The Role of Mobile Health in the Developing World: A Review of Current Knowledge and Future Trends

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***Abstract*— The current use and development of Mobile Health (mHealth) applications is on the rise in the developing world. mHealth applications are being used in the developing world to improve health education and awareness, diagnostic treatment and support services, data collection and remote monitoring services, surveillance, emergency medical services and other healthcare services. This paper provides an overview of healthcare systems in the developing world and addresses the role of mHealth applications in improving healthcare delivery. Issues on technical and policy issues are also discussed as well as the future trends for mHealth technologies.**

***Index Terms*— Mobile health, mHealth, Developing countries, mHealth potential, Challenges, Saudi Arabia.**

I. Introduction

THE proliferation and adoption of mobile phone technologies within the developing world has created an opportunity for governments and healthcare institutions to reach millions of people who otherwise would have been out of reach. Even though many of the studies today in both the developed and developing world focus on mobile phones as a primary mobile health (mHealth) intervention, it is only one of the many mHealth technologies in use today. mHealth technologies are classified into the following categories: mobile phones, smart phones, mobile tele-health devices, MP3/MP4 players, and mobile computing. A study by the United Nations Foundation and Vodafone Foundation has listed 51 mHealth programs that are operating in 26 developing countries all over the world. These programs and projects focus on six main areas: treatment and support services, health education and awareness services, data collection and remote monitoring services, disease surveillance and drug adherence services, health information systems and point of care services, and emergency medical services [1-3].

Developing countries are struggling to provide adequate healthcare to the needy people, especially in the rural areas. Availability of accessible and quality healthcare services has been the key challenges in the developing world. mHealth technology is considered to be the fastest growing phenomena in healthcare [4] with around eighty percent of rural areas in the developing world having access to the mobile networks [5-7]. Although mHealth is still in its early stages of development, it has already started to transform healthcare delivery due mainly to the success of mHealth applications and programs that have been implemented in the developing world. The goals of implementing these mHealth applications are to enhance the efficiency and the accessibility of healthcare systems and to reduce the mortality in developing countries [2]. These features have the potential of greatly improving the healthcare systems in the developing countries, which will improve the quality of life for millions of people [8,9]. Rajput et al. [10] developed and implemented a mobile device-based system for home-based care in developing countries and concluded that using such system was viable and cost-effective for data collection and facilitating the work that then leads to improvement in healthcare outcomes. Currently the healthcare system in the developing world is witnessing a cultural shift from a traditional approach that relied on the patients following the doctors' orders without their involvement in decision making to a more patient centered approach where the patient is equipped with information and knowledge gained from easy access to modern technology, as reported by The Boston Consulting Group [11]. Given the increasing use and reliance on the mobile technology, we believe that using mHealth in the developing countries, and the Arab world in particular, will positively impact the healthcare outcomes and will significantly increase the access to the healthcare systems.

Manuscript received January 22, 2014.

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II. The Need for mHealth in the Developing World

The primary purpose of a healthcare system is to address people health needs and provide high quality of services. The technologies that are currently being used in healthcare sector have provided much hope for a significant improvement in population health on account of their wide-ranging accessibility. mHealth is one of the most effective communications technologies that support healthcare services in many countries all over the world. In the developing world, the main factors that are conducive to the implementation and

use for such tools are poor access to healthcare, higher healthcare costs, emerging diseases, and sub-standard healthcare quality [7,12,13]. According to Jeannine [7], the factors that have led to the current rapid development of mHealth in the developing world are the growth of mobile phone users, the need to treat many people in the rural areas, the lack of timely disease control, decreasing cost of mobile phones, the cultural factors, the shortage of healthcare workers, and the lack of resources and infrastructure.

