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Proposing Parameters for Evaluating Sustainability of mHealth Systems in Developing Countries.

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ABSTRACT

The exponential rise in global healthcare challenges; the rise in morbidity and mortality, especially in developing countries have compelled stakeholders to explore alternative ways of overcoming the crisis. Guided by the recommendation of WHO (2013), efforts have been directed towards prevention, response and strengthening of the existing healthcare systems. There have also been efforts to explore the potential of mobile technology towards healthcare provision, with numerous mHealth projects being reported across the developing world. Reports indicate that a significant number of these solutions have failed before realizing the primary goals, pointing to possible mHealth sustainability challenges. The study explored literature covering global health challenges, use of mobile technology healthcare solutions in developing countries, as well literature covering evaluating technology sustainability. Through the review, key factors that influence sustainability of technology were identified. A cross-sectional survey using questionnaires and a qualitative exploratory study using interviews and Focused Group Discussion, targeting mHealth stakeholders were used to map and contextualize the identified sustainability factors to the developing country context. The identified factors were categorized into three broad categories; Individual factors; User Satisfactions, Access to system, and User Support, Technological Factors; System Quality, System Scalability, Technology Sustainability, Technology Relevance and System Interoperability and Management Factors; mHealth Ownership and Net Benefits (Return on Investment). The paper identifies challenges in the sustainability of mHealth systems in developing countries; using Kenya health sector as a case and proposes the sustainability evaluation parameters for mHealth systems in developing countries.

Indexing terms/Keywords

Sustainability, mHealth, Evaluation, Technology

Academic Discipline And Sub-Disciplines

Technology in Healthcare; mobile technology in healthcare

SUBJECT CLASSIFICATION

Technology in Health

TYPE (METHOD/APPROACH)

The study adopted an exploratory approach utilizing both qualitative and quantitative tools

INTRODUCTION

1.1 Global Health Crisis

Global statistics[1] on mortality resulting from non-communicable diseases showed that 36 million deaths, approximately 63% of the 57 million global deaths that occurred in the year 2008, were caused by non-communicable diseases in developing countries. Further, a significant number of deaths were caused by preventable diseases, which was traced to lack of relevant disease prevention healthcare information, as well as delayed medical intervention, occasioned by lack of appropriate data[2]. Globally, emerging infectious diseases have been found to be leading causes of death, accounting for as much as a quarter of all global human deaths [3, 4]. Starting from the year 2000 up until 2015, global efforts towards addressing the disease burden challenge was guided by the Millennium Development goals 4, 5 and 6 [5], which have since been succeeded by Sustainable Development Goal 3 [6]. An evaluation of global healthcare landscape and transformations in the period 1990 to 2010 [7], revealed that a number of countries had made significant steps and gains with regards to addressing the challenge of disease burden as defined in the millennium development goals 4, 5 and 6. However, the developing countries in particular Sub-Sahara Africa still lagged behind, plagued with many healthcare challenges. The Sub-Sahara region is characterized by a growing burden of communicable diseases, maternal, nutritional and newborn diseases, malaria, diarrhea and HIV/AIDS [2]. Other reports have also pointed to gradual increase in instances of non-communicable diseases ranging from cardiovascular diseases, diabetes, cancer and obesity-related conditions, which traditionally were associated with developed countries [2, 8, 9].

Global efforts aimed at ensuring steady global economic development and improved quality of life have been greatly hampered by the current global health challenges [1, 10]. To effectively tackle this challenge, the World Health Organization hold the position that the global toll of morbidity and mortality resulting from the global diseases may be greatly reduced by adopting a three key pillars strategy; directing more effort towards *prevention*, enhancing disease *surveillance* for prompt and effective response and *strengthening* of existing health systems[1]. The *Prevention* pillar focuses on effectively provision of relevant health promotional information to the general population, on disease prevention, contraction and spread. The *surveillance* pillar focuses on identifying, collect and analyze data on instances of

