

Chapter 22

Mobile Health for Africa

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Introduction

Africans are faced with limited access to healthcare services, a lack of financial resources dedicated to healthcare, a shortage of skilled healthcare professionals, a shortage of medical instruments and equipment, and poorly maintained health facilities (Latif et al., 2017). Telemedicine, the use of telecommunication and information technologies to provide healthcare from a distance, is one of the strategies used to address the shortage of healthcare professionals and improve access to healthcare services in rural, remote areas and poorly resourced communities. The uptake of telemedicine in developing regions such as Africa has been hampered by poor telecommunication infrastructure, especially in rural areas where it is needed most, as well as high service costs, limited awareness among healthcare workers and the patient community, and lack of government support (Mars, 2013). The evolution of telecommunications from fixed to mobile networks has resulted in renewed interest in the provision of healthcare services using telecommunication systems.

The African continent has seen a tremendous increase in mobile subscriptions and network penetration, which is expected to reach 50% by 2020 (GSMA, 2017). Mobile technologies have the potential to bring telecommunication services into almost every household globally, a feat that was not possible with fixed telecommunication systems. Mobile technologies can overcome the hurdle of infrastructure cost that has hampered the full adoption of telemedicine. This is because access networks built using wireless technologies are much cheaper than those based on wired technologies, on which telemedicine was initially based. Furthermore, broadband wireless technologies offer improved network capacity and better quality of service.

The use of mobile networks and devices by healthcare workers and in the healthcare system (mobile health or mHealth) has changed clinical practice and has the potential to improve the public health system (Latif et al., 2017); such devices make it possible to disseminate health information, gather intelligence on disease outbreaks, perform remote diagnosis of diseases, and provide health education to healthcare professionals as well patients. The World Health Organisation defines mHealth as “medical and public health practice supported by mobile devices such as mobile phones, patient monitoring devices, personal digital assistants (PDAs) and other wireless devices” (WHO. Global Observatory for eHealth, 2011).

These devices may embed programmable sensors such as gyroscopes, cameras, microphones, touch sensitive screens, ambient light sensors, proximity sensors, accelerometers, and global positioning systems. These sensors can be used to gather behavioural and physiological information. Most manufacturers of mobile devices now offer software development kits which allow developers to create novel mHealth applications. Such applications are supporting the drive towards maintaining wellness, rather than caring for the sick. A comprehensive outline of the applications of these sensors in the medical field is given by (Latif et al., 2017). Incorporation of connectivity capabilities such as Wi-Fi and Bluetooth enable the devices to connect to external networks, thus increasing their information distribution capabilities.

The decreasing costs of internet-enabled smartphones also make mHealth a powerful platform for extending healthcare services to poor people in Africa. mHealth therefore has the potential to assist African countries towards achieving the third United Nations Sustainable Development Goal, namely achieving wellness for all at all ages by 2035 (United Nations, 2017). Several initiatives to address the health challenges in Africa using mobile technologies already exist (Latif et al., 2017). However, despite the promise of mHealth, most of the implementations have either been unscalable or unsustainable.

In this chapter, we identify the opportunities driving the adoption of mobile technologies to address healthcare challenges in Sub-Saharan Africa and discuss the hurdles that have been identified in the realisation of sustainable and scalable mHealth initiatives.

Opportunities for mHealth

There is strong evidence that millions of people in Africa suffer and eventually die from diseases for which effective treatment and prevention are possible. According to a WHO report published in 2017, 15,000 children under the age of five died every day in 2016, and children in Africa are 15 times more likely to die than those in developing countries. Diarrhoea and malaria are among the leading causes of death (WHO, 2017). mHealth has the potential to assist governments in preventing the spread of diseases and deliver quality healthcare to all citizens. This can be achieved by creating awareness through dissemination of health information to the public and health professionals, surveillance of disease outbreaks to minimise transmission, training healthcare professionals, and using remote diagnosis and treatment to increase the effectiveness of the few skilled medical practitioners. This section reviews the use of mHealth to achieve these goals.