The mobile market in the developing world is considered to be the most rapidly growing sector -from the world's 5.3 billion people that were using mobile phones in 2010, 70% were from the developing world [14]. In India, a country with 1.21 billion people, the number of mobile subscribers increased from 652 million in 2010 to 858 million in 2011 with a better coverage in the rural areas [15]. The number of mobile users in Africa has jumped from 280 million in 2007 to around 600 million in 2012. This has made the mobile phones to be the most widely used computing devices for the Africans [16,17]. Furthermore, 49% of Nigeria's population had used mobile phones in 2009 [18]. The Arab world, and Saudi Arabia in particular, has witnessed a significant expansion in the field of technology and communication. Saudi Arabia is considered as the second biggest market for mobile phones in the Middle East. The usability of mobile phones with their attractive capabilities is on the rise especially among the teenagers. Saudi Arabia recorded a high mobile penetration rate (186%) compared to the developing countries average of 73%, and the developed countries average of 116%. Recently, the advanced wireless fourth generation (4G) technology has been made available in Saudi Arabia with its large bandwidth and a faster transfer rate, and it is expected that Saudi Arabia will be the leading 4G market in the Middle East by 2016. Additionally, the amount of internet usage in the Arab world in general and Saudi Arabia in particular has risen over the past few years to about 41% at the end of 2010, which is one of the highest in the developing world [19-22].

In view of this rapid expansion in the usage of mobile phones in Asia, the Middle East and Africa, mHealth can be the most effective and accessible way to solve many issues in the healthcare sector of the developing world. According to the World Bank [14], the world's attention to health has been on controlling communicable and chronic diseases such as HIV/AIDS, malaria, tuberculosis, heart diseases and diabetes. mHealth can play a major part in halting the spread of these diseases and improving the quality of life for millions, for instance, by expanding the healthcare services, increasing the awareness and encouraging behaviors that limit infections. In addition, maternal and child health is another major concern in the developing world. For instance, in Bangladesh, the possibility of surviving to the age of 10 years is 24% for children who lose their mothers compared to 89% for children with living mothers. mHealth can deliver valuable information to the people who struggle with this problem [2,9,14,16]. Furthermore, mHealth can be used to monitor epidemic diseases. As stated by the Pyramid Research [18], Non-Government Organizations (NGOs) monitor the spread of pandemics and viruses, in Africa, Asia and Brazil, through use of mobile networks and satellite communications. By undertaking this kind of health surveillance via mHealth tools, the progress of these diseases can be delayed or stopped, the financial cost of the diseases can be reduced, and the quality of patient life can be improved [17].

Although several countries in the developing world have limited resources, they can still employ mHealth tools to ensure the high quality of healthcare services. mHealth can support the monitoring of health workers, and can help in controlling the distribution and use of fake drugs. In addition, mHealth can provide timely information for medical, educational and emergency situations thereby helping in the allocation of the right resources for the right individuals. For example, a call center in India is using mobile phones to collect information from patients trying to find emergency care and then sends ambulances with the needed equipment for each case. Another example is the Nokia pilot project in Brazil which supports NGOs and health organizations in gathering, communicating and saving data using smartphones with internet connectivity [11,14,18]. Some countries in the Muslim developing world have specific religious values concerning interaction of males and females. mHealth can be an effective tool to service people without infringing on their religious beliefs. For example, women can use mobile devices to contact their health providers without presenting for the face-to-face contact. Additionally, some matters with associated cultural sensitivities such as family planning can be handled secretly via mHealth [14]. mHealth applications can also allow elderly and disabled people to communicate with healthcare workers without leaving their place which can improve the delivery of care for such cases [14]. For instance, Philips Lifeline medical alert product has permitted aging individuals to access the emergency services with one click of a button [18]. The shortage of the human resources has increased the burden on developing world's healthcare systems and according to the United Nations Foundation [2], the countries in the developing world have an acute shortage of healthcare workers. mHealth can be the solution in this case as the healthcare can be made accessible and effective even with a reduced number of the healthcare workers [23].