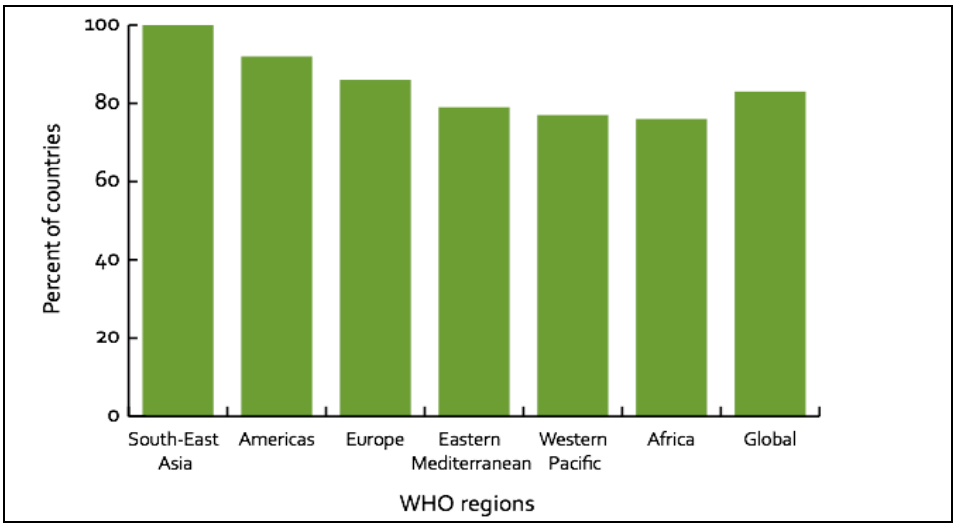
disease encountered to inform appropriate responsive to avert the far reaching negative consequences. The strengthening pillar focuses on formulating and implementing ways or approaches that make the current system stronger and more effective. Technology has been proposed and exploited as a tool for tackling and managing global disease burden, through prevention and routine surveillance.

The rapid growth in the uptake and use of mobile technology, especially in the developing countries has provided hope in tackling current health crisis[10]. Use of Mobile technology in healthcare, also called *mHealth* is defined as medical and public health practice that is aided by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices [11]. There are numerous documented attempts to exploit the potential mobile telecommunication through development and deployment of mHealth applications/systems. The deployment and use of these applications/systems is aimed at enabling better healthcare service provision; enhancing prevention through dissemination of relevant healthcare related information as well as enabling effective surveillance through real-time data collection and reporting on disease instances for appropriate and prompt response.

1.2 Global uptake of mHealth systems/applications and areas of Utilization

A global survey by the World Health Organization among the member countries indicated that mHealth systems and applications have explored globally (Figure 1) with the aim of harnessing the potential of these solution towards enhancing healthcare and lowering of the global disease burden.

Figure 1*: Uptake of mHealth Solutions globally by region* [12]



In practice[12], mHealth systems and application have been used the following thematic areas;

Table 1.1: Thematic mHealth Application Areas

Category (Themes)	Areas of Coverage
Healthcare promotion and Awareness	• Health Call Centers • Emergency toll-free telephone lines • Community Mobilization and health Promotion
Data Collection and submission to a centralized repository	• Survey and surveillance on health and health issues • Patient monitoring through health records
Diagnostics procedures, treatment support and training of healthcare personnel.	• Mobile telemedicine
Remote monitoring	• Scheduled Appointment reminders • Medication adherence reminders
Disease tracking and surveillance	• Health surveys and surveillance

1.3 mHealth in Developing Countries: Initiatives and Challenges

The need to tackle the disease burden in developing countries has propelled governments, healthcare practitioners and information and communication technology professionals to explore the use of technology. A review of mHealth projects implemented across the developing countries reveals projects covering five application areas; Monitoring & surveillance,

Diagnosis and Treatment Support, Training and Health worker Support, Data Collection, Education and awareness [7, 13, 14, 15, 16, 18, 19].