Health education and awareness

Education is an essential component of promoting health and preventing disease. Lack of knowledge about disease prevention, detection and treatment is a contributor to morbidity and mortality (Mechael, 2009). mHealth presents an opportunity for

improving the health literacy of populations through raising disease awareness and management, as well as awareness of available interventions and treatments.

Mobile devices have proved to be an effective tool for disseminating health education information around the world (O'Donovan et al., 2015). In South Africa, the MomConnect project has successfully been used to provide health-related information to more than 1.8 million South African mothers, and is being extended to provide HIV-related information to HIV patients (Pillay, 2015). The global initiative "Malaria No More", which has saved millions of lives among people suffering from malaria through traditional diagnosis, prevention and vaccine management, is now combining its efforts with mHealth to drive life-saving results (Potyraj, 2016).

The VAS321 project, launched in Malawi to provide maternal health information to expecting mothers, has recorded a 14% increase in knowledge about appropriate breast feeding and a 22% improvement in breastfeeding behaviour (Larsen-Cooper et al., 2016). The Grameen Foundation launched the Mobile Midwife project in Ghana in 2014. The project uses SMS and interactive voice recording to deliver information about hygiene, nutrition, malaria, and immunisation. Due to positive feedback from consumer surveys, the project was adapted for implementation in Nigeria (GSMA, 2016). A project aimed at providing HIV/AIDS awareness in Uganda resulted in a 40% increase in the number of people signing up for HIV/AIDS tests (Latif et al., 2017).

While text messaging has been successfully used for mHealth, the use of internet-based instant messaging tools on mobile phones, such as WhatsApp, is emerging. Such tools can facilitate quick teleconsultation, information sharing and decisions to start treatment (Giordano et al., 2017). In South Africa, UNICEF launched WhatsApp messaging among youths to share information about HIV/AIDS and teenage pregnancy (Tshuma, 2016). In Malawi, WhatsApp is being used to assist community health workers in mobilising health resources (Pimmer et al., 2017). WhatsApp has also been piloted for use on the MomConnect project in South Africa (Praekelt, 2017).

The shortage of doctors in Africa has resulted in some unqualified people operating as professional medical doctors. An mHealth project designed to create awareness of fake doctors has been launched in Kenya (Gicheru, 2016).

Clinical decision support

Clinical decision support systems (CDSS) are computer applications that use information, rules within information databases, and patient and clinical data to improve clinical decision-making on prevention, care, diagnostics and prescription by healthcare professionals (Musen et al., 2014). Mobile technologies are currently being developed to extend the reach of CDSS to rural and remote areas, enabling healthcare professionals to make life-saving decisions and allowing patients to make appropriate choices regarding

their own healthcare. The tools used in CDSS include computerised alerts, reminders to patients and care givers, patient-specific data reports, diagnostic support and documentation templates, among others (Bakibinga et al., 2017). In Africa, CDSS are particularly important given the shortage of healthcare workers. CDSS are currently being used for supporting patients suffering from diseases such as HIV/AIDS and diabetes, supporting maternal healthcare, and assisting community health workers with disease monitoring and ensuring treatment adherence by patients (Garten, 2016).

Several CDSS have been implemented in Sub-Saharan Africa. These include:

- OpenMRS, a system supporting personalised care for patients suffering from TB, bronchitis and hypertension, which uses an app installed on a mobile phone to collect data about a patient's disease symptoms, analyse the data and provide information to the patient on how to access healthcare services (Bediang et al., 2010);
- a system aimed at improving the management of adherence to malaria treatment in rural facilities in Kenya, which was used to send SMS messages daily to patients for six months, and resulted in a 37% improvement in adherence to treatment (Zurovac et al., 2011);
- a handheld mobile device used in South Africa to screen HIV/AIDS patients for further treatment (Marc, 2009);
- an aftercare module designed for voluntary community-based health workers to provide therapeutic counselling to people living with HIV/AIDS (Bediang et al., 2010);
- the Uganda Health Information Network (Källander et al., 2013);
- the Partnership for Maternal, New-born and Child Health in Nairobi, Kenya, which aims to strengthen the healthcare delivery system in urban informal settlements, with a focus on improving the health of pregnant women and new-born babies (Bakibinga et al., 2017);
- Moby App, an Android-based system to support health workers by providing them with information to help prevent mother-to-child HIV infection (EGPAF, 2016); and
- a CDSS to reduce the number of avoidable visits by patients to a hospital in Malawi, which allowed villagers to communicate with physicians before visiting the hospital, leading to reduced patient travel costs (Latif et al., 2017).

