, there is no universal method of evaluating the effectiveness of mHealth interventions, so comparisons of programs will be subject to my own interpretation of the existing data. Interviewing US donor organizations can be biased in terms of the type of information and perspective of

information that is discussed or presented to me. Lastly, the full-scale effectiveness and outcomes based projects have not yet taken place because most of the evaluation and existence of mHealth projects are in a pilot phase.

Literature Review

mHealth for the greater Millennium Development Goals

mHealth is defined as "the use in medicine and public health of mobile communication devices such as mobile phones, patient monitoring devices, personal digital assistant (PDAs), and other wireless devices, to enhance access to health information, improve distribution of routine and emergency health services, or provide diagnostic services" (Folaranmi, 14). mHealth has emerged as a technological innovation to improve maternal health services across Sub-Saharan Africa. Interventions in maternal health continue to evolve because health systems continue to face limitations. mHealth is being used as an intervention to close the gap of unmet maternal mortality targets between the Millennium Development Goals (1990-2015) and the Sustainable Development Goals (2015-2030). The Millennium Development Goals had aimed to, "reduce by three quarters, between 1990 and 2015, the maternal mortality ratio [and] achieve, by 2015, universal access to reproductive health" (United Nations, 2015). The Sustainable Development Goals aim to reduce the global maternal mortality ratio to less than 70 per 100,000 live births by 2030 (Sustainable Development Goals, 2015).

Community Health Workers

For community health workers, the most salient aspects of mHealth include reducing the need for travel, improving healthcare efficiency and planning, receiving feedback and information, and improving communication with supervisors, patients and other community health workers. This is made possible mostly through short message service (SMS) and other text communication via mobile phones. Community health workers can use their mobile devices in a variety of ways such as clinical data collection and reporting, decision support tools and training, emergency referrals and alerts and reminders (Agarwal et al, 2015). mHealth application for clinical data collection and reporting removes the need for face-to-face communication between the community health workers, the patient, other members of the health delivery team and health facilities located at the regional and national level because; the health worker can transmit data from her/his phone into the health system's database (Agarwal et al, 2015). The decision support tools and provider training allows the health worker to utilize treatment guidelines for specific health problems straight from his/her phone (Agarwal et al, 2015). Emergency referrals allow the community health worker to arrange emergency services to a patient based on the patient's health status that allows the data to be connected at the facility level (Agarwal et al, 2015). Alerts and reminders assure community health workers to conduct follow-up visits (Agarwal et al, 2015).

The training of community health workers to use mHealth can last from a few hours to a week depending on the type of mHealth intervention being carried out.

Such training includes an overview of the phone's function and overview of software being used (Agarwal et al, 2015). Regular training for mHealth clinical data collection application use is said to reduce the error rate for data entry from 54% to 8% within a one year span (Agarwal et al, 2015). In addition for the benefits to direct healthcare provided by CHW, there are broader benefits to using mHealth with community health workers

Benefits of mHealth

In countries with weak primary healthcare systems and where access to care is limited, utilizing community health workers in partnership with facility-based health systems is the best way to maximize benefits and reach the population with the greatest need (Panel, African Progress, 2010). According to existing research, mHealth, as part of the delivery of maternal health care, aims to lessen the distance, whether it is financial, structural, or political so that the lives of women and children can be saved each year by better addressing preventable health problems (African Progress Panel, 2010).

Author Aranda and colleagues believe that the benefits of mHealth projects can reach various stakeholders in the healthcare system. First, mHealth benefits the entire health system in the country from the intervention as it would increase direct communication among health workers throughout the country, but especially rural areas and mHealth would increase the support for patient management in the healthcare system (Aranda-Jan et al, 2014). Second, mHealth allows community health workers to prioritize where they are most needed because; mHealth

interventions target populations who have the least access to health services (Aranda-Jan et al, 2014). Lastly, the intervention benefits patients because it saves them money from paying for a regular doctor consultation, bridges the communication gap between them and the community health workers, and because of mHealth that allows community health workers to utilize cell phones, communication has improved between them and the providers because they have better access to information (Aranda-Jan et al, 2014). As a result, "low-cost, ease of use and wide spread availability were frequently cited as the main drivers for implementation" (Aranda-Jan et al, 9).

mHealth helps to narrow the gap between access to services in urban versus rural areas attributed to the fact that health care providers are more likely to be located in densely populated cities where hospitals and clinics are more available. For this reason, mHealth not only compensates for poor or inconsistent access to health services in rural areas, it can also help in delivering faster and better quality care. This highlights how mHealth allows people to overcome geographical limitations in health care. mHealth can also address the chronic shortage of healthcare workers for example in sub-Saharan Africa, as described by Agarwal, "this shortage will further exacerbate the inequity in distribution of healthcare providers in low-resource settings as evidenced by the fact that of the 57 countries facing a shortage, 36 countries are in Sub-Saharan Africa" (Agarwal et al, 1004).

