Socio-technical Arrangements for mHealth: Extending the Mobile Device Use and Adoption Framework

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Abstract. This paper extends the mobile device adoption model by Sarker & Wells [1]. We extend this model from being focused on individuals, to discuss intra and extra organisational socio-technical arrangements that interplay with mHealth solution implementation and adoption, in low resource contexts. Among others, highlighted factors include user characteristics, influence of supported work, modality of user mobility, technological characteristics, change management, and other contextual factors such as economic, social, and political factors. This is done by reviewing an mHealth initiative from Malawi and related mHealth literature. We argue that the above mentioned factors form the installed base on which solutions are built, and continuously interplay with the use of mHealth solutions, thereby influencing adoption outcomes.

Keywords: mHealth, heterogeneous, information infrastructure, socio-technical.

1 Introduction

The penetration of mobile phones and other mobile technologies in developing countries has spurred increased diffusion of mHealth applications [2, 3]. Some areas of application include the use of mobile phones to enhance communication between medical personnel and community health workers [4], digitization of records and data reporting [3, 5], education and awareness, remote monitoring, communication and training for healthcare workers, disease and epidemic outbreak tracking, as well as diagnostic and treatment support [3].

Despite the promise shown by mHealth as regards enhancing care delivery in low resource contexts, the implementation of such solutions is not always easy and smooth sailing. The adoption and use of mobile devices interacts with and is influenced by a multiplicity of factors [1, 6, 7]. Similarly, mHealth involves the convergence of heterogeneous socio-technical arrangements. These, among others, include mobile and desktop health information systems, as well as people and healthcare processes, facilitated by both wired and wireless connectivity [8]. Thus, mHealth implementations can be considered information infrastructures. Information

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infrastructures are *"shared, evolving, heterogeneous installed bases of IT capabilities among a set of user communities based on open and/or standardized interfaces"* [9:pp 208]. This necessitates the need to understand and continuously investigate multiple system development and implementation issues, to enhance the continued adoption and use of mHealth solutions. According to Yu et al. [8] such issues include healthcare workers' information needs, workflow and usability requirements, available technology options, and how best technology can be adapted to suit these needs and requirements. The ensemble of such heterogeneous socio-technical factors, can be referred to as an *installed base* [9], through which solutions are constructed. Thus, the complexities of the installed base are critical to successful implementation of mHealth solutions.

This paper extends the mobile device adoption model, proposed by Sarker and Wells [1], which is individual user-centric, to discuss mHealth use and adoption, which interacts with multiple intra and extra organisational arrangements. Sarker and Wells [1], argue that mobile device use and adoption is influenced by factors such as user characteristics, modality of user mobility, type of supported work, technological characteristics, as well as economic, social, and political factors. In extending their model, we have added extensions to some of these factors but also added the dimensions *change management and research*, to the model. Our arguments have been developed by applying the model by Sarker and Wells [1] to an mHealth implementation from Malawi, as well as reviewing extant literature on mHealth. The rest of this paper is organised as follows: firstly, we present the methodology employed by this research. This is followed by a review of relevant literature. Following the literature review, we present the mHealth solution from Malawi. This is then followed by a discussion of our findings. Lastly we present our conclusions.

2 Research Methodology

This paper is based on a review of literature and a mobile phone-based Anti-Retroviral Therapy (ART) protocol developed by Baobab Health Trust. The solution was developed to automate a paper-based protocol used by HIV/AIDS counsellors, under the Malawi AIDS Counselling and Resource Organization, during consultations with patients and when deciding on referrals for the patients. This case review is partly based on first hand experience of the second author, who is the solution's lead developer. The author's experiences were supplemented by in-depth discussions, on the solution, between the two authors. In addition, we have reviewed literature on mHealth adoption and associated challenges, with a focus on developing countries. Sense making of findings used in this paper is guided by the interpretive paradigm. The paradigm builds on the fundamental assumption that knowledge is socially constructed [10]. Interpretive research is therefore focused on investigating and understanding phenomena by considering meanings subjects under study attribute to such phenomena [11]. This, allows a researcher to describe, interpret, analyze, and understand the social context of elements under study [12]. Adopting this paradigm was therefore critical to this study's analysis of socio-technical factors of interest that together shape the implementation, management and use of mHealth information infrastructures.

