AN EVALUATION OF EHEALTH SYSTEMS IMPLEMENTATION FRAMEWORKS FOR SUSTAINABILITY IN RESOURCE CONSTRAINED ENVIRONMENTS: A LITERATURE REVIEW

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ABSTRACT

The burden of disease is higher by far in developing countries than in the developed world. Although significant progress has been made towards health related Millennium Development Goals (MDGs) in the past years, developing countries still lag behind in achieving these targets.

Some innovative ways of solving healthcare problems have been introduced to improve healthcare services and achieve healthcare goals. Information and communication technology (ICT) for health, or eHealth, is one of the innovations that have been brought to the healthcare sector to improve the efficiency, effectiveness, access and quality of the healthcare system.

It is believed that eHealth can help reduce the healthcare budget and relieve the shortage of healthcare professionals. This is done through remote diagnosis, remote monitoring of patients' conditions and the electronic sharing of patients' medical records.

It has been reported that many ICT for health systems could not demonstrate sustainability beyond the pilot phase, or after the seed money of the project had dried up. Some of the sustainability challenges of eHealth implementation in resource constrained environments are related to weak ICT infrastructure; shortage of funding; lack of technical skill to support technologies brought from the developed world; and the introduction of technologies that were not innovated in the context of developing countries. Although the implementation of successful eHealth systems is a global challenge, developing countries exhibited much more failures than the developed ones.

Several eHealth implementation frameworks have been reported on literatures. However, this paper assesses the ability of these frameworks to ensure sustainability of eHealth systems in resource constrained settings. The evaluation framework for sustainability of eHealth systems considers the three pillars of sustainability (social, environmental and economic factors) to evaluate eHealth system's operational environment, and technological factor to assess the systems of interest.

The majority of eHealth sustainability factors link to the environments in which systems function. It is also observed that most eHealth success challenges are associated with system environments that differ significantly in developing and developed worlds.

All four eHealth frameworks evaluated in this paper address the technological factors; but they either lack depth, or miss some of the system environment factors (social, economic and environment). Therefore, an eHealth framework's ability to ensure sustainability in resource constrained environments depends not only on technology, but is also determined by the social, economic and environmental aspects of the system environment.

Key words: eHealth implementation; eHealth systems; sustainability; eHealth framework; resource constrained environment.

INTRODUCTION AND RESEARCH METHOD

The burden of disease, the shortage of skilled healthcare professionals, and inequity in healthcare service delivery between rural and urban, are some of the major challenges of healthcare services in developing regions (WHO, 2011).

The eight Millennium Development Goals (MDGs) are derived from the United Nations Millennium Declaration, signed in September 2000, to combat poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women (Islam, 2004). Although all eight MDGs directly or indirectly influence health , three of them are specifically related to health: to reduce child mortality; to improve maternal health; and to combat HIV/AIDS, malaria and other diseases (United Nations, 2013).

In 2012, the average under-five mortality rate in low-income countries (82 deaths per 1 000 live births) was 13 times more than the average rate in high-income countries (WHO, 2014). According to the United Nations (2013) report, in sub-Saharan Africa countries in 2011, one in nine children died before age five. This indicates the highest under-five mortality rate in the world, which is more than 16 times the average for developed countries.

Similarly, in 2013, the lack of access to quality maternal care by pregnant women before, during and after childbirth was the reason for the death of nearly 800 women every day; and almost all these deaths (99%) occurred in developing countries (WHO, 2014). Although the coverage of women who gave birth with the assistance of skilled birth attendants increased in the developing world, the United Nations (2013) report indicated that the urban-rural gap remains high. In developing countries in 2011, 53% of women in rural areas were assisted by skilled personnel at delivery, compared to 84% in urban areas (United Nations, 2013).

Globally, an estimated 2.3 million people were newly infected with HIV in 2012 and sub-Saharan Africa accounted for 70% of this incidence (WHO, 2014). "The Africa region also bears the highest burden of malaria, with 80% of the estimated 207 million cases and 90% of the estimated 627 000 malaria deaths worldwide occurring in this region in 2012" (WHO, 2014:17).

In summary, although significant progress has been made towards health related MDGs in the past years, developing countries still lag behind in achieving these targets.

In this paper, an exploratory research method is followed, mostly based on reviewing academic literature and international agencies' reports on eHealth systems. The key factors that influence sustainability of eHealth in resource constrained environments are examined in related literature. The structure of this examination is based on systems concepts to develop conceptual frameworks

for the sustainability of eHealth systems implementations. An exploratory research is a qualitative research approach that helps to find a hypothesis to be tested (Welman, Kauger and Mitchell, 2012).