Literature Strengths and Weaknesses

Majority of literature findings are based on pilot studies, for which small samples and local geographical areas are not representative of the national scale of mHealth. There is only a handful of literature that analyzes a national scale mHealth project that has been incorporated into the national health system. Findings based on pilot projects only show potential of mHealth rather than the reality. For this reason, the interviews were conducted in order to help reflect the realities of mHealth intervention on the ground. Over the course of this research, redundancy in information in the literature occurred often because, not enough varying information is out there about mHealth interventions in Sub-Saharan Africa. However, the literature did a good job of contextualizing and highlighting the demand for mHealth in the African continent.

Findings/Results

Although literature reviews presented new knowledge about mHealth in Sub-Saharan Africa, the majority of the findings surfaced from the interviews. Three health professionals and practitioners were interviewed for this research. All three individuals encompass extensive technical expertise in global public health within their prominent public health organizations in Boston. These experts foresee how technology can transform health and health care for populations living in underserved communities across the globe. To do so, mobile technology has allowed community health workers to keep health records electronically using an open-source SMS (short message service) platform. The interviews with these experts

echoed many findings in the literature; one being that the global public health sector has embraced mobile interventions in Africa because mHealth pilot interventions have shown the cost benefit to the health system. These individuals are also cognizant of the fact that mHealth is currently in demand globally, both in developed and developing countries, and that technological advancements can be used to address many challenges community health workers had often faced prior to the introduction of mHealth. The discussion with global health specialists and practitioners reveals several challenges in mHealth applications and three limitations not adequately discussed in the literature, which are inadequate monitoring and evaluation framework for mHealth applications, difficulties for project scalability, and local and international partnership that is not inclusive of all the necessary stakeholders when conducting the project interventions.

Challenges

As discussed earlier, although mHealth may reduce burden of care for community health workers, there are barriers community health workers may face when they adopt mHealth tools that the implementation team and project funding organization should keep in mind. First, the implementing team should keep in mind that most health workers are volunteers and may have low levels of literacy, as a result, the mHealth interface tool should be tailored to their abilities and made sure it is readable, easy to understand and easy to navigate (Agarwal et al, 2015). It is common for the older community health workers not to want to remain in conducting the interventions, but to also fail to adapt the tool because of unfamiliarity with

technology. In addition according to a technical advisor for an organization that provides sexual and reproductive health services worldwide, in their mHealth for maternal health department, utilizing mHealth tools meant additional work for community health workers: *"The main reason they might be a little bit amiss is if they have to double data a report on paper and on mobile because they're not paid a lot and it requires extra work* (Senior Technical Advisor for mHealth, 2016).

Second, because most mHealth systems have not been scaled up and integrated into the national health system yet, it may be difficult to train health workers with the existing poor health system capacity that is not adequately integrated to make their work easier (Agarwal et al, 2015). Third, having participated in numerous mHealth pilot studies, community health workers lose motivation and become difficult to retain in the system. To address this issue, World Vision International has identified education, supervision and feedback as a way to retain them in the community (World Vision International, 2011). The organization has noticed that the cellphones that the community health workers receive has been an incentive to stay in the program. Because community health workers are often "unpaid volunteers: chosen by their communities, their motivation stems from community recognition for their work, and mobile phone ownership is an incentive. This may be because of its basic utility or the novelty of the software provided, but also because using a phone for their work may enhance their credibility in the community" (World Vision International, 2011). However, it is unclear as the existing general mHealth policy stands, it does not articulate which community health worker

gets paid and which ones do not. The findings have shed light that perhaps all community health workers should receive monitory incentives because their work in the community brings benefits that should be recognized by all stakeholders. As the role of mHealth in health delivery evolves over time, finding alternative and sustainable ways of retaining and motivating community health workers is essential in the sustainability of the intervention itself because health workers have the respect from the community and that is an asset the implementing team cannot afford to lose.