Table 1.2: Disease and Epidemic Outbreak Surveillance Projects

Disease and Epidemic outbreak surveillance		
Project Name	**Country**	**Source**
Malaria Surveillance & Mapping	Botswana	http://www.pingsite.org/tech- projects/disease-surveillance-project/
PDAs for Surveillance and Data Collection	Fiji	https://www.ncbi.nlm.nih.gov/pubmed/19369114
Handhelds for Health	India	http://handheldsforhealth.org/
mHealth Tanzania Public Private Partnership	Tanzania	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2011/03/IDSR-Outbreak-Highlight_mHealth_1-00.doc
mTrac - SMS to monitor malaria in remote areas	Uganda	http://www.ajtmh.org/content/85/1/26.full

Table 1.3: Training and Support to Healthcare Workers Projects

Training and Support to Healthcare worker		
Project Name	**Country**	**Source**
Uganda Health Information Network (UHIN)	Uganda	http://www.mhealthinfo.org/project/ugandahealth-information-network-uhin
HealthLine	Pakistan	http://www.cs.cmu.edu/~healthline/
Mobile Technology to Reduce Maternal Death	Senegal	http://www.waha-international.org/?projects&id=37

Table1.4: Education, Healthy Living Promotion and Awareness Projects

Education, Healthy living Promotion and awareness		
Project Name	**Country**	**Source**
Project Mwana	Zambia	http://www.unicefinnovation.org/projects/project-mwana
Mobile Midwife	Ghana	http://www.grameenfoundation.org/sites/default/files/MOTECH-Early-Lessons-Learned-March-2011-FINAL.pdf
Text to Change	Uganda	http://www.texttochange.org/
SMS alerts for infant vaccinations	India	http://www.deccanherald.com/content/140333/kerala-launch-sms alertsvaccinations.html

Table 1.5: Health Data Collection Projects

Health Data Collection		
Project Name	**Country**	**Source**

TRACnet	Rwanda	http://www.un.org/esa/sustdev/publications/africa_case studies/tracnet.pdf
SMS for Life	Ghana	http://www.rollbackmalaria.org/docs/SMSdetailReport.pdf
m4RH	Kenya	https://www.fhi360.org/sites/default/files/media/documents/m4rh-kenya-brief.pdf

Table 1.6: Drug Supply Chain and Stock Management Projects

Drug Supply Chain and Stock Management		
Project Name	**Country**	**Source**
Tupange SMS Commodity Tracking System (TSCTS)	Kenya	http://www.africanstrategies4health.org/uploads/1/3/5/3/13538666/tupange_sms_commodity_tracking_system.pdf
KEMSA e-Mobile platform	Kenya	https://ehna.acfee.org/read/art-54da4caf56689

Table 1.7: Diagnostic and Treatment Support Projects

Diagnostics and Treatment Support		
Project Name	**Country**	**Source**
TeleDoc	India	http://healthmarketinnovations.org/program/teledoc
Pambazuko PALM	Kenya	http://www.pambazuko.org/
M-DOK: Mobile Telehealth and Information Resource System for Community Health Workers	Philippines	http://healthmarketinnovations.org/program/m-dok-mobile-telehealth-andinformation-resource-system-for-communityhealth-workers

1.4 mHealth Utilization Challenge

Studies show that the mHealth initiatives and projects have demonstrated potential to aid in enhancing healthcare provision[10]. However, it has also been noted that a significant number mHealth projects implemented in developing countries have failed before realizing the primary objectives. This scenario has and continues to lead to wastage of enormous amounts of financial resources and time invested in these initiatives hence slowing down the fight against global disease burden [20, 21, 22]. Studies have pointed to challenges in the sustainability of these projects, where *sustainability is viewed as the ability of the* mHealth projects to meet the present healthcare needs, without compromising the ability of future generations to meet their own healthcare needs, using the same system or application[23].

Studies have identified several factors that present a challenge to the sustainability of mHealth systems deployed in the developing countries context. The weak economies in many developing countries mean that the health sector and healthcare activities are largely sustained through donor funding. This is also true for a significant number of mHealth solutions, projects and initiatives which are donor funded and whose continuity is largely dependent on availability and steady flow of funding from these agencies, a situation that presents sustainability challenges [20, 24].

Scholar [25, 26] have attributed part of the failure of mHealth projects to the fact that a significant number of mHealth and eHealth applications or solutions are donor initiatives, which are designed in the developed countries, and later deployed in developing countries without taking into consideration the local dynamics that include culture, stakeholders and relevance of the technology to the local context, social-technical and economic factors.