An image-based mHealth CDSS for diagnosis of latent tuberculosis is in development at the University of Cape Town (Dendere et al., 2017). The system, consisting of a mobile app and algorithms installed on a computer, uses a smartphone to capture 2D images of the tuberculin skin test (TST) induration and transfer them to a remote database. The size of the induration is determined using algorithms that analyse the images and provide a diameter of the induration as an output. A pilot study has shown agreement between app-based and clinician measurements of the TST response. The app, which can be used

by health workers or patients themselves, has the potential to provide decision support to clinicians and reduce the need for patients to return to clinics for assessment of the TST response.

A comprehensive review of more studies on CDSS in Sub-Saharan Africa, covering maternal health, TB, malaria, HIV, hypertension and childhood illnesses is given in (Adepoju et al., 2017). The decision systems include algorithms for incorporating data, individualised alerts and reminders and one-way text messages.

Disease outbreak surveillance

Disease surveillance is the continuous scrutiny of the occurrence of diseases and health-related events, and has been recognized as an effective strategy for prevention and control of epidemic-prone diseases (Adepoju et al., 2017). In most African countries, disease surveillance and notification involves immediate notification of epidemic-prone diseases, and monthly notification of those targeted for elimination and eradication (Kebede et al., 2010). Successful surveillance requires ongoing systematic collection, curation, analysis and interpretation of data on disease occurrence, as well as cooperation by healthcare institutions in identifying outbreaks, and dissemination of information.

Many disease outbreaks in Africa have been caused by lack of, or late, reporting. Studies have shown that failure to report disease outbreaks by health workers is attributed to lack of knowledge of existing reporting networks and of diseases to be reported (Kebede et al., 2010). While most countries have implemented successful surveillance systems which include training for healthcare workers, most of the systems are still paper-based (Isere et al., 2015; Kaboré et al., 2001). The high penetration rates and increasing adoption of mobile devices in Sub-Saharan Africa has the potential to enhance the development of effective disease surveillance systems in the region. Efforts to migrate some of these systems are already underway. Some of the initiatives are summarised below.

The WHO has ongoing projects for strengthening the early warning, alert and response systems (EWARS) for disease outbreaks in South Sudan, Ethiopia and Nigeria (Wamala, 2017). The web-based system, which replaces paper-based standardized data tools, strengthens the surveillance of and response capacities to disease outbreaks. The system allows real-time information sharing when disease thresholds are exceeded. The information is shared by all stakeholders via email, SMS and voice messaging using mobile phones. Epidemiological bulletins and other information are also frequently published automatically.

The Ebola disease which broke out in seven West African countries in 2013 resulted in 25,000 infections and nearly 11,000 deaths (Sacks et al., 2015). Controlling the epidemic

required community engagement, identification of contacts, monitoring of symptoms, timely lab responses, patient isolation, treatment of new infections, and decent burials. Real-time availability of data to coordinate these activities was critical.

This was accomplished by the establishment of a real-time informatics system in Guinea (Sacks et al., 2015). The system comprised a mobile application and business intelligence software, enabling health workers to trace infected individuals.

Nigeria has a well-established national disease surveillance system, the strengthening epidemic response system (SERS), which allows community health workers to detect and report disease outbreaks. To improve the performance of the system, the government migrated it to a digital mobile platform, mSERS, in March 2017. This made it possible for most of the reporting to be done using mobile phones. A report released in November 2017 showed an annual increase in reported cases of Lassa fever and cholera. This was attributed, not to increasing outbreaks compared to the previous year, but rather to the affectiveness of the mSERS system (Nigeria Centre for Disease Control, 2017).

