Technology matters! Sustaining eHealth in developing countries: Analyses of mHealth innovations

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Abstract

Focus on eHealth implementations in developing countries have been on 'soft' social aspects to the detriment of the technology ones. This paper addresses this erroneous omission. Case study analyses of six mHealth projects from developing countries are employed for this purpose. Mobile or portable computing devices and different wireless networks are technological innovations enabling health workers' access to medical information in these countries. Organizational benefits, afforded by the mHealth systems enabled, effective and distributed medical knowledge management, with improved health system performance attained. Patients' outcomes are also reportedly improved. Successful implementations of these mHealth cases were mostly informed by the mobile/wireless technologies adopted. Therefore, minimising failure of, or maximising success of, eHealth implementations in developing countries should consider incorporating technology factors, vis-a-vis mobile/wireless ones into their design processes.

1 Introduction

Using mobile/wireless information and communication technologies (ICTs) has transformed health care operations not only in developed countries, but also in developing ones. This application of ICTs in healthcare has been termed eHealth [1].

Mobile eHealth, or mHealth, involves using wireless technologies such as Bluetooth, GSM/GPRS/3G, WiFi, WiMAX and so on to transmit e-health data and facilitate services. Usually these are accessed by the health worker through devices such as mobile phones, Smartphones, Personal Digital Assistants (PDAs), laptops or tablet PCs. Health data stored on devices such as USB memory sticks and memory storage (SD) cards can also be regarded as mHealth tools. Emerging research works, on mHealth in developing countries (DCs), are reporting already, the positive impacts these tools have on healthcare delivery in these regions [2-5]. Aside, the relevance of mobile/wireless technologies to most DCs' telecommunications infrastructure needs [6] warrants closer attention to how these can be successfully employed for innovating their health systems. For example, evidence from DCs has shown that mHealth systems have enabled rural health workers to access e-learning through PDAs and mobile phones over GPRS network in a large-scale project [5]. Improvement in organizational data collection and knowledge management, made possible by the mHealth system, has also transformed organizational decision making in this project. Improvement in quality and access to healthcare, especially for rural-based populations, has also been witnessed in another mHealth project from a DC [7].

Regarding technology diffusion studies in DCs, publications have often focussed narrowly on social and developmental impacts of mHealth on health systems and workers, without paying due attention to the also important technological aspects. This focus on the 'soft' side of information systems to the detriment of 'hard' ones has been implicated as a cause of failures [8]. In this context, by failure we mean the inability of eHealth projects to achieve the set-out or intended organizational objectives. Project failure, an unintended consequence of this focus, is a common feature of eHealth projects globally and also in DCs [9, 10]. Moreover, this lopsided view of mHealth has also diverted attention from the integral roles that hardware and software play in building successful eHealth systems. Henceforth, a departure from this narrow focus will assist in ensuring e(m)Health projects' success.

This paper therefore aims to address the gap. This will be through case study analyses of mHealth projects in DCs. These cases involve equipping community based health workers in DCs with mobile technologies for their primary healthcare activities. The next section of this paper will provide a brief introduction to the use of mHealth for tackling health problems in DCs. This will be followed by a section, summarizing the technologies adopted in these mHealth cases. The discussion section will follow next and ending with the conclusion section.

2 mHealth and health problems in DCs

Health systems in DCs have to tackle a double burden of chronic and infectious diseases facing their populations. Scarce financial resources, coupled with the brain drain, have led to the loss of mostly high and medium level health workers. The Millennium Development Goals (MDGs) set

out by the United Nations in 2000 provide targets for tackling the disease burdens in developing countries.[11] The health-related MDGs are:

- to reduce child mortality from childhood diseases;
- to improve maternal health;
- to combat HIV/AIDS, tuberculosis (TB) and malaria

These diseases are burdensome to the health system and have affected the fabric of society. Timely achievements of the health related goals of MDGs (according to the World Health Organisation–(WHO) can be attained by adopting the principles of the Alma Ata Declaration of Primary Health Care (PHC) [12]. This implies that the PHC service model could provide the best approach to the management of MDG-health related goals in DCs. Community Based Health Workers (CBHWs), as long standing providers of primary healthcare in many DCs, are the focus of this paper.

Supporting, health workers in DCs with eHealth has been the strategic focus of many national and global health policies. The WHO has proposed eHealth for improving the quality of healthcare service delivery and to build up health workers' capacity especially at the primary healthcare (PHC) level[13].

Most e-health development in DCs has since been aimed at employing mobile/wireless ICTs for PHC service. The next section will summarize the hardware and software employed in five mHealth projects from these regions.

3 mHealth Case Studies

Case study analyses of six mHealth projects from developing countries have been carried out. mHealth projects from India in Asia, Uganda and South Africa from Africa and Peru from South America were employed for this analysis. The mHealth hardware and software (collectively regarded as innovations in this paper) are summarized in the table below.