Access to the deployed mHealth solution has also been found to be a challenge in the vast rural and remote areas. The areas may be outside the coverage range of the mobile telephony network, which implies that while many countries desire to deploy mHealth solutions to these areas, lack of network coverage or poor network signals limits this endeavor [27, 28, 29, 30]. In addition, other access issues identified include; lack of mobile devices or a single mobile device shared among family members through swapping of SIM cards, affordability of airtime, keeping the mobile phone charged in rural areas that are far from the grid [31].

The lagging behind in technology for most of the developing countries presents a challenge in terms of capacity to expertise in the design, development, maintenance and support both the mHealth solutions and the users of the solution.

It has also pointed out [25, 26] that failed large scale mHealth implementations in the developing countries especially the sub-sahara African region and attributed this failure to the fact that the donor driven initiatives tend to be small scale pilot solutions that aim at meeting the donor's objectives and may not be built with scaling capabilities [32].

Traditionally, mHealth solutions have been designed, developed and implemented as standalone solutions, aimed at realizing the donor's goals and objective. More often, the need to design a system that can interface with other systems is normally not considered[33, 34]. Multiple individual systems that overlap in terms of functions and goals often lead to inefficiency, duplication and wastage of effort especially where the data in one system can be used to accomplish a function in another system [32].

Scalability and technical support have been identified as critical components in the utilization, expanding reach and ensuring sustainability of the solutions [33]. The failure of mHealth projects have been attributed to the lack of sufficient expertise in the design, development, implementation, maintenance and capacity to provide technical support for the implemented mHealth systems [24, 33, 35, 36].

2.0 METHODOLOGY

The study was exploratory and was designed around six key steps. In order to realize this overall objective, study defined and carried out several activities following the steps defined below;

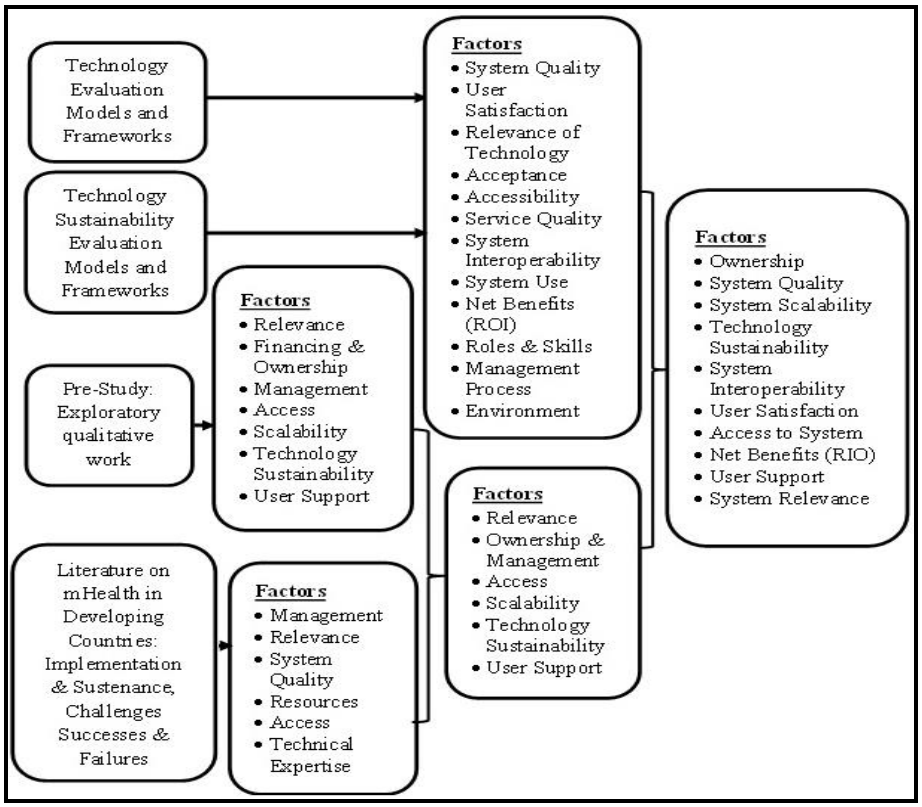
- **Step 1**: Reviewing literature on healthcare challenges in developing countries and narrowed down to disease challenges in Kenya. Kenya was selected as a representation of the general health scenario in developing countries. In addition, literature by the World Health Organization was reviewed in order to understand the strategies and measures recommended by the WHO towards tackling the growing disease burden, especially in developing countries.
- **Step 2**: Review of literature on the use of Information and Communication Technology in healthcare globally. This was narrowed down later to mHealth systems and applications in developing countries; a number of mHealth initiatives and projects and areas of utilization of mHealth systems.
- **Step 3**: Reviewed of literature on mHealth projects in the developing countries and attempted to understand why some were considered successful while others were considered failed. In those that are considered successful, factors that may have contributed to the success were identified while in those that failed, reasons cited for the failure were identified. In addition, literature was reviewed in order to understand the general challenges relating to mHealth in developing countries.
- **Step 4**: Factors that may be considered in evaluating sustainability of mHealth systems were identified by reviewing existing technology evaluation models and frameworks. In particular, *technology evaluation models and frameworks* [37, 38, 39, 40] as well as technology *sustainability evaluation models* [33, 41, 42] were considered and for each model or framework, factors and their potential in influencing sustainability of mHealth systems/applications in developing countries context were evaluated and selected out.
- **Step 5**: A cross sectional survey using a tested questionnaire (n=216) and a qualitative exploratory study that involved interaction with mHealth stakeholders (n=23) who had experience with mHealth application of at least12 months, using interviews and Focused Group Discussion. The interaction with the stakeholders was through interviews and focused group discussion. The responded included; mHealth system/application users, who were mainly patients and healthcare practitioners, technical and administrative managers of mHealth systems, mHealth system user support staff, designers and developers of mHealth applications and systems as well as the ministry of health officials who are working in the area of mHealth. We used this exercise to map the identified factors to the developing country scenario as well as capture any other factors that may have been left out, but considered significant by the stakeholders.
- **Step 6**: The final list of proposed factors was generated by mapping the outcome of the exploratory qualitative study to the factors identified through review of existing literature and any other additional factors identified through the exploratory study. Each of the factors in the final list is justified by explanation and literature.