3 Literature Review

mHealth comprises multiple socio-technical arrangements, which, among others, include workers' information needs, workflow and usability requirements, available technology options, and how best technology can be adapted to suit these needs and requirements [8]. Sarker and Wells [1] argue that user interaction with mobile devices is influenced by user characteristics, modality of mobility, communication and task characteristics, technology characteristics, network externalities, as well as context-centric social and economic factors [1]. Efforts to implement mHealth solutions therefore, need to consider particularities and sensitivities of the socio-technical ensemble of factors that interact with such solutions [5]. The interaction of these factors to influence mobile device use is modelled in **Fig. 1.**

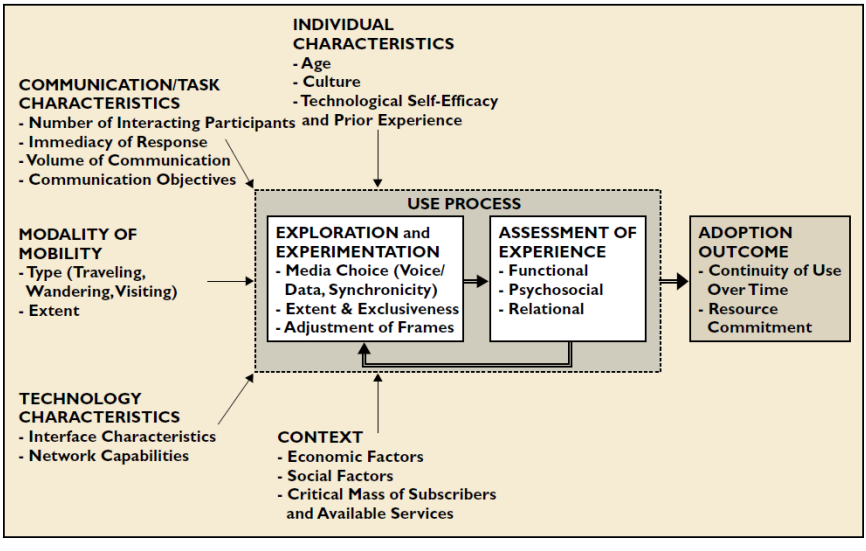

Fig. 1. An integrated framework for mobile device use and adoption – **Source [1]**

Under the model, the use process comprises *exploration and experimentation*, and *assessment of experience*. Under *exploration and experimentation,* users choose a medium of communication and desired synchronicity, as well as extent and exclusiveness of use. They also improvise and develop new ways of using mobiles as new motivations, modes, and consequences of applying technology emerge [1].

Assessment of experience is done along at least three dimensions: *functional, psychosocial, and relational* [1]. The *functional* dimension evaluates the effectiveness and efficiency with which people can perform their work and manage interpersonal relationships, using implemented mobile technologies. The *psychosocial* outcomes relate to less tangible impacts of mobile technology use, such as sense of security, as well as professional and social self-worth. The *relational* dimension assesses how mobile technology use impacts the establishment and maintenance of functional ties, as well as frequency, volume, and coordination of communication [1]. The totality of

the use process, then, informs long-term user adoption of mobile devices. We now review the factors influencing the use process, and link them to mHealth.

3.1 User Competencies/Individual Characteristics

User characteristics such as demographics, technology-related skills, and culture substantially influence the implementation and acceptance of mobile devices [1]. Literacy also affects how well people can use certain solutions. SMS-based solutions, for example require a good level of writing skills [4]. Furthermore, for medical practitioners to effectively use mHealth applications, they need to posses a sufficient level of technological competencies [13]. The standardisation of required technology-related competencies is however not a straightforward matter. Thus, the advancement of mHealth is to an extent hindered by inadequate availability of expertise to bridge the gulf between health and technology [8].