Short messaging service (SMS) - an important feature of mobile communication - can be used for a quick transfer of health information such as delivering reminders. As stated by Piette et al. [12], 60% of the high income countries and 30% of the low-and-middle income countries are using the SMS to improve the patient treatment compliance. In a trial related to smoking cessation, the percentage of people quitting smoking doubled after 6 months of receiving "txt2stop" messages on their mobiles [7,12,24]. In the Arab World, growing cost, shortage of trained staff, and increasing prevalence of lifestyle related diseases such as diabetics, all have negatively affected the quality of healthcare systems [4,24,25]. According to the World Health Organization (WHO), the rate of chronic illnesses, such as diabetes and heart diseases, in the Arab countries is higher than the African and Asian countries [26]. mHealth can provide a reasonable solution in the disease

management and real efforts are already underway to improve the healthcare services in the Arab World. Mplushealth conference is conducted annually, which is the only platform where healthcare specialists, insurance providers, telecommunication decision-makers and government managers are meeting to discuss the potential, issues of concern, and roll-out of mHealth in the Middle East. Qtel group is working to help patients manage their health easily and efficiently in the Middle East. It is delivering a few mHealth innovative solutions and also undertaking various studies on the need for developing new mHealth applications in the region. In 2011, Qtel group announced partnership with Mobile Health Company in Saudi Arabia with the intention of providing guidelines and healthcare instructions through mobile phones. Also, patients in Iraq and Kuwait are supported with different SMS/MMS information, educational services, and health tips from Qtel group [4,24,25]. In Saudi Arabia, the readiness of the citizens to adopt new technology, the accessible and increasing use of mobile phones, and the availability of good technical mobile infrastructure have presented a worthy opportunity for mHealth applications that are able to provide high quality of services for all citizens and residents [19].

The developing world has a clear need for innovative and effective solutions for its healthcare issues. Based on the above narrative, mHealth is essential in sorting out the healthcare issues of the developing world and can strengthen the healthcare systems [1,2]. mHealth can provide both clinicians and the patients with a better and flexible way to manage and improve the health and has also supported the delivery of quality healthcare to many people in the remote areas [2,15,17,24]. We will witness a rapid development in mHealth technologies over the coming years. This expansion will help in bridging the gap in healthcare based on several factors: first, mHealth technology will be widely available at a reasonable price and high performance; second, mHealth is public centered and can be accessed from anywhere at any time; third, it provides timely and high quality healthcare; fourth, mHealth and its applications are empowering people as well as enhancing preventive care; fifth, it fills the gap in health funding and the shortage of healthcare workers. The potential of mHealth, however, is wide-ranging and is not only limited to the above-mentioned five factors [27].

III. mHEALTH CHALLENGES IN THE DEVELOPING WORLD

As we have noted above, mHealth can provide a great opportunity to solve several issues in the current healthcare systems, and can help in improving the quality of healthcare in the developing world. On the other hand, various challenges and barriers can also affect the success of this new health-technical innovation.

First, although the mobility feature has made it easy to access mHealth tools in the developing world yet many network challenges remain that can reduce its effectiveness. The internet is unreliable and/or expensive in many of the developing countries and that presents a real barrier to the mHealth implementation. As a result of the limited internet connectivity, various countries are not able to access health information. The voice recognition mobile phone application can be a very supportive tool for providing the healthcare in countries with the high levels of illiteracy but this kind of application requires a third generation (3G) network which is not currently available in many of the poor-resource countries in the developing world [28,29].

Second, mHealth can be a good solution for communities with unique culture and customs such as the developing world, but at the same time this cultural diversity may restrict the implementation of mHealth applications. People in these countries have different cultural values, beliefs and customs which affect their health behaviors and reduce their ability to take control of their health. One of the solutions for that diversity is to customize mHealth applications so they can meet the community needs [14,17]. Besides, illiteracy as well as a range of spoken languages in the developing world is another barrier that could reduce the benefit of mHealth tools such as SMS text massaging [5].

Third, the security and privacy of the transferred information is another important challenge [22,23]. A serious concern about violations when dealing with electronic communication was revealed by the 1996 Health Information Portability and Accountability Act (HIPAA), which is responsible for protecting the personal health information [17]. Some personal devices, such as the cellular phones, smartphones and PDA, have limited security features that cannot restrict unauthorized access to confidential information or they have difficult security mechanisms which reduce the accessibility of the device itself [13]. In addition, many people are worried about losing their devices that contain personal medical information, thereby predisposing the people to exploitation by illegal individuals [4,30,31].