In addition to concerns mHealth may present to community health workers, there are other challenges other stakeholders face. For example, not all stakeholders of mHealth will have adequate levels of health literacy. Use of mHealth disregards face-to-face medical interactions for treatment by relying predominantly on digital or mobile tools. Implementing mobile programs requires the cooperation of technology providers, government agencies, private sector, non-profit organizations, and health care experts. It is typically difficult to get all these people to work together. Decision-making is compartmentalized and fragmented among many agencies and it is difficult to develop policies that cut across departments. Additionally, because mHealth presents an evidence-based, data-based paradigm of health management, for people who usually make decisions on their own and based on very limited information, it might be difficult to transition to data-based protocols. Although there has been an increase of mHealth pilot projects across the continent, a large proportion of these projects are unsustainable and expire once initial funding is exhausted. Expectations

of mHealth benefits will not carry through regional and national levels if project funders do not address these limitations.

Long-term impact for mHealth remains uncertain because, the capacity of the project is determined by the capacity of the technology as well (Aranda-Jan et al, 2014). In some standard SMS messages, only a certain amount of text messages can be sent, which limits what kind of intervention can be conducted. mHealth interventions are susceptible to network losses if there is unreliable infrastructure, lack of guaranteed electricity access and reliable network , the inability of the software to be flexible and adaptable to the environment highlights reasons why the technology itself can be limiting at the implementation level of the project (Aranda-Jan et al, 2014). Most importantly, according to author Marshal and colleagues, "although failure rates specific to mHealth are unknown, it is estimated that 30-70 percent of all health IT projects fail and it can be reasonably expected that mHealth projects would parallel this experience" (Marshall et al, 14). This calls into question the capability for mHealth to be a sustainable and scalable effort given the high failure rate of IT. Although these findings are specific to the mHealth pilot projects, the challenges could potentially be greater if and when projects are scaled to the national scale. The following mHealth limitations that surfaced from the interviews highlight important aspects to consider should an mHealth project be nationalized and incorporated into the national health system.

Limitations of mHealth

Existing evidence for mHealth interventions appears to suggest potential rather than achievement of mHealth as it exists currently. This was evident throughout the current existing literature and from the three interviews conducted with the working professionals of mHealth programs. The biggest limitations for mHealth are inadequate monitoring & evaluation strategies, inability to scale–up projects from pilot phase to regional and national levels, and the challenge of establishing a mutually beneficial and sustainable partnership between in country stakeholders and donors. Without addressing these limitations, the future of mHealth as a health development tool will be bleak.

Limitation1: Monitoring and Evaluation

Existing literature indicates that currently most mHealth projects have inadequate evaluation methods. Monitoring in a project assesses what the project is achieving and doing (Bakewell, 2003). Evaluation is concerned with periodically assessing the relevance, performance, efficiency and impact of the project based on its stated objectives (Bakewell, 2003). It is pertinent that development projects embed a monitoring and evaluation strategy in their projects for a variety of reasons. Measurement and evaluation are essential for:

1. ***Accountability***: accountability comes from both the donor for the project; to monitor how the money for the project is being utilized and accountability to project users; to show the users what they have been doing and explain their actions (Bakewell, 2003)

2. ***Improve performance***: measuring and evaluation would improve performance by highlighting problems as they occur so they can be addressed throughout the project life cycle and provide an overview of project's achievements and direction (Bakewell, 2003)
3. ***Learning***: provide valuable lessons for those partaking in the project or other projects by other organizations in the same sector or location. Conducing measure and evaluation strategy develops new skills for stakeholders by increasing their motivation to participate in planning and implementing activities (Bakewell, 2003)
4. ***Communication*****:** increase the communication between different stakeholders by exposing them to each other's perspectives on an intervention (Bakewell, 2003).

Based on an interview conducted at a public health consulting organization in Boston, many organizations working with mHealth may not have an interest in monitoring and evaluating their projects because of the cost and time it takes to conduct such analysis:

> *In the public health world, usually the impact you would share are more about meeting project goals, deliverables, and timeline because most of the donor organizations want to put money into a problem and have immediate results and don't want to take the time to measure, they don't want a control group, they don't want to try to spend a bunch of money on someone who is trying to*

> *write and do research, they want direct implementation* (Director for Center for mHealth, 2015).

