Evaluating the Sustainability of mHealth Systems in Developing Countries: the Knowledge Gap

Muhambe Titus Mukisa[1], Daniel Orwa Ochieng[2], Peter Wagacha Waiganjo[3]

School of Computing & Informatics Maseno University, Kenya

School of Computing &Informatics, University of Nairobi, Kenya

Abstract: *The use of mobile technology in healthcare, known as mHealth is being explored across the developing countries as part of the effort to tackle growing disease burden through, prevention and appropriate and prompt intervention strategies. Although the outcomes of some of the implemented mHealth projects have been successful with very promising results, a significant number of the projects have failed after a short period of use. Studies carried out on the failed projects pointed to lack of sustainability. Review of existing technology evaluation model against the cited challenges reveals significant deficiencies in the models and thus not suitable to evaluate sustainability of mHealth system in developing countries. It is clear that there exist a knowledge gap and hence the need to develop and validate a suitable mHealth system sustainability evaluation model.*

Keywords: Evaluation, mHealth, Model, Sustainability

1. Introduction

The health sectors in developing countries face multiple challenges and as such there have been challenges in tackling the growing disease burden. World Health Organization reporton global morbidity and mortality rates indicates that a significant number of deaths in developing countries result from easily preventable diseases. The continued growth of disease burden in developing countries has and continues to have profound negative impact on the quality of life and the economy[1]. There are many ongoing initiatives and efforts to tackle the disease burden including the use of Information Communication Technology [2, 3]. One of the technologies that have been exploited is the use of mobile technology also known as mHealth; a medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices[2, 3]. The efforts aim at exploiting potential presented by mobile technologies, towards prevention and intervention in tackling the disease burden challenge. Despite the enormous potential, utilization of mHealth initiatives and innovations faces multiple challenges and obstacles that need to be urgently tackled if the benefits of this strategy have to be realized.

2. Literature Review

2.1 mHealth Application Areas

Multiple studies have identified the mHealth application areas [2, 3, 4, 5, 6,7];
- *Appointment and Medication reminder*; a system that enables sending of alerts or reminders to patients using mobile phones. The reminder alerts are aimed at reminding a patient to take medication at recommended times or to honour doctor appointments. The overall aim of this type of solution is to enhance the level of the patient's adherence to medication and treatment regime.

- *E-prescribing for repeat prescriptions:* a tool that enables a patient to make requests and gets prescription a medical practitioner over the mobile phone using text messages.
- *Remote monitoring of patients conditions;* a system that monitors and reports on patient's current status; reports on patient's blood pressure, temperature and pulse rate. This is achieved using mobile devices and sensor attached to the patient's body.
- *Transmission of test results to patients*; aimed at providing some level of convenience to the patient by lowering the cost of travelling to the healthcare facility by a patient to collect test results. Using the results transmitted in the form of text, the patient can seek medication at the nearest healthcare facility.
- *Clinical advice*; tool or solution enables automated clinical tips of specific health issues. A customer sends a text message to a specific known number, where the system automatically generates responses depending on the user request.
- *Data Collection and surveillance;* mainly utilized by community health workers or epidemic/disease surveillance field personnel, to collect and submit health indicators and disease occurrence data to a central repository via mobile phone SMS or custom made mobile phone applications.
- *Linking Community Health Workers(CHW) or Community nurses in remote areas with clinical expert;* the solutioncreates a channel of communication between community health workers or community nurses working in remote regions and a clinician expert and allows for consultation and advices on complex medical cases.
- *Public health and lifestyle promotional messages* – used as a public awareness platform that enables dissemination of information via Short Text Messages, that aim at promoting health living and good public health. Mostly used in national health campaign programmes.