EHEALTH SYSTEM

eHealth Definitions

Following the explosion of the internet in the 1990s and the emergence of words such as e-Business, e-Solutions and e-Commerce, the term eHealth or e-Health was introduced to represent the promise of ICT to improve healthcare services (Eysenbach, 2001; Oh, Rizo, Enkin and Jadad, 2005). Despite the lack of consensus on a clear definition of eHealth, there is a tacit understanding of its meaning and the term is widely used by industries, academic institutions, funding agencies, professional bodies and many individuals (Oh *et al.*, 2005).

In the systematic review of eHealth definitions, Oh *et al.* (2005) observed that 'Health' and 'technology' were the dominant terminologies linked to eHealth in almost all the 51 analysed definitions of eHealth. According to Eysenbach (2001), the association of the term 'technology' with eHealth makes it difficult to precisely define eHealth, because technology is a dynamic field in which different terminologies evolve at a fast pace. Currently, there are a number of terminologies that link technology with healthcare, such as health technology; health information system; electronic medical device; electronic medical equipment; medical informatics; health informatics; telemedicine; telehealth; telecare; electronic medical records; health medical records; electronic patient records; mobile health (mHealth), etcetera.

In addition to the explosion of vast numbers of terminologies that represent various forms of technology, the increasing convergence of technology and digital media blurs the boundaries among technologies. This, in turn, increases the challenge to clearly define technologies (Dutta and Mia, 2010). The integration of mobile phones, music players, digital cameras, Global Positioning Systems (GPS), alarm clocks, flashlights, calculators, handheld gaming devices, e-book readers, voice recorders, electronic dictionaries, computers and internet browsing makes the boundaries among them unclear.

Similarly, electronic medical technologies communicate with each other and are linked to central databases for easy access by different groups of people via the internet. This further complicates the boundaries and the naming of health technologies.

As a result of frequently emerging technical terminologies and the fast pace of technological convergence, several terms have evolved in the healthcare environment that are related to the words 'technology' and 'health'.

Some of these terminologies are used interchangeably in different reports, e.g. Electronic Medical Records and Electronic Health Records (WHO, 2011:Vi); Electronic Medical Records and Patient Health Records (Vital Wave Consulting, 2009:14); Telehealth and eHealth (van Dyk, 2014:1285).

For the purpose of this paper, the following definitions of eHealth is adopted "the cost-effective and secure use of information and communications technologies (ICT) in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research"(WHO, 2005).

eHealth Benefits

eHealth solutions were introduced in both developed and developing worlds to alleviate some of the healthcare challenges. Since healthcare is an information intensive environment, eHealth systems are believed to be conducive to improve the quality of healthcare by providing up to date information about patients (WHO, 2012). The review of the 51 published definitions of eHealth systems resulted in a positive connotation to eHealth systems, without any adverse, negative, harmful or disadvantageous effect (Oh *et al.*, 2005). This indicates the benefits expected from eHealth systems, which include (WHO & ITU, 2012):

- Improved access to healthcare services, especially in rural and remote communities that do not have access to healthcare specialists
- Enhanced efficiency in healthcare delivery
- Increased quality and safety in healthcare services
- Improved health monitoring and reporting
- Improved access to health knowledge and education

eHealth Implementation Challenges

Despite a number of efforts to deliver efficient, effective and sustainable eHealth systems, eHealth systems could not demonstrate sustainability beyond the pilot phase (van Dyk, 2014). In resource constrained settings, where both ICT and enabling environments are at the early stage, eHealth projects are rarely sustainable, because of inadequate ICT infrastructure, skills and ownership (WHO & ITUT, 2012). In both developing and developed countries, only a few eHealth projects managed to sustain themselves once the initial seed funding ended (WHO, 2010b). The reported challenges in the lack of longevity of eHealth projects in resource constrained environments are associated with (Molefi, 2010; WHO, 2010a; WHO, 2010b; WHO and ITU, 2012) :

- Patients' and healthcare workers' resistance to change
- Lack of ownership
- Lack of ICT skills or inadequate human capacity
- Cultural differences and language barriers
- Lack of enabling policy environments
- Weak leadership and coordination
- Weak ICT infrastructure and services
- Inadequate financial resources
- Weak monitoring and evaluation systems
- Legal issues

Several frameworks were developed to address these challenges in the development, implementation and evaluation of eHealth systems. This paper assesses the contribution of eHealth frameworks to ensure sustainability by addressing the above implementation problems of eHealth systems in resource constrained environments.

SUSTAINABILITY

Sustainability is the term often associated with improving ecological efficiency to enable human beings to live on Planet Earth for the indefinite future (Dodds and Venables, 2005; Fiksel, 2003;

Gmelin and Seuring, 2014). Sustainability is defined as the goal of sustainable development, which is the developmental process to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (Diesendorf, 2000; Dodds and Venables, 2005). However, Fiksel (2003) and Hay, Duffy and Whitfield (2014) argue that it is rather an emergent property of a particular system of interest.