3.0 RESULTS AND DISCUSSION

3.1 Proposed Mhealth Sustainability Evaluation Parameters Generation

The map in **Figure 2** summarizes the process and outcome of the final list of proposed mHealth sustainability evaluation parameters.

Figure 2: Summary of approach used for parameters generation



3.2 Proposed Sustainability Evaluation Factors

The proposed sustainability factors are grouped into three broad categories: *Individual factors, Technological factors* and *management factors*. This is justified by the fact that technology is designed to work and aid the human and therefore must be tailored to suit the human (individual factors) and in order to effectively utilize the technology and derived maximum benefits from it, it must be well managed (management factors). Finally, the technology must be designed in such a way that it is relevant and meets a minimum set of requirement so that it generates useful outcome in addition to its ability to be used to meet both immediate and long term needs hence the technological factors (Technology factors).

3.2.1 Individual Factors:

a) User Satisfaction

User satisfaction with technology system is defined as user's response to the system use and user's is fulfilled with the functions available in the system and the perceived user enjoyment in using the system [40]. Users who are dissatisfied with a system are likely to develop a negative attitude that may later discontinue use of the system. Failure to use the system will inevitably lead to failure to realize the original objective. User satisfaction forms an important component of system evaluation that focuses on assessing user's experience and attitude towards the system influenced by personal attributes [38]. Since the user's attitude towards the system is a critical element with the potential to determine the user's level of utilization of the system, it has the potential to impact long term use of the system either positively or negatively hence the need to evaluate the degree to which the users of mHealth are satisfied with the available mHealth solution.

b) System Access

System access is described as the ease with which the user can obtain access to or reach and utilize a technology. In a formal environment, where the organization provides means and tools to access technology, the challenge of access may not be experienced. mHealth systems provide a different scenario. Individual users must operate from within the range of telecommunications network connectivity and in addition, they must possess the right mobile phone gadgets and airtime in order to access and use the mHealth system. An alternative source of power supply for re-charging the phones, especially for practitioners – community health workers or healthcare practitioners and users in remote and regions that are located far from the mains power grid line must be considered in the deployment and utilization of mHealth system. In low and middle income economies where other pressing needs like food, shelter and clothing are of higher priority, access and use of mHealth system be a challenge. The typical developing country scenario captured in the evaluation of mHealth use in Cambodia revealed that owning the mobile phone is a challenge to many low income brackets[31]. Inability to access the mHealth solution may either be as a result of lack of device or airtime or unstable network connectivity. These factors have the potential to cause the users to discontinue the use of an otherwise nobble initiative[28, 29, 30].