2.2 mHealth Systems Sustainability Challenge

Although many mHealth projects have shown potential to aid in the tackling of disease burden, reports indicate that a

significant number of mHealth solutions deployed in the developing countries have failed. A number of reasons are cited but when summed up, these reasons points to sustainability challenges. Various studies [8, 9, 10, 11] highlight reasons why some of the mHealth projects failed; factors relating to users include *user dissatisfaction* with the deployed systems, *insufficient user support*; lack of or insufficient technical expertise and manpower to provide the much needed user support, *System access challenges*; inability of users to gain access to the mHealth system especially where there is cost element associated with using the system, lack of appropriate mobile gadgets, lack of power to recharge the gadgets especially in remote locations of developing countries and limited or poor network connectivity and coverage. Some of the technological factors cited as possible causes of failure of the mHealth projects in developing countries include *relevance challenges*; mismatch between technological features in the mHealth solution and tasks or healthcare needs of the locality where the project is implemented. The technology is designed elsewhere and deployed without considering the social technical issues of the locality where the mHealth technology would be deployed. Other technological challenges cited include; inability of the solution to scale, inability of the mHealth system to interface and interoperate with existing healthcare systems and poor system quality. The management and administration aspects cited as possible contributors to failure of mHealth projects include; challenges in strategy and planning, lack of sustainable financial resources and challenges in the governance of mHealth systems.

2.3 Evaluating mHealth Sustainability

Design, Implementation and maintenance of the mHealth solutions consume valuable yet scarce resources. Failed mHealth projects leads to wastage of the scarce resources and in addition, slows down of the fight against the growing disease burden. There is therefore a need to ensure that the implemented mHealth solutions are sustainable; ability of the deployed solutions to meet current needs without compromising on the ability of the same system to meet future needs, even when the environment and the dynamics change [12]. Structured evaluation of the sustainability of a solution requires a tested and validated guiding model.

Evaluation of sustainability of a technology solution is a post-implementation activity that focuses on assessing overall system effectiveness while in operation as well as the ability of the technology solution to realize the current objectives, goals and user needs as well as the objectives, goals and user needs in the future. The eco-system within which the system operates is defined and influenced by; users factors, management practices and the technology factors and therefore, evaluation of sustainability of a technology artefact must considerand include applicable aspects of all these factors[13].

2.4 Social-Technical Models

Technology has been applied in almost all spheres of life. The application of technology is aimed at ensuring efficiency and effectiveness in the process of accomplishing of the objectives and goals associated with a certain task or activity. Successful utilization of technology in an enterprise involves complex social-technical relationships and interactions that influences the acceptance, adoption, implementation and sustainable utilization of technology. Social-technical thinking has been supported [13] by the arguments that human principle plays a significant role in defining how a technology is accepted and utilized. It is argued that evaluation of health information system is challenging and difficult to perform in particular, selecting appropriate framework and methods to use happens to be the most challenging part [14]. The success of any technological innovation in terms of acceptance, adoption, implementation and sustainable utilization, depends on the level of understanding of the social technical forces that define the utilization environment. Proponents of social-technical thinking have strongly argued that it should positively influences a technology designer to deliberately enhance the quality of working life of a user in order to guarantee job satisfaction and hence positively influence adoption, utilization, outcomes and sustainability of the technology [15, 16, 17].

The social-technical thinking school of thought has it that three key paradigms must be understood and considered when understanding the design, deployment, acceptance, adoption, utilization and sustainability of technology [18, 19, 20]. These are; technical, social and environmental paradigms. The technical aspects of a technology cover the tools and devices that make up the technology and techniques utilized when converting given inputs into desired outputs. The social components on the other hand covers knowledge and skills of users, the attitudes of the users towards the technology artefact, expected value outcomes and the unique personal needs that must be addressed by the environment that they find themselves working in. Finally, the environmental paradigm includes governance, management and authority structures defined within the organization, policies and regulations that govern activities and interaction relating to the deployed technology in the organization [15, 17].

It is therefore necessary to review existing social-technical models and assess their suitability in evaluating sustainability of technology.