Even when a monitoring framework is in place, it is important to be critical of the narrative these reports show. The monitoring and evaluation reports may only reflect the view of the monitoring and evaluation team, not the end user of mHealth (Bakewell, 2003). The evaluation and monitoring is a report written in a way that emphasizes a quantitative measurement tool using objectives and numbers and not so much using judgment or interpretive methods to measure outcome and impact (Bakewell, 2003). By focusing solely on numerical measures of progress rather than more descriptive measures, the evaluation is less useful for tracking social change, impact and highlights. Emphasis on numerical measures reinforces the views from a project management prospective and evaluators at the expense of stakeholders like CHWs, who might be disempowered by this rigid process (Bakewell, 2003). Assessing the project impact can be complex, especially the long term impact because numerical indicators may not represent it. It disregards the qualitative change that may take place that cannot be quantified. To assess development aid, the Development Assistance Committee of the Organization for Economic Co-operation and Development (OECD) developed five evaluation criteria a project must consider: efficiency; effectiveness; impact; relevance; and sustainability (Bakewell, 2003). Overall, if an mHealth project does not incorporate a monitoring and evaluation framework, it would be difficult to measure the project's efficiency, effectiveness, impact, relevance and sustainability in the long term.

A quality monitoring and evaluation process will shed light on the potential sustainability and scalability of an mHealth intervention. An mHealth intervention is only sustainable if the outcome and impact evaluation showed positive change in people's behavior or in health outcomes. Although it can be done, some mHealth applications targeting health outcomes are difficult to measure. For this reason, when it comes to measure and evaluating at the national level, the impact cannot be directly associated with mHealth applications at local level (Marshall et al, 13). These results show a promising potential, however, very few interventions are implemented at the national level. Without a rigorous monitoring and evaluation system, scalability will be another barrier that prevents pilot mHealth intervention projects from becoming long-term systematic and policy level innovative tool.

Limitation2: Scalability

Successful mHealth pilot projects are in abundance, but the mHealth sector has been slow to reach scale. Scalability is defined as, "the potential of performing the intervention on a large scale, for instance, by extending the intervention from one district to the entire state/region" (Urban Reproductive Health, 2013). This process can include but is not limited to, bring more inputs (funds and staff), outputs (access to and range of services), quality, efficiency, outcomes (coverage or utilization) or impact (morbidity or mortality)" (Keisling, 2013). As mHealth stands currently, the pilot studies conducted in the past few years identify the inputs, such as establishing funders for the projects and collaboration of the local and donor organizations with ease. However, the literature discusses the outputs, which compromises of access to

and range of services available, but falls short when it comes to measuring and quantifying the impact mHealth can have for long term. Right now, mHealth is a stand-alone intervention that is not integrated into the main health systems in most countries where intervention is conducted. It should be designed to meet the needs of the main primary care health system and not compete with other efforts that may force stakeholders into discontinuing of services after projects are terminated.

Like any project, mHealth interventions have various stakeholders. Such stakeholders can include the government who invests at the national and district level, IT managers, institutions, NGOs, donor organizations, policy makers, and implementing partners. At the initial stage, the donor organization(s) is one of the most important stakeholders because without financing, the project, everything else would not be feasible. Based on the findings in the literature and interviews, the donor organization(s) are often more interested in seeing quick results from interventions. Donor organizations are interested in funding and investing in new technology and not necessarily for establishing long term research, while the grantee agency in return wants to receive recognition from fellow global health consulting agencies for completing an innovative project most efficiently. The development agency is a stakeholder because through such interventions, it further legitimizes foreign interests and security with the country that's receiving the aid. Local governments as stakeholders want to increase efficiencies and improve health outcomes through mHealth. Particularly for mHealth, local mobile phone industries are stakeholders and could benefit from such intervention if it can generate revenue

for providing the network and mobile services for mHealth solutions. Although scale – up may be comprised of various stakeholders, it does not mean the process is a successful or attainable one as a result of many challenges along the way.