The three essential dimensions of sustainability – economic, environmental and social factors – are adopted by a wide range of literatures (Harris, 2003; Fiksel, 2003; Diesendorf, 2000). Sustainability simultaneously evaluates achievements against economic success, social benefit and high environmental quality by satisfying the constraints in all three pillars of sustainability (Dodds and Venables, 2005).

To ensure sustainability of a technology, it is necessary to understand its social, environmental and economic implications before implementation (Dodds and Venables, 2005). For the purpose of this paper, sustainability is defined as the ability to sustain, continue or maintain a system by addressing the three dimensions of sustainability and other important factors of the intended system (Hay *et al.*, 2014). A system cannot be sustainable in an absolute sense (Fiksel, 2003), moreover it is vital to understand a system to be sustained during its duration of sustainability (Hay *et al.*, 2014).

Hay *et al.* (2014) explain the Sustainability Loop (S-Loop) at three different levels: the systems, activities and knowledge levels. People focus on sustainability of different systems that interests them, such as agricultural systems, transport systems, healthcare systems, political systems and so on. Therefore, defining a system's boundaries and the environment in which the system operates helps to understand activities that transform inputs into outputs in the context of the defined system.

Fiksel (2003) and Kossiakoff, Sweet, Seymour and Biemer (2011) appreciate the challenges associated with defining system boundaries. From an activities perspective, sustainability can be viewed as the ability of an activity to continue operating within a system. From a systems perspective, it is the ability of a system to continue operating within its environment in a socially acceptable manner (Hay *et al.*, 2014). Through an iterative process, "human interpret the behaviour of activities in a system to produce knowledge, and on the basis of the knowledge, then take action to alter the behaviour of the activities" (Hay *et al.*, 2014:249).

To better understand sustainability in a system context, Fiksel (2003) discussed three 'nested' systems:

- *Sustainable society:* to satisfy the needs of the present without compromising the needs of future generations.
- *Sustainable enterprise:* a component of the socio-economic system that continues to grow and adapt to meet the expectations of stakeholders and shareholders.
- *Sustainable product or service:* a component of the overall enterprise system that continues to meet the needs of its stakeholders (producers, distributers and consumers).

The environmental pillar of sustainability that encompasses all three 'nested' systems mentioned above seems to be missing in this categorisation. Dodds and Venables (2005) indicate that social and economic dimensions of sustainability fit within the environmental dimension as a system progresses towards sustainability.

MEASURING SUSTAINABILITY

Gmelin and Seuring (2014) discuss the triple bottom-line of sustainability in a new product development environment to ensure the consideration of sustainability factors in product life-cycle management.

- The life-cycle assessment (environmental) evaluates the impact of the product or service throughout its entire life span on the environment.
- The social life-cycle assessment (social) focuses on the level of social benefit for stakeholders of the product or service across its life-cycle.
- Life-cycle costing (economic) analyses the cost-effectiveness of the development, use and disposal of the product or service.

The three dimensions of sustainability: economic, social and environmental are used to measure corporate sustainability. However, researchers used different indicators for each dimension of sustainability, showing the lack of a standardised method to measure corporate sustainability (Montiel and Delgado-Ceballos, 2014).

These three pillars are also used to measure the sustainability of the dairy industry (Buys, Mengersen, Johnson, Buuren and Chauvin, 2014), the sustainability of system design (Fiksel, 2003) and the sustainability of financial institutions' lending policy (Zeidan, Boechat and Fleury, 2014). Although the three dimensions of sustainability are common, the focus of the indicators in each dimension varies, based the system of choice.

SUSTAINABILITY OF EHEALTH SYSTEMS

It is evident that the environmental, social and economic dimensions within the developing and developed world vary significantly. Developing countries suffer from inadequate ICT infrastructure, shortage of ICT skills and shortage of funds, whereas the developed world has better capacity and competence in this aspects (WHO and ITU, 2012).

The World Economic Forum (WEF) and INSEAD report on countries overall Network Readiness Index (NRI) ranking reflected that developed countries lead the digital ecosystem development, whereas developing countries remained comparatively stagnant (Bilbao-Osorio, Dutta and Bruno, 2014).

It is important to understand a system's operational environment and its interaction with the system of interest. This is necessary so that the full range of operational environment dynamics required for the successful implementation of a system shall be considered throughout the entire life cycle of the system (Kossiakoff *et al.*, 2011).

The system environment is anything outside the system of interest that interacts with the system of interest (Kossiakoff *et al.*, 2011). To define the system boundaries, one should consider the following important conditions (Kossiakoff *et al.*, 2011).

- Developmental control: If the system developer does not have control over an entity's development, the entity does not belong to the system of interest.
- Operational control: If the entity is beyond the operational control of the organisation that owns the system, it is not part of the system.