2.2 Technology Evaluation Models

Several technology evaluation models have been developed, tested and validated in various contexts. Existing technology evaluation models have been here analysed in light of the failure of mHealth projects in developing countries. The table below shows a summary of the key models for evaluation of technology.

Table 1: Summary of Evaluation Models

Model	Targeted System/Component of Evaluation
Task Technology Fit Model [21]	Designed for evaluating the degree to which technology artefact feature map to the task at hand
Information System Success Model [22]	Developed for evaluating Information System Success
Human Organization	A model tailored to evaluate Health

Technology Fit Model[23]	Information System
Integrated Acceptance and Sustainability Assessment Model (IASAM) [24]	Generic Model for evaluating Sustainability of a Technology
Design and Evaluation Framework for mHealth [25]	Designed to Evaluate Sustainability of mHealth Systems

3. Problem Definition

The disease burden in developing countries have made it necessary to adopted technology as strategies for tackling the challenge in order to lower the rising mortality and morbidity. Across many developing countries, mHealth solutions have been embraced but a significant number of the implemented mHealth solutions are reported to have failed after a short period of usage and the main reason cited is lack of sustainability. In order to establish the sustainability of an mHealth solution or system, a structured evaluation must be carried out; various tested parameters must be used to gauge and establish the sustainability of the mHealth solution. In the effort to develop a solution for the mHealth sustainability challenge, existing models must be assessed to determine their suitability to evaluate sustainability of the mHealth solutions in developing countries context.

4. Methodology / Approach

The study was carried out through six main steps:

- Review of literature to understand the growth and utilization of mHealth utilization in the developing countries context.
- Establishing the thematic areas of mHealth application in developing countries.
- Understand the success and failures of mHealth projects in developing countries and some of the reasons cited for failure.
- Review of literature to identifying sustainability challenges of mHealth system in the developing countries context.
- Analyze existing models and assess their suitability of existing models in evaluating sustainability of mHealth systems in the developing context.
- Make recommendations on the need for a more comprehensive model.

5. Results & Discussion

Review of literature on the challenges of mHealth system and projects in developing countries reveals that a combination of *human*, *technology* and *management* factors contribute to failure of mHealth projects. Analysis of the existing technology evaluation model reveals that each has weaknesses and thus non is suitable for evaluating the mHealth systems sustainability in the developing countries context.

Table 2: Information System Success Model

Information Systems success model [22]		
Constructs in the model	Strengths of the model	Weakness of the model
System Quality	Designed to assess and establish whether a system is successful. It capture technological factors (*System Quality, Information Quality*) Individual Factors (*System Use, User Satisfaction and Service Quality*) and the outcome of using the system (Net Benefits),	The weakness of this model is that it does not explain whether a successful system will necessarily be sustainable. In addition, it is silent on the role of management factors in the success and sustainability of a system that is being evaluated and furthermore the individual factor "*access to the system*" and its role is not mentioned. This model assumes a formal environment where access is guaranteed, which might not be the case for mHealth systems in developing countries. It is also silent on role of Technology Interoperability and Technology scalability in the sustainability of mHealth system.
Information Quality		
Service Quality		
System Use		
User Satisfaction		
Net Benefits		

Table 4: Task Technology Fit Model

Task Technology Fit Model [21]		
Constructs in the model	Strengths of the model	Weakness of the model
Task Requirements	Best suited to evaluate how well the technology functional feature map to the task at hand	Fails to address the role of *individual factors* and *management factors* in the sustainability: it fails to state whether a technology whose functional features match the tasks at hand will be sustainable
Tool Functionality		
Task-Technology Fit		

Table 3: Human-organization-technology fit Model

Human-organization-technology fit (HOT-fit) [23]		
Constructs in the model	Strengths of the model	Weakness of the model
System Quality	It is a powerful model that was designed specifically to evaluate Health Information Systems. It highlights the Human (Individual), Technology and Organizational factors that are key in the evaluation of healthcare information systems.	The model assumes a formal environment where challenges of accessing the model are not experienced a typical case for mHealth solutions in the developing; it is silent on access issues. Further, the model fails to address the role of technology interoperability and technology scalability in the sustainability of the mHealth systems in the developing countries context.
Information Quality		
Service Quality		
System Use		
User Satisfaction		
Net Benefits		
Organization Structure		
Organization Environment		