Case	*Technological innovations*
Ca:sh	*PDAs* *Compact storage card (SD)*
EHAS	*VHF wireless networks and transceivers* *Wi-Fi wireless networks and transceivers* *Wi-Fi cards and routers* *Laptops* *Email*
Cell-Life	*Smartphones and mobile phones* *SIM cards* *SMS/GSM/GPRS/3G* *Mobile web*
Jiva TeleDoc	*Smartphones* *GSM/GPRS* *Mobile web*
UHIN	*Personal Digital Assistants* *Portable wireless servers* *GSM/GPRS* *Mobile email*

4 Discussion

Analyses of these mHealth case-studies have provided some insights into different technological innovations being used by health workers in DCs. The types and nature of infrastructure and devices are presented. Barriers to their sustainable adoption and diffusion are also discussed.

4.1 Wireless Infrastructure

The EHAS with Wi-Fi wireless networks provided more bandwidth for the CBHWs to be able to conduct, store and forward e-mail teleconsultations. This was evaluated to have a positive impact on their PHC activities and improved patient outcomes were observed [14]. The innovative use of long distance Wi-Fi wireless networks made it possible to connect rural HPs and HCs with urban-based hospitals thereby making it possible for CBHWs to seek second opinions during clinical encounters. Moreover, patients' referrals were effectively coordinated through e-mail and voice communications over VHF and "Voice over Internet Protocol" (VOIP) over Wi-Fi networks. Recently, internet access through broadband Wi-Fi networks has been provided for CBHWs in the EHAS innovation for web browsing [15] which can be employed for real-time telemedicine services.

The TeleDoc innovation also enabled CBHWs to conduct web-based near real-time teleconsultation through a GPRS public cellular network [3]. This innovation empowered the CBHWs to be able to offer quality PHC services to usually underserved rural communities through second opinions obtained from urban-based physicians. In addition, PHC telepharmacy services were implemented, as drugs prescribed during any clinical encounter are delivered to the patient's home through a sort of "community courier network" [16].

The UHIN innovation employed store and forward model (also on GPRS wireless networks) to deliver eLearning services. This has been anecdotally reported to be beneficial to the CBHWs' learning and grasp of PHC procedures [5]. The Cell-Life innovation, on the other hand, enabled voice teleconsultation by CBHWs with their supervisory clinical nurses over GPRS/3G wireless networks [17]. This, together with their ability to collect data and access their electronic medical and drug records on a real-time basis, has empowered them to improve the people living with HIV/AIDs (PLWHA) clinical outcomes [17]. In contrast, the Ca:sh innovation is the only project considered here without any form of wireless connectivity–rather health data was collected and transported on a storage card to the nearest district hospitals [2].

These different mHealth innovations have some implications on how CBHWs communicate with and work within the district health system (DHS). For instance, whether voice or data media is employed could have impact on CBHWs' PHC activities. Voice communication employed by the CBHWs in the Cell-Life and EHAS innovations allowed real-time communications between CBHWs and their superiors while on the field. Even simple SMS proved effective in the Cell-

Life innovation for data transmission [17], but with a limit of just 160 words, it will not be able to support effective health data transmission required for advanced eHealth services.

4.2 Of Voice, SMS and Broadband

Healthcare is knowledge-, information- and process-intensive endeavour where patients' data such as electronic medical records and even images and video in cases of telemedicine purposes are exchanged. Voice alone will therefore be not adequate enough for quality e-health applications. Quality e-health applications will require connectivity and access technologies with broadband and internet capabilities. Supporting this view is a recent programme in rural South Africa where a low-cost wireless Wi-Fi-enabled eHealth network has enabled CBHWs to conduct both web-based real-time and store and forward teleconsultation sessions with urban-based doctors during clinical encounters [7]. Here the impact on quality eHealth services has been rated positively by the CBHWs.

The increasingly emergent nature of mobile/wireless telecommunications in numerous developing countries [18] makes internet access to CBHWs more feasible. The EHAS innovation's move towards low-cost Wi-Fi networks for providing the required bandwidth for internet access and web services to support their CBHWs is a good example of this kind [15]. Moreover, the EHAS innovation has also demonstrated how even simple e-mail can assist in enabling CBHWs' communication with the DHS [4]. The use of GPRS (bandwidth similar to a western home broadband of about three years ago) in the UHIN, Cell-Life and Jiva TeleDoc innovations are moves in this direction. More bandwidth is also accessible through increasingly available 3G networks in most developing countries, and already being used in the Cell-Life mHealth innovation [19]. Also, the use of increasingly available CDMA and WiMAX for e-health purposes is also expected in the near future. Even with the limited GPRS network, personalised e-mail accounts are currently being piloted with CBHWs in the UHIN innovation [20]. These mHealth innovations make the case for providing broadband access to support CBHWs' eHealth activities beyond the previous focus on SMS and voice.

Interestingly, the Jiva TeleDoc innovation had on their strategic plan to incorporate video and audio functionalities to m-health innovation so as to enable and improve patient care through real-time teleconsultation. The embedded camera on the mobile device was proposed for use in this. However doubt has been expressed whether the existing GPRS network will or can support video teleconsultation due to its limited bandwidth [21]. This issue highlights some of the various barriers encumbering the full exploitation of mHealth innovations for supporting CBHWs in DCs.