3.2 Technology Characteristics

Usability aspects of applications and the extent of mobile network coverage have considerable impact on the use and adoption of mobile devices [4, 8]. The level of integration between solutions also impacts users, considering that there is a multiplicity of mHealth solutions [8]. It is therefore imperative that health care providers and health authorities are able to integrate new technological capabilities to existing settings in order to leverage their capacities and quality of services [13].

Although mobile technologies have made inroads within low resource contexts, certain areas that would benefit the most from mHealth solutions remain underserved in terms telecommunication capabilities [13] and access to electricity [4].

3.3 Desired Communication and Supported Work

Mobile device-led communication is sensitive to the number of interacting participants, immediacy of response desired, volume of communication desired, and communication objectives [1]. It is therefore imperative that mHealth solutions be designed with users' information needs, workflows, and usability requirements in mind [8]. This is of particular interest because mobile devices have become an integral part of people's work and social lives [14]. More than this, the success of mHealth applications significantly depends on how well they are integrated with users' workflows [8].

3.4 Economic Factors

Availability of adequate funding to finance routine operating expenses, maintenance costs and systems upgrades, all intrinsic features of ICT systems, is a vital element towards the sustainability of ICT driven initiatives [15]. For example, solution implementers need to know that users' willingness to use a technology does not imply long term commitment to meeting any adoption or sustainability costs [2]. mHealth projects must therefore implement financial sustainability models for usage beyond

pilot level, before project initiation, to understand who will eventually support, maintain and manage the initiatives [2]. To the contrary, most ICT led initiatives for health in low income countries remain heavily reliant on external support [15, 16].

3.5 Additional Factors Not Covered in the Model by Sarker and Wells

We argue that to inform the use and adoption of mHealth solutions beyond individual users, it is necessary to consider the role change management and research play. Next we present an overview of these factors, but elaborate on their relevance when discussing the mHealth solution from Malawi, later in the paper.

3.5.1 Change Management

Change management is vital to the diffusion of information systems, as various socio and political forces impact technology diffusion [5, 8]. For example there has to be sufficient acceptance for a solution from both users and high-level managers. When people have adopted solutions, there is also need for mechanisms to manage knowledge related to adopted solutions, make data from varied sources accessible at the point of care, and ensure that people have access to appropriate devices for the work [13]. Scaling of mHealth initiatives is also not a straight forward thing, as solution pilots do not always portray a complete picture of costs and technical implications associated with scaling [15].

3.5.2 mHealth Research

Common barriers to mHealth scaling and sustainability are a result of limited knowledge of what works, how it works, and how much it costs [17]. Several authors agree that there is a dearth of research on mHealth [5, 17-19].The future of mHealth, therefore, depends on the establishment of a critical knowledge and evidence base that enables key decision makers to make informed decisions on how to invest limited health resources in technology [20]. To achieve this, there is need for the implementation and researching of large scale mHealth solutions to demonstrate where, how, and why mHealth works best [20].

4 The Case: Mobile Phone-Based ART Protocol

Baobab Health Trust has developed a mobile phone-based Anti-Retroviral Therapy (ART) protocol to guide HIV/AIDS counsellors, under the Malawi AIDS Counselling and Resource Organization (MACRO), with decision making and data capture, when consulting with clients. The solution which is currently being piloted in Malawi, seeks to replace paper-based protocols used by the counsellors. Currently the mobile phone-based solution is being used in parallel with the paper-based protocols.

4.1 MACRO and the Work of HIV/AIDS Counsellors

MACRO is a non-governmental organisation providing voluntary counselling and HIV testing (VCT) services in Malawi. MACRO has several testing sites, including

mobile sites. Its HIV/AIDS counsellors also go around different busy trading centres to conduct HIV tests and counsel people. They also have door-to-door initiatives as part of their work. When going about their work, the counsellors use a paper-based protocol to collect data and consider patient referrals based on captured data and guidelines on the protocol.

Before the introduction of the automated mobile phone-based protocol, all counsellors only used paper forms for data capture. The data was then recorded in registers and forwarded to the district level. At the district level, data was then manually aggregated to provide a picture of service delivery in the district.