In 2015, the government of Rwanda invested in an early warning system to strengthen the country's response to natural disasters due to climate change. This would minimize the health risks associated with natural disasters such as floods and drought (Vital Wave Consulting, 2009). The project makes use of mobile phones as a communication tool that can reach over 5 million people, out of a total country population of 11.5 million. In case of emergency, warning information is quickly shared among people in the affected areas using SMS messages.

Point-of-care diagnostic and treatment support

Healthcare facilities in developing countries tend to be located centrally in major towns, with limited facilities in rural, remote, and underserved communities, leaving them more vulnerable to treatable diseases. Low-cost point-of-care diagnostic, treatment and monitoring tools could improve the delivery of healthcare services to individuals in such settings, and efforts have been made in this direction (McNerney, 2015; Sharma et al., 2015; Ertola et al., 2016). Most of the proposed solutions address cost, portability and ease of use. A report by OpenMind identifies seven studies where low-cost devices have been proposed for disease diagnosis in poor countries (OpenMind, 2015). They include blood-based devices used for testing diabetes, malaria, E. coli, hepatitis, influenza, sickle-cell anaemia and dengue. Some of these devices can be connected to mobile phones; adding mobility and internet access to the devices. This would assist healthcare workers in providing remote diagnosis and treatment to populations with limited access to healthcare facilities. It could also give healthcare workers real-time access to remote databases. The United States Agency for International Development (USAID) has published some successful implementations of mHealth initiatives in Africa for remote diagnosis and treatment support (Levine et al., 2015).

Training health workers

In most African countries, community health workers are the first line of defence against illness (Levine et al., 2015). Effective delivery of health services requires that these workers be equipped with the appropriate knowledge. Mobile phones are being used widely in developing countries to improve the knowledge of healthcare workers. Examples include:

- The HealthWiki, an online searchable database of health information, which is accessible via a mobile device (Hesperian Health Guidelines, 2018) and allows users to browse information on a range of health topics (Levine et al., 2015);
- Learning about Living, a collaborative pilot project in Nigeria for training volunteer health workers to interact with Nigerian youth, teaching them about AIDS, sex, personal development and living skills (Garten, 2016);
- OppiaMobile, an open source interactive mobile learning platform for delivering learning content in low-resource communities with poor internet connectivity (Vintimilla-Tapia et al., 2017), which is being tested in Ethiopia to deliver Ministry of Health approved training materials to healthcare workers (Levine et al., 2015); and
- mHealth for Community-Based Family Planning, which allows healthcare workers in the Shinyanga region of Tanzania to access information using their mobile phones, and receive reminders to follow up on their patients or to confirm successful referrals to healthcare facilities (Levine et al., 2015).

Disease management

mHealth is an effective tool for providing remote monitoring services for improved disease management (GSMA, 2017). Remote diagnosis, management and intervention before acute phenomena such as heart failure can lower hospital admission and utilisation costs. Diseases such as HIV/AIDS and TB have lengthy treatment periods and require strict adherence to treatment for positive results. Treatment effectiveness in such cases can be improved by ensuring reliable drug supply and sending reminders to patients to ensure adherence to treatment, while prompt messages can be sent to care givers to intervene in case of non-compliance. Quality of care can be improved by giving care givers and patients tools to manage disabilities associated with chronic diseases. Remote collection and analysis of patient data can help improve disease management and accelerate research innovations. Finally, remote monitoring has the potential to reduce the need for hospitalisation. While remote patient monitoring initiatives in Europe and the Americas are more established than is the case in Africa (Kahn, 2010), several initiatives have been established in Africa and research into implementation is also ongoing (Haas, 2016). Below are examples that have integrated other technologies with mobile applications.

A system for remote monitoring of foetal heart rate was implemented in South Western Uganda (Mugenyi et al., 2017). The system consists of a battery-powered device that uses Doppler technology to obtain foetal cardiocographs (CTG) and connects wirelessly to an android device which displays the results and sends them to a cloud-based storage system via a mobile network. Clinicians can access the information via a password-protected website. An evaluation of the device showed that 92% of CTGs were successfully recorded and stored. The pregnant women reported liking the device, as well as high levels of comfort, system flexibility, ease of use and time-saving. Education of the participants resulted in improved correct and safe usage.