4.3 Device Forms and Shapes: Mobile phones or Laptops?

The type, nature and size of the devices used in the m-health innovation cases also had impact on the CBHWs. In the TeleDoc innovation, the Smartphones employed enabled almost real-time access to health data over the internet which assisted the CBHWs "bed-side" decision making [3, 16]. However, in the UHIN innovation, similar and newer devices are currently being considered to replace the old PDAs deployed three years ago [22]. This is to allow CBHWs to be able to analyse collected health data on the devices for immediate decision making. Notwithstanding the termination of the Ca:sh innovation, its customization of deployed PDAs to the CBHWs' environmental contexts should be regarded as ingenious [2]. As CBHWs usually work within the community outside their protective HCs or HPs, their devices are usually prone to excessive heat from sunlight and also from dust in their environment. To forestall this and to improve the devices' durability, they were tropicalised in order to optimize their performance [2]. An action-oriented research focussed on developing appropriate mobile computer devices for CBHWs in a DC has also found this innovative engineering as important to sustainable mHealth innovation diffusion [23, 24].

First generation mobile phones were initially deployed with the CBHWs in the Cell-Life case because of the security concern of carrying about an expensive device in a crime-ridden environment [25]. However, due to negative impacts on the CBHWs' healthcare activities, newer devices including Smartphones and advanced PDAs were subsequently deployed. It has therefore been reported that these newer technological innovations with bigger screens, improved and longer battery life and ability to receive feedback on sent information were rated positively by the CBHWs [25]. Longer battery life is very important as most developing countries do not have the guaranteed and continuous power supply required for recharging device batteries, especially in the rural regions. The effect of this environmental constraint was also reported in both the UNIN and EHAS innovations. There, solar energy was adopted to overcome this constraint [4, 5].

As these different device characteristics could impact on CBHWs' PHC activities by ensuring sustainable m-health innovation's diffusion, a case can be made for newer advances in mobile ICTs. Low-cost laptops currently epitomised by the One Laptop Per Child (OLPC) [26] device (codenamed XO1), presents a opportunistic solution for developing countries' CBHWs. The XO1 is built to withstand the harshest environmental conditions with an intuitive user-interface. It could enhance the sustainable diffusion of m-health innovations for CBHWs in developing countries. XO1 and its inspired competitors have bigger screens, longer battery life and more processing power. Consequently, they have more to offer developing countries' CBHWs than smaller PDAs and mobile phones. In addition, the presently quoted cost of USD180 is more or less equal to or competitive with the costs of mobile phones and PDAs.

Advanced eHealth applications such as ECG, digital stethoscope, electronic health records and teleconsultation

web services are currently being pilot with the XO1[1]. The advanced camera and wireless connectivity embedded on the XO1 could also be very useful for real-time teleconsultation between a CBHW and a remote superior as proposed in the Jiva TeleDoc case.

Moreover, laptops were initially deployed with the CBHWs in the EHAS case but these were not sustainable because of frequent breakdowns induced by "technology-environment misfit" [27]. Most of these laptops have since been replaced with cumbersome, power hungry and archaic desktop computers.

Conclusion

Frequent misalignment between hard and soft aspects of eHealth projects in DCs has been observed as a major cause of failure of initiatives and of wasted resources [9]. Often there was a lack of coherence between social and technological aspects of eHealth system design and practice [10] [28]. The technological innovations from the above m-health cases are representative of increasing use of mobile/wireless ICTs within the health systems of developing countries.

The use of different mobile/wireless technologies demonstrates that health workers in DCs can employ them for meeting organizational healthcare objectives. Portable devices such as mobile phones, PDAs and laptops make it possible for health workers (HWs) to access medical eLearning, clinical decision support systems (CDSS) and EHR software for their clinical activities. An advanced eHealth application, like telemedicine, is even possible with rural HWs in DCs. Wireless networks such as Wi-Fi, GSM/GPRS and the increasingly available WiMAX and CDMA will ensure that HWs in DCs are always connected for communication, coordination and cooperation with other health system actors and systems. Obviously, the move from voice-based eHealth applications to data and video applications as observed in these projects is made possible by the increasingly affordable wireless broadband technologies and high performance computing devices. As a result, the effective and quality delivery of healthcare services in DCs is now being made possible through medical knowledge capture and exchange.

The nature of eHealth technologies employed in these cases is representative of the practice in most DCs. The reason is that traditional wire-line networks and desktop computers are not available and affordable in these countries. The ease and better speed of installing wireless networks and the amenability of mobile/portable devices to the environmental threats of irregular power supply and harsh climatic conditions are further reasons for supporting this assertion.

Finally, preventing or minimizing e(m)Health projects failure will be attainable by adopting these technologies, and understanding that they are also important to the successful eHealth implementations in DCs. This is bearing in mind that successful eHealth projects will help in empowering HWs in tackling health problems in these countries.

[1] http://wiki.laptop.org/go/Health

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