Over time, it has been noted that manual data aggregation is time consuming and there are inconsistencies in referral recommendations by counsellors when using the paper-based protocol. Enforcement of recommendations by paper-based protocols is largely dependent on the user. It has also been noted that, at times, counsellors lose paper forms before reporting collected data.

4.2 The Mobile Phone-Based Protocol

The mobile phone-based protocol was implemented to enhance consistency in referrals as the application makes recommendations based on input data. The mobile phone-based protocol also fast-tracks data reporting and aggregation, as counsellors can immediately send their captured data to a central server. Currently, the solution is implemented in two districts, and plans are underway to extend to two other districts.

Despite its promise, the solution is not without some challenges. Two important challenges include lack of a well developed mHealth solution developer community in Malawi and concerns by data clerks at MACRO for their jobs, fearing that the application would render them redundant. To have the clerks' buy-in, they were trained on how to use the new solution. However, not having a sufficiently developed mHealth developer community limits innovation in that there are very few people on the ground to collaborate with developers at Baobab Health Trust. There are also just a handful of mHealth research publications from Malawi. In addition to these challenges, there is also the challenge of recharging mobile phones in remote sites. In Malawi, only 2.5 % of the rural population has electricity at home [21], despite around 85 % of the country's population residing in rural areas. Furthermore, since the mobile solution has not yet scaled, cost and technical implications associated with such an undertaking remain unknown.

5 Discussion

We now discuss how mHealth solution implementations should be approached by applying the model by Sarker and Wells, and other reviewed literature, to our case.

5.1 Baobab Health Trusts' mHealth Solution

The mobile phone-based ART protocol solution demonstrates an interaction of multiple heterogeneous elements, which form the installed base upon which the

solution has been developed and operates. These interactions are what shape this mHealth solution. Firstly, the case demonstrates the importance of technological characteristics and integration with users' workflows. For example, the mobile phone-based protocol builds on an existing paper-based protocol. The use of mobile phones also affords users sufficient mobility and integrates into their mobile work patterns, thereby permitting use of the technology during service delivery. This fits with the proposition by Yu et al. [8] that to enhance adoption, mHealth applications should be designed with users' information needs, workflows, and usability requirements in mind [8]. On the other hand, short battery lives for mobile phones and challenges with recharging them, especially in remote areas, reflect the role of technological characteristics and infrastructural sensitivities in shaping their use. Beyond this, use of the mobile phone-based protocol requires that users possess a sufficient level of literacy and technological skills. This indicates that user characteristics are an important factor in shaping mobile device use, as argued Sarker and Wells [1].

The approach taken by solution implementers to dispel fears by data clerks concerning their job security, by empowering them with new skills to use the mHealth solution, demonstrates the importance of change management and negotiating with users when implementing solutions. Furthermore, by easing the process of data reporting and aggregation, solution implementers have introduced added value for solution, beyond the ART service delivery protocol. mHealth solutions cannot survive without sufficient buy-in from both users and high-level managers [8]. Keeping with change management, it is not easy to tell how well the solution will scale, since it is still in pilot phase. Solution pilots hide cost and technical implications that have the potential of overturning initial success registered by solutions [15]. Furthermore, that the solution will need a sound financial basis to scale and be sustainable over time needs no further argument. Routine operating expenses, maintenance costs and systems upgrades are intrinsic features of ICT systems. Having sufficient funding to cover such costs is a vital element towards the sustainability of ICT driven initiatives [15].

On the other hand, the infancy of Malawi's mHealth community negatively impacts the mHealth solution in question as regards sharing of technical and research expertise. Limited availability of mHealth literature from Malawi also makes it hard for the solution implementers to learn from other initiatives, within their context of operation. Knowledge management is an essential part of mHealth solution implementations [13, 17], as mHealth scaling and sustainability is dependent on solution implementers having the knowledge of what works, how it works, and how much it costs [17].

5.2 Approaching mHealth Implementations

Considering the multiplicity and heterogeneity of socio-technical composite elements and the dynamics involved in managing divergent and competing interests among stakeholders, we argue that mHealth implementations should be considered information infrastructures. Hanseth and Lyttinen [9] define an information infrastructure as *"a shared, evolving, heterogeneous installed base of IT capabilities among a set of user communities based on open and/or standardized interfaces"*

[9:pp 208]. Viewing mHealth solution implementations as such helps highlight associated complexities.