Table 5: Design & Evaluation framework for mHealth

Design & Evaluation framework for mHealth [25]		
Constructs in the model	Strengths of the model	Weakness of the model
Governance Models	The model is specifically designed to evaluate mHealth systems and it specifies four	The sustainability phase in this
Financing		

Models	stages/phases of evaluation: Design, Development, Implementation and Sustainability. It further specifies what need to be evaluated when attempting to establish the sustainability of an mHealth system. It clearly points factors that are critical to sustainability; Return on Investment, Financing, Outcome of System Use, Interoperability plan, Governance models and security (privacy and compliance)	model fails to address the role of system quality, system support, Access to the system, user satisfaction, system scalability and system interoperability.
Interoperability Plan		
Privacy and Compliance Plan		
Outcome measurements		
Return on Investment		

Table 6: Integrated Acceptance and Sustainability Assessment Model

Integrated Acceptance and Sustainability Assessment Model [24]		
Constructs in the model	Strengths of the model	Weakness of the model
Management Factors: Staff, Political Support, Resources, Evolution, Strategy and Planning.	The power of this model lies in the fact that it is a generic model specifically designed to evaluate the sustainability of technology. It also captures factors that include technology, management, technology acceptance and technology development issues.	The weakness of this model in that it is silent on; individual factors such as user satisfaction with the technology, technology factors such as interoperability and technology scalability. I also fails to mention the role of: Returns on Investment" in the sustainability of mHealth systems in developing countries.
Technology Factors: Product Quality, Production Quality, Accessibility, Service Quality.		
Acceptance Factors: Relative Advantage, Trialability; Complexity, Compatibility, Observability, Economic Situation		
Development Factors: Role of technology and Market Situation		

6. Conclusion

The mHealth strategy for tackling disease burden provides a promising alternative strategy that could aid in lowering morbidity and mortality in developing countries. Failed mHealth systems slow down the fight against the disease menace. Sustainable solutions would greatly contribute to the efforts of tackling the disease challenge. Structure evaluation to establish the sustainability of implemented mHealth system in necessary and the current model have significant weakness hence not suitable. There is an urgent need to develop and validate a comprehensive model for evaluating sustainability of mHealth systems in development countries.

7. Future Scope

The future research will focus on developing and validating a comprehensive model for evaluating sustainability of mHealth system in developing countries context. The research will be carried out under the following steps; identifying factors that should be considered when evaluating sustainability of mHealth systems, designing a model for evaluating sustainability of mHealth systems and validating the model in the

References

[1] WHO (2013) Call for innovative health technologies. http://www.who.int/ehealth/en/. Accessed 15 January 2015.

[2] WHO 2011c, mHealth: New horizons for health through mobile technologies, WHO, Geneva.

[3] Vital Wave Consulting, (2009). Health Information Systems in Developing Countries: A Landscape Analysis

[4] Muhambe T. and Orwa D. (2015) Tackling the Disease Burden: A Case for mHealth in Kenya. Journal of Emerging Trends in Computing and Information Sciences. Vol. 6, No. 8, August 2015

[5] Zurovac et al., (2011), Raymond K Sudoi, Willis S Akhwale, Moses Ndiritu, Davidson H Hamer, Alexander K Rowe, Robert W Snow (2011) Kenyan health workers' adherence to malaria treatment guidelines: a cluster randomised trial. www.thelancet.com Published online August 4, 2011.

[6] Gold et al., (2012) Using mobile phone text messages (SMS) to collect health service data: Lessons from social franchises in Kenya, Madagascar and the Philippines. Journal of Health Informatics in Developing Countries Vol. 6 No. 2, 2012 www.jhidc.org (Accessed July 2016)

[7] West, D. (2012). How mobile devices are transforming healthcare. Issues in Technology Innovation, 18, 14.