One of the first barriers for project scale-up is the lack of funding and coordination among various bodies. When mHealth pilot studies are conducted, funding only covers that stage and nothing long-term. Most times once the pilot study is conducted, the funding has already been exhausted. Because most of the fund may come from the donor/development agency, local governments may not be able to finance the project themselves. For this reason, pilot phases should be conducted with long-term impact, outcome and financial security in mind. Furthermore, at this stage of evolution of mHealth innovation, there is no standardized and regulated framework to guide scale-up projects (Menu, Open Top, 2014).

Lastly, "inadequate monitoring and evaluation and use of meaningful and consistent indicators along with a rigorous evaluation method for cost-effectiveness may make it difficult to scale up mHealth interventions" (Menu, Open Top, 2014). According to an employee working with an organization in Boston on mHealth projects, the challenge to scale the projects is also partially funding when it comes to project scale up:

> *It becomes a routine piece of budgeting that the country themselves do, if that is not possible, the* idea *is to try and extend the life of the project, find other donors that are willing to contribute to it, submit proposals for different pieces of funding and try to keep the thing going as long as you can, try to design it so that*

> *it integrates into the country's operations way that they work so that you don't want to building something that you have a bunch of foreigners there running and disappearing* (Director for Center for mHealth, 2015)

When funding becomes exhausted, often the project in the field is halted or terminated. At this stage, employees at the donor organization or development agency vacate the country they are work in, leaving local stakeholders unable to continue the project, leaving the government with the option of waiting for another international agency or organization to carry out the project or dismiss the project all together.

So based on these findings, what do the factors for failed versus successful scape-up mHealth projects look like? Reasons a project may fail in terms of scalability is because of lack of inadequate planning and poor project design, limited funding for long-term projects, research limited to pilot project or donor reporting external factors, lack of organizational capacity, lack of standards, and limited local technical support and capacity (Aranda-Jan et al, 1). On the other hand, factors for successful scale up may consist of high availability of mobile phones, overall positive perception and option of positive outcomes at small-scale, provision of incentives, not resource exhaustive and low replication costs (Aranda-Jan et al, 1).

Many criteria go into making scalability possible in mHealth. These range from calculating cost to scale, to the need to invest in a rigorous monitoring and evaluation that is not only concerned about the most cost-effective way to incorporate such framework, but rather a framework that critically analyzes and

evaluates the best method to measure impact and long-term outcomes. One way to facilitate scale up is to establish a strong foundation of collaborative partnership between the donor organizations and stakeholders on the ground.

Limitation 3: Partnership

One of the aims for a strong partnership should be collaborating to scale mHealth into the mainstream health system rather than developing mHealth to be its own separate entity. In recent years, a technical advisor for mHealth in Boston highlights that there are too many pilot studies taking place in the African region. The reason for this, he explains, is that a common complaint coming from the stakeholders on the field is "pilotitis" (the idea that everybody will conduct little tiny pilot studies "(Director for Center for mHealth, 2015). When various organizations come and develop their own projects rather than collaborating to establish one system of technology, the recipients of these interventions get overwhelmed and exhausted. Lack of collaboration, as in this particular example, creates project redundancy, which is an ineffective way of maximizing the benefits mHealth could offer if those implementing mHealth do not collaborate. Another issue that arose from one of the interviews was stakeholders not being on the same page in terms of what the in country stakeholders want versus what the donor organization implements. For this reason, the health technicians/health advisors at times clash with the IT team in regards to the logistics of developing the technology for intended aims:

> *They don't speak the same language, they don't-they're not trained to approach problems in the same way. They don't use the same tools or techniques for bringing,*

for designing things and for bringing things to fruition [24.11], they really don't

(Senior Advisor for Research and M&E)

Similar to the partnerships to determine scalability, a majority of the stakeholders that make up the partnerships are those with technical and content expertise. The funding partners, where a majority of the them come from Europe or USA, distribute their funds through local organizations in hopes of building capacity for development and implementation of mHealth solutions (Curioso & Mechael, 2010). There is a push to involve private mobile network companies to mHealth because they may offer financial and/or infrastructure assistance in exchange for increase use of the company's services (Marshall et al, 25). The end result of a good partnership in mHealth should result in the local stakeholders establishing local ownership of the project once external stakeholders leave the country.