The case and literature review demonstrate that mHealth solutions build on existing installed bases and are impacted by their dynamics. Among others, these include user competencies, workflows, individual and organisational interests, as well as existing technological arrangements. Implemented solutions also grow in importance by supporting integration. The level of integration between solutions impacts users' workflows and adoption of mHealth solutions, considering that there is a multiplicity of mHealth solutions [8]. This does require standardisation of interfaces. We have modified the framework by Sarker and Wells [7], as shown in Fig. 2, to reflect these interactions and their resultant influence on mHealth solution implementations. This is supplemented by insights from our case review.

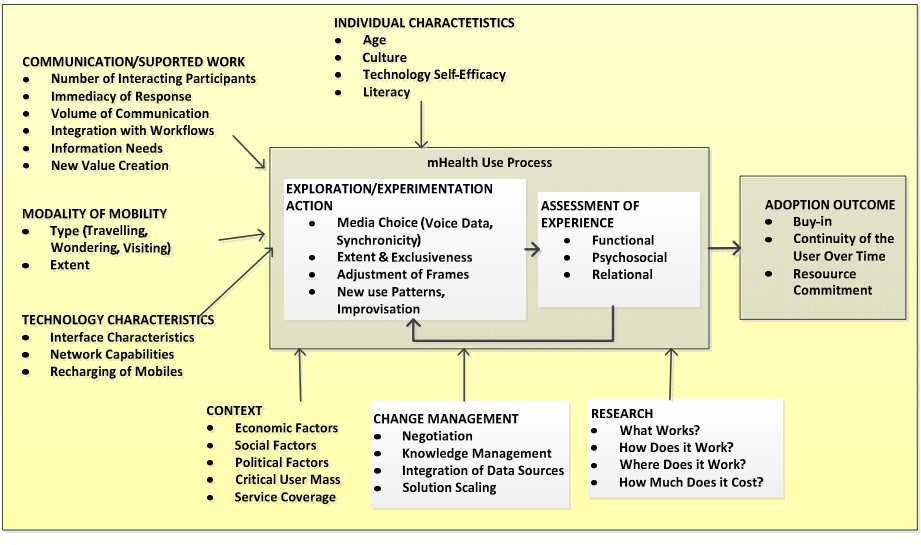

Fig. 2. An integrated framework for mHealth use and adoption – **Adapted from Sarker and Wells [1]**

In line with the propositions by Sarker and Wells, we argue that change management supported work, users' modality of mobility, technology characteristics, research and various other contextual factors, together influence users' interaction with mHealth solutions. In the end, the resultant user experience, as shaped by these factors, determines the adoption of mHealth solutions.

Change management is concerned with negotiation, knowledge management, and integration of data sources. The component on *communication/supported work* is concerned with number of interacting participants, required immediacy of response, volume of communication, integrations of technology with workflows, users' information needs, and value creation for users. *Modality of mobility* assesses extent and types of user mobility. The *technology characteristics* dimension is concerned with interface characteristics -usability and logic, network capabilities, and recharging

of mobile devices. The *research* component looks at the questions: what works? How does it work? Where does it work? How much does it cost? Additional *contextual* factors of interest include economic, social, and political factors, adoption by a critical user mass, and service coverage.

6 Conclusions

In this paper, we have extended the *mobile device use and adoption framework* by Sarker and Wells [1] to fit the case of mHealth. We have mostly adjusted the model to give it an organisational and extra-organisation perspective on mHealth solution use, rather the individual user-centric framework proposed by Sarker and Wells [1]. In going about this, we have discussed how socio-technical arrangements such as user characteristics, influence of supported work, modality of user mobility, technological characteristics, change management, and other contextual factors such as economic factors shape mHealth implementation and adoption.

We argue that the above mentioned factors form the *installed base* on which solutions are built. These factors also continuously interplay with the use of mHealth solutions by users, thereby influencing adoption outcomes.

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