[8] Déglise C, Suggs LS, Odermatt P. Short message service (SMS) applications for disease prevention in developing countries. J Med Internet Res 2012;14(1):e3 [FREE Full text] [doi: 10.2196/jmir.1823]

[9] Chigona, Wallace., Mphatso Nyemba-Mudenda., Metfula, Andile Simphiwe (2013). A review on mHealth research in developing countries. The Journal of Community Informatics Vol 9, No 2 (2013)

[10] QuintanaY. m-Health Design and Evaluation. Mobile World Congress. 2015.

[11] Smith C. Vannak, U. Sokhey L. Cockroft M. Overcoming mHealth Operational Challenges in Cambodia (RE: JMTM 2013, 2: 20_23)

[12] Brundtland, Gro Harlem (1987). Report of the World Commission on Environment and Development: Our Common Future. Oslo, 20 March 1987

[13] Land, F.F., (2000), Evaluation in a Socio-Technical Context

[14] Aggarwal Y. P. (2008),Science of Educational Research, Nirmal Book Agency.

[15] Cherns, A., (1976), The Principles of Sociotechnical Design, Human Relations, Vol.2, No. 9, pp 783-792

[16] Avgerou, C., Ciborra, C. and Land, F.F., editors, (2004), The Social Study of Information and Communications Technology: Innovation, Actors and Context, Oxford, OUP

[17] Clegg, C.W., (2000), Sociotechnical Principles for Systems Design, Applied Ergonomics, Vol. 31, pp 463-477

[18] Sawyer, S., and Jarrahi, M. H. (2014). Sociotechnical Approaches to the Study of Information Systems

[19] Heller, F. (1997) Sociotechnology and the Environment, Human Relations, Vol. 50, No 5, pp. 605-624

[20] Bostrom, R. P., & Heinen, J. S., (1977). MIS problems and failures: A socio-technical perspective, MIS Quarterly, Vol. 1, No. 3, pp. 17-32

[21] Goodhue, D.L. and Thompson, R.L. (1995). Task-technology and individual performance, MIS Quarterly 19(2), 1995, pp. 213-236.

[22] DeLone, W.H. and McLean, E.R., (2004) Measuring e-commerce success: applying the DeLone & McLean Information Systems Success Model, Int. J. Electron. Commerce 9 (1) (2004) 31–47.

[23] Maryati Mohd Yusof, Jasna Kuljis, Anastasia Papazafeiropoulou, Lampros K Stergioulas (2008). An evaluation framework for Health Information Systems: human, organization and technology-fit factors (HOT-fit). International journal of medical informatics. Volume 77(6) 386-398. Elsevier

[24] Aizstrautaa D, Gintersa E, Eroles MP. Applying Theory of Diffusion of Innovations to Evaluate Technology Acceptance and Sustainability. ICTE in Regional Development, December 2014, Valmiera, Latvia. Procedia Computer Science 43 (2015) 69 – 77. www.sciencedirect.com

Author Profile

Muhambe Titus Mukisa Holds an MSc in Information Systems from University if Nairobi and currently afinalizing PhD candidate at the School of Computing and Informatics of the University of Nairobi, specializing in health Informatics. Research interests include; ICT for Development and Information system design, development, development, evaluation and Audit.

Daniel Orwa Ochieng holds a Doctoral Degree in Information Systems, is currently a Senior Lecturer in School of Computing and Informatics and an Experienced researcher in ICT for development; focusing on Agriculture, health and education. Prolific author and reviewer in several reputable international journals in the areas of information system and ICT for development.

Peter Wagacha Waiganjo hold a PhD in computer science and is currently Professor of Computer Science in the School of Computing of the University of Nairobi and researcher in ICT for development.Research interests covers artificial intelligence, machine learning, ICT for development. Also an author and reviewer in several reputable international computer science journals.