A system for remotely monitoring high blood pressure patients has been implemented in Ghana (Sarfo et al., 2016). The system consists of a pill box that records medication intake and a blood pressure monitoring device. The intake record and blood pressure readings are sent to a smartphone via Bluetooth connectivity. The smartphone, in turn, sends the information to a remote database.

Challenges for adoption of mHealth

Despite the promising opportunities for mHealth in Sub-Saharan Africa and the increasing number of pilot projects and case studies, adoption of mHealth is slow. Challenges associated with successful adoption include low health literacy, the cost of mobile devices, language and culture barriers, limited healthcare infrastructure, limited internet connectivity, lack of coordination, and other socio-economic obstacles. This section discusses some of these challenges.

Low literacy

With low levels of health literacy, an individual cannot understand consent forms, medicine labels and other healthcare information. Most countries in Sub-Saharan Africa have low general literacy rates, making it difficult for individuals to be health literate. According to a UNESCO report published in 2017, the average literacy in Sub-Saharan Africa is 75%, compared to 93% for the rest of the world (UNESCO, 2017). Low literacy impedes the impact of health education. In developed countries with high literacy rates, education campaigns to promote immunization and other preventative health services have been used effectively to improve health and prevent diseases (Nutbeam, 2000).

The WHO defines health literacy as “the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health” (Kickbusch, Pelikan & Apfel, 2013). Health literacy is therefore more than the ability to read pamphlets and successfully make appointments, but being able to access health information, understand the relevant information, appraise or judge the information and apply it to make informed decisions (Kickbusch, Pelikan & Apfel, 2013; Mayagah & Wayne, 2009). Just as low literacy is

related to low health status, low health literacy contributes to overall socioeconomic disadvantage (Kickbusch, Pelikan & Apfel, 2013).

mHealth technologies have the capability to avail health information to large populations. However, if the individual cannot process the information and make sense of it, this negatively impacts the effectiveness of mHealth interventions designed to improve healthcare delivery. mHealth can therefore bring health resources to the neglected, but cannot solve the problem of health illiteracy which leads to low utilization of mHealth services (Albertain et al., 2014).

The health literacy problem could be mitigated with the development of interactive voice and video mHealth applications which would not require users to read, but would enable them to view and listen to instructions in their own language. However, such services would require high quality, low cost networks, which are only promised by next generation technologies (Latif et al., 2017).

Language and cultural barriers

The language diversity in most African countries limits the potential of mHealth projects. Most of the target populations in rural and resource-limited areas are more comfortable communicating in their own languages. mHealth projects implemented in English can potentially have limited impact or even adverse results due to misunderstanding between patients and healthcare practitioners. However, most app developers are currently making efforts to translate their mHealth apps to local languages (Pillay, 2015).

In addition to the language barrier, cultural beliefs and tradition can also have a negative impact on uptake of services. For example, a project for improving maternal health in rural pregnant women in Malawi was viewed as satanic by some of the local villagers who questioned how the system knew the mothers' exact delivery dates (Nyemba-Mudenda & Chigona, 2017). Some husbands prevented their wives from participating in the project. The cultural barrier could be mitigated by educating the communities before project implementation. However, this could result in additional project costs.

Poor health facilities and infrastructure

As evidenced in most of the studies summarised above, mHealth can provide access to healthcare services to larger proportions of society, resulting in more people being aware of their health conditions and realising the need to seek medical attention. However, most health systems in Africa suffer drug shortages, limited medical practitioners and limited healthcare facilities, and could not cope with increased demand from a more informed population. Other challenges include shortage of medical equipment and poor referral systems e.g. unreliable ambulance services.

From an mHealth project implemented in Malawi, it is reported that pregnant women preferred to deliver their babies in the comfort of their homes under supervision of community healthcare workers, rather than go to understaffed hospitals where they would sleep on the floor while waiting to deliver (Nyemba-Mudenda & Chigona, 2017).