Fourth, another barrier is the cost of mHealth devices. While mobile devices are becoming affordable for many people in the developing world, they are still expensive for a large majority especially in the rural areas [5]. In addition, customers in the developing world are mainly using mobile phones with chargeable minutes: additional minutes are required for health consultation or personal health monitoring which might be unaffordable for numerous people in the developing world [17]. In South Asia and Africa, women are less likely to own a mobile phone compared to men due to the cost, illiteracy and unavailability of electricity. People usually own a mobile phone for business needs and they borrow a phone from a short time for any other purpose [32]. Some developing countries also have a low adoption rate for mHealth applications as it is difficult to achieve a higher return on investment on such applications [30,33].

Fifth, lack of required education, the needed knowledge, and availability of relevant training are also important hurdles in the effective use of mHealth applications. The low education and few health literacy skills in some countries of the developing world lead to low utilization of mHealth applications. The health professionals are also required to have a high level of knowledge and skills to use mHealth

technology safely and effectively [29]. In general, old people are slower to accept any new technology compared to the young ones. For that reason, good education and strong training can increase the old users' acceptance of mHealth technology in the developing world [33]. Besides, the availability of many mobile devices with lack of service support can add extra challenge for both patients and clinicians. All these issues result in users' resistance or medical treatment errors [4,29].

Sixth, the current policy environment and the absence of mobile phone usage guidelines and standards also impact the expansion of the mHealth projects in the developing world [7,22]. Usually, there is almost never a single "owner" of the health systems elements which affect the integration and the interoperability. A need for an agreed upon mHealth technical architecture as well as data exchange standards is essential to overcome this barrier. Moreover, the governments in the developing world prefer to wait for broadband networking before implementing health related applications. This leads to unnecessary investment barrier to the mHealth deployment. To solve this issue, policies are needed to indicate the mHealth goals and objectives and take benefit of the current commercial wireless networks [30]. Specific policies must be added in order to use the advance features of the mHealth technologies. Additionally, all parties must be involved in the designing and implementation phases in order to develop the most effective mHealth applications for their countries [7].

Seventh, another important barrier in the developing world is to develop mHealth applications based on the community needs and resources. Commonly, in the developing world, rural and urban areas have dissimilar resources which may affect the mHealth structure and content. Rural areas suffer from poor infrastructure and lack of healthcare workers thus requiring a high-quality medical products and services to overcome this shortage. On the other hand, urban areas have their own specific problems. Higher population number, unequal distribution of resources, and unhealthy diets all lead to different needs and expectations from the health system [14,34]. In addition, some countries in the developing world have shortage of capacity and resources for the health research institutions which limit their ability to design and develop mHealth applications based on the population needs [15].

Last, the quality of mobile services in the developing world is another major challenge. The mobile service quality is influenced by a range of things such as the mobile device, the mobile network, information system, the information itself, the reliability, flexibility and usability of mHealth applications, cost, security, and cultural factors [1,23,30]. In addition, the service quality includes the battery life and memory storage of the mHealth devices. By controlling for these factors, the efficiency of mHealth services will be greatly enhanced [30,33].

To summarize, although mHealth presents with many opportunities in the developing world, various significant challenges and barriers remain. These issues require serious consideration and research as well as efficient involvement from the governments, NGOs, various other stakeholders with an interest in this matter, and the health providers who will benefit from this much-needed technology.

IV. Future Directions

There are clear and distinct differences among countries in the developing world at the economic level, availability of the technical infrastructure, the network generations, the cultural practices and the literacy stages. However, the future of mHealth in all of these countries is likely to be bright. As stated by the United Nations Foundation [2], the main technology trends in mHealth will be the same as what has been categorized in the technology improvement in the past 40 years, i.e., reducing diseases, enhancing speed of networks and decreasing costs. mHealth intervention has clearly shown a great enhancement of health and lives for numerous people in the developing world. In the future, more pilot projects will be implemented based on specific needs of the countries. If a project considers the community needs, use available technology, improve the control of individual's health, and collaborate with local organizations, there will be a great chance for its official acceptance and usage [35].