c) User Support

User Support, also referred to as the *Service Quality* is a measure that assesses the overall level of support by the technical support personnel, and is evaluated by the attributes; quick responsiveness, assurance and follow up service [38, 40]. Effectiveness of user support service for any technology system has the potential to impact the ability of the user to continuously use the technology, the user satisfaction and attitude towards the technology hence the success of the technology [41].

3.2.2 Technological Factors

a) System Interoperability

In information societies like the environments in which modern enterprises operate information and data are components that greatly define the success of the enterprise. In quest to improve effectiveness, efficiency and lower costs of operation, organizations explore the potential of various systems and tools that aid in the capture and processing of information [42]. Deployment and use of distinct systems and tools to realize the same goal can be costly and leads to duplication of functions and data hence inefficiencies. Design and deployment of newer systems or tools with the aim of increasing functionality and meeting organizational objectives should be done in a way that allows interfacing and interoperability with existing systems [41]. Systems that are designed and deployed without provisions and plans for future interoperability with other systems may later be abandoned because of inefficiencies; time and costs associated with data conversion from one system to another.

b) System Scalability

The need for data processing, transmission and storage in any modern enterprise keeps growing. Technology Systems that are designed and implemented with capabilities to grow in order to accommodate future growth in terms of increased number of users and increased needs for data processing will save the cost building a new infrastructure and possible interruptions to service provision that would be caused by building of new infrastructure. [25, 26, 43].

c) System Relevance

Technology artifacts whose functional features are relevant and are appropriately mapped to the tasks is likely to generate positive attitude from the users and a greater level of satisfaction and hence leads to higher levels of utilization and productivity [37]. Design and deployment of technology should consider the tasks at hand as well as the environment and the locality's cultural dynamics. Technological solutions with features that do not match the tasks will not be utilized or may be abandoned by users [25, 26].

d) System Quality

The quality of system is evaluated by considering the attributes that include ease of use, ease of learning, response time, usefulness, availability, reliability, completeness, flexibility and security [38, 40, 41]. System quality impacts productivity, the frequency of user support and user attitude towards the use of the system. Complex systems that are not easy to learn, Poor production quality low levels of accuracy, longer response times, challenges in availability and reliability of the system and poor security implementation will negatively impact negatively on the use of the system, leading to low or non-use of the system.

e) Technology Sustainability

Technology is constantly changing and periodically, systems within the organization require upgrades, updates and modification to deal with security requirements, processing needs and collaboration and interoperability requirements; when different systems are interfaced. When systems are built using proprietary software, royalties must be paid to obtain licences for higher versions of the software. In resource constraint situations where financial challenges are experience, an alternative approaches that will ensure future upgrades, updates and modification in line with changing technology can be realized. Use of open source technology platform provides such a cost effective alternative.

3.2.3 Management Factors

a) Ownership

Ownership of technology system is defined as the right of possessing, managing, controlling and directing the use of the technology. The ownership of a technology defines and influences the environment where the technology is used, the governance of the technology, the resources – manpower and financing available to support the implementation and use of the technology, the strategy and planning for growth of the system [39, 40, 41, 42].

b) Net Benefits (Return on Investment)

Any investment is expected to generate some tangible and intangible benefits that either match or exceed the value of the investment. An mHealth solution that does not generate satisfactory benefits will inevitable be discontinued. Net benefits accrued from using an mHealth solution will drive further investment into the solution and hence contribution to its sustainability [38, 42].

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

The study considers mHeath systems/application sustainability evaluation in Evaluation of the sustainability of mHealth systems in the developing countries context must not only consider the technology, it must also consider the environment within which the mHealth solution operates. Evaluation of sustainability must cover the individual factors, technology factors and the technology factors.

4.2 Recommendation for Future Work

Future research in this area may involve statistical and stakeholder validation of the proposed parameters and design of a score criterion for each of the factors.

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