Limited network infrastructure

Despite the hype about increasing mobile network coverage in Africa, coverage gaps still exist in many rural communities (Latif et al., 2017). According to the GSMA mobility report of 2016, 3G networks cover only 50% of the population in Africa compared to a global average of 78% (GSMA, 2016). Africa is therefore home to an uncovered population of 0.6 billion people (GSMA, 2016). The mobile coverage gap is viewed as an economic rather than a technical challenge. The coverage gaps usually exist in rural locations with low population densities and low per capita income levels. Full 3G/4G coverage is only expected in 2020 in Sub-Saharan Africa (Mzekandaba, 2015). Furthermore, infrastructure such as electricity provision and high-capacity fixed communication networks may be non-existent. The lack of fixed telecommunication infrastructure such as fibre optic cables limits access to internet services, on which mHealth services ride (Albaptain et al., 2014).

For network operators, the revenue opportunities in rural areas would be lower than in urban areas, while operational costs can be significantly higher (GSMA, 2016). These business challenges could be addressed through infrastructure sharing between mobile operators and cooperation with government in sharing the cost and risk of investing in rural and remote locations. In addition, the unknown cost-effectiveness of large-scale deployment and maintenance of mHealth projects and the management challenges which remain underestimated, threaten the success of mHealth projects (Aranda-Jan et al., 2014). Careful assessment of mHealth projects is therefore required before implementation.

Cost of mobile devices and services

Cost is one of the challenges in the implementation of mHealth projects in the developing world, including Africa. Despite the decreasing cost of mobile devices, many people in Africa may still be unable to afford a mobile phone or pay for mobile or internet services (Kaplan, 2006). Community mobile phones have been used in some mHealth projects to mitigate the shortage of devices (Nyemba-Mudenda & Chigona, 2017). However, in case of emergency, access to these shared devices can be a challenge. In very poor communities, personal health monitoring would also be unaffordable on shared devices for which access is charged by the minute.

Other mobile device requirements such as battery life negatively impact the quality of mHealth services delivered. Most mHealth applications are complex and require

significant battery power. Since many rural areas with no access to electricity rely on solar systems to charge their devices, developing power-aware applications is critical (Nyemba-Mudenda & Chigona, 2017).

Government involvement and integration with existing health systems

Some of the challenges for mHealth implementation are related to government and existing health systems. Government support is of fundamental importance for the success of mHealth projects, as their political responsibility is to create optimal conditions for implementation of the required mHealth infrastructure and regulatory frameworks. Some of the reasons why mHealth is not given priority on the political agenda include lack of evidence of scalability, lack of evidence of long-term impact on health outcomes, and the need to justify the use of public funds (Gicheru, 2016). Project scaling can be difficult in poorly organized health systems, and mHealth cannot be used as a “treatment” for poor health systems (Mechael et al., 2010).

Healthcare providers should also develop the cultural and organizational capacity required to manage mHealth information (Leon et al., 2012). Lack of these skills can result in late reporting, incomplete data collection and insufficient feedback from mHealth implementations. There must also be capacity to use the collected data. The benefits of mHealth can only be fully realised if individuals are assured of the privacy of their health information, and if governments are confident that the information is secure, and its integrity maintained. It is therefore important to develop systems and strategies for ensuring the security, integrity and privacy of health information.

Conclusion

The main drivers for mHealth in Africa include high mobile penetration, increasing mobile subscriptions and the high burden of disease. Several opportunities for implementing mHealth projects exist in providing health education and creating awareness, personalised and remote patient monitoring, disease surveillance, and building clinical decision support systems. Possible challenges to full-scale and sustainable deployment include low health literacy levels; poor network, power supply and hospital infrastructures; socio-cultural barriers; and lack of political will by governments to support mHealth projects. Most mHealth projects in Sub-Saharan Africa do not advance beyond the pilot stage. To build scalable and sustainable mHealth systems that will enable the region to meet the UN Sustainable Development Goal 3 of health and well-being for all by 2030, there is need to foster strong public-private partnerships, to develop mHealth systems that can be easily integrated into existing healthcare systems, and to develop health information systems that ensure the security, integrity and privacy of patient data.

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