Vital Wave Consulting [3] has revealed that, in the next 15 years, the healthcare policy makers and providers in the developing world will focus more on prevention instead of treatment of non-communicable diseases and the issues related to the aging population. Although it is expected that these countries will have shortage or unequal distribution of healthcare workers, mHealth will be used to overcome these issues due to its benefits in the areas of relative low cost, broader coverage and timely health solutions. The advance technologies, such as new network generations, WiMAX, intelligent mobile devices, and dedicated wireless devices, will support the mHealth applications to reduce the impact of such health issues and provide more valuable solutions [3]. Some countries will soon be able to use 4G technology which will provide additional benefits to ensure cost-effective high data transmission rates and larger bandwidth that will reduce the gap in medical care [22,29]. Text messages applications will remain relevant with large scale deployment in other new areas of healthcare. Various reports have shown that the number of smartphone users will grow rapidly and as a result, additional smartphone applications will be developed to be used in many healthcare services such as home management of chronic diseases or supporting people to adopt a healthy lifestyle [35].

According to West [31], in the future doctors and patients will use mobile devices to manage numerous health issues and for that reason the remote monitoring will heavily depend on mHealth market all over the world including the developing world. Besides, mHealth applications will use images and video tools in addition to text messages for specific health fields such as diagnosis, consultation and follow-up. Different sensors in the mobile phones will be used in the healthcare field, for instance, the data will be provided by camera, GPS, acceleration sensors, and processed by custom mobile applications which will then be sent using SMS or MMS tools.

Moreover, some telemedicine applications will be developed to send visual information via mobile phone cameras [35]. Also, speech recognition technologies will be integrated with the mHealth application to increase the use of interactive speech by both doctors and the patients [33].

With regards to the mHealth economic impact, mHealth will be expanded in the number and types of initiatives. It is expected to reach a multi-billion dollar industry by 2017. According to West [31], the PwC report has estimated that annual revenues will reach US$23 billion worldwide including US$6.8 billion in Asia, US$1.6 billion in Latin America, and US$1.2 billion in Africa. As soon as communication and delivery services are improved and transmission errors are reduced, the mobile device will play an active part in the economic growth and healthcare improvement throughout the world including the developing world. In addition, the use of mHealth applications will help consumers and healthcare workers in the developing world to become more educated and proactive in looking for the best healthcare services that have the potential to improve their health and support their economics [14].

In the Middle East, mHealth is growing at an impressive rate. According to Pillai [4], it is predicted that the size of healthcare marker in the Middle East will increase to US$100 billion in the next 15 years. The regional governments are heavily investing in the healthcare sector to enhance the services and improve the quality of healthcare. For that reason, new and advanced technologies such as mHealth will certainly be a part of daily living [4]. In Saudi Arabia, the availability of advanced technical and economical infrastructures in addition to the usability of various resources will greatly support the implementation of mHealth. It is estimated that by 2016, Saudi Arabia will be the leading 4G market with just above 11 million 4G subscribers. Moreover, it is expected that smartphone penetration rate will increase from 25% in 2011 to 49% in 2016 [20]. As a result of these services, the data mobility will be enhanced, the delivered information will be up-to-date, and the citizen's services will be more effective and efficient. All citizens will be able to access the internet over wireless networks using smartphone applications and other wireless devices to manage their personal health information, monitor and diagnose their health conditions and improve the quality of their life [19,20]. The strong and stable implementation of wireless technologies supported by the availability of educated generation and efficient financial planning will increase the adoption of various mHealth applications in Saudi Arabia [36].

V. CONCLUSIONS

The published literature and the technical papers have clearly documented the current status and the challenges of mHealth in the developing world. There is an essential need for using mHealth to overcome various healthcare issues. Facts revealed that various challenges and barriers exists, however, good planning and effective solutions will enable the developing countries to reap the maximum benefit of mHealth technology and improve their healthcare services as well as enhance the quality of people's life. We believe that mHealth offers an effective solution for various healthcare issues in the developing countries. In spite of the challenges, the developing countries have the capability to control these issues. With time, the mHealth applications will be used by all people regardless of their education level or social classes. They will remotely monitor their health information, consult their doctors, see their high quality health-related images and videos whenever and wherever they want, and use the valuable applications to control their health at home which will result in healthier communities in the developing world.

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