Local ownership can be defined in various ways. Local ownership could mean that an mHealth concept is presented to a group of stakeholders in the field and they have signed off taking the ownership of the project. Local ownership could mean that an idea of mHealth was born in the country and was materialized with external project resources. Lastly, it could also mean that the service was developed, implemented and funded with local human and financial resources. However, currently, local ownership has come to mean mHealth concept has been developed and implemented by external bodies, but once the life of the project has come to an end, the in-country internal bodies have taken over. Partnership is heavily influenced by who is in charge of funding the project.

As the partnership in mHealth innovation stands today, the funding is not directly linked to local institutions in partnering countries. Rather, the funding is funneled through an implementing organization that is a U.S organization with which a development agency might have established a long-term relationships to allocate funding for the projects rather than a locally based organization. This strategically set up fails to recognize the important role that international partnerships can play in expanding local capacity. In addition, western consultants are often ineffective because they lack detailed knowledge of local conditions. What this highlights is that the work typically performed by contractors actually undermines the local institutions and indigenous capacities the aid process is presumably trying to build.

Although a partnership is meant to create collaborative efforts, the current literature highlights how it can also create exclusions for certain stakeholders. The partnership should include community health workers in the decision making process of mHealth design rather than only during the service delivery or implementation phase. Community health workers should be involved in the decision making process to encourage bottom-up innovation of the mHealth intervention to contribute to the process of realizing desired health outcomes (Chigona, 2009). If an mHealth project does scale to the national level and into the mainstream healthcare system in the particular country, primary healthcare workers should be included in the process as well since their focus is on prevention of diseases and illnesses. These partnership dynamics highlight power structures that exist between the development

agency donor organization and the developing country receiving these technological interventions.

Much of the narrative about the challenges and benefits of mHealth that exist in the database are told through the funding organization perspective. It has been difficult to identify the realities of mHealth written by an African organization or an African individual who has participated in this intervention. This could highlight the incompatibility between what the developed world wants for the developing world and what the developing world desires for itself. Aid recipients with few resources are not in a position to complain about aid they receive, even if it eventually proves counterproductive. As a result, the partnership should be established with the local stakeholders in mind primarily and include diverse voices about the process, development, implementation, and impact of mHealth from all stakeholders rather than those who are in the financial position to direct the narratives about them.

Conclusion

Although the literature claims mobile health is on the rise in Africa and offers effective and accessible solutions to improve care, discussions with global health professionals revealed mHealth challenges and limitations not presented in the literature.

These challenges were, difficulty in retaining community health workers in the system because of their inability to adapt easily to the software, having low levels of literary, and not being financially compensated for their work. Specific limitations that surfaced through the interview discussions were inclusive partnerships,

inadequate monitoring and evaluation framework, and barriers for project scalability. First, as it exists currently, the biggest stakeholders for mHealth are community health workers, who are often the first to interact with the innovation. However, community health workers are not included in the development and implementation phases of mHealth. Solutions are developed without them although they are the end-users. For this reason, it is imperative that community health workers are included in the mHealth project partnership. This partnership is also essential among other organizations in order to avoid project redundancy by reinstituting similar interventions by different external stakeholders in the same country, which can often exhaust community health workers and the existing mHealth system. Second, there is a need to finance the implementation of a rigorous monitoring and evaluation framework to analyze long-term impacts and measure the success or failure of mHealth interventions. The success of a mHealth intervention should hinge on the quality of its implementation as well as the evidence. As it stands, mHealth has been evaluated for feasibility, rather than impact on health outcomes. Third, mHealth application intervention should be instituted with the intention of scaling results into the national healthcare system rather than as an add-on project.

The future of mHealth interventions in sub-Saharan Africa will be influenced by several trends. The proliferation of pilot projects in the region's healthcare landscape has shown that pilot phase interventions seem to show success in a small group of clinics and hospitals. However, the project can't grow beyond this phase without local ownership, the inclusion of different partners like the government, private sector and

mobile phone providers. Now that most projects have completed pilot phases, subsequent phases require implementation and integration into mainstream healthcare systems in countries where mHealth pilot studies have been conducted. mHealth is only as good as the target group it aims to serve or the health system it's connected to. One can get excited about this new innovation, but the real impact comes from thinking about the social, cultural and professional context in which it's being implemented. mHealth is one component with the opportunity to address many needs of the underserved populations in resource poor countries in Sub-Saharan Africa. Using mHealth to provide access to care is an important step for providing a better future for mothers and children in the region.

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