- Unity of purpose: If the entity cannot be removed without objection by another entity, it does not belong to the system of interest.
- Functional allocation: If it is not possible to allocate function to the entity in the process of defining functional requirements of the system, it is not part of the system.

eHealth systems that are successful in the developed world may not replicate the same result in resource constrained environments, because of differences in the operational environment in which the system operates. This paper aims at supporting the sustainability of eHealth systems in resource constrained environments until another system evolves to better manage information within the healthcare environment.

The Networked Readiness Index (NRI) framework comprises four sub-indexes: the environment for ICTs; the readiness of a society to use ICTs; the actual usage by all main stakeholders; ICT impact on the economy and society (Bilbao-Osorio *et al.*, 2014). The first three sub-indexes are the drivers that contribute to the results of the fourth sub-index, ICT impacts, as shown in Figure 1.

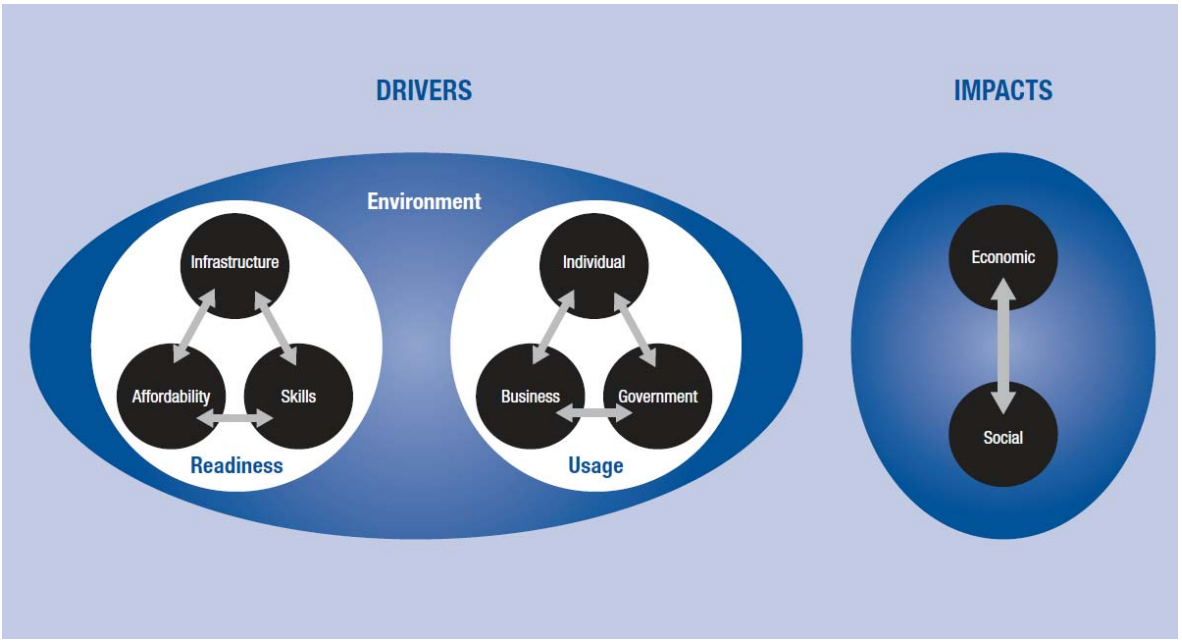

Figure 1: The Networked Readiness Index framework, Source: Bilbao-Osorio et al., 2014

Since eHealth is the use of ICT in health, the indicators described in NRI also influence the sustainability of eHealth systems. The four sub-indexes of NRI are divided into 10 pillars composed of 54 individual indicators in total, as shown below (Bilbao-Osorio *et al.*, 2014).

- **Environment sub-index:** the friendliness of the country's market and regulatory framework in supporting ICT uptake.
  - *Political and regulatory environment* (nine indicator variables)
  - *Business and innovation environment* (nine indicator variables)
- **Readiness sub-index:** the preparedness of a society to make use of an affordable ICT infrastructure and digital content.
  - *Infrastructure and digital content* (five indicator variables)
  - *Affordability* (three indicator variables)

- *Skills* (four indicator variables)

- **Usage sub-index:** the effort of a society to use ICT in its day-to-day activities.
  - *Individual usage* (seven indicator variables)
  - *Business usage* (six indicator variables)
  - *Government usage* (three indicator variables)
- **Impact sub-index:** reflects the transformation toward an ICT- and technology-savvy economy and society.
  - *Economic impacts* (four indicator variables)
  - *Social impacts* (four indicator variables)

The NRI sub-indexes share commonalities with the three sustainability measures – social, economic and environmental. The focus of the NRI framework is to measure the ICT systems environment; therefore it does not directly assess the system of interest. The success of a system looks beyond the obvious and the immediate, it understands the user's problems and assess the environmental conditions the system will be subjected to during its operation (Kossiakoff *et al.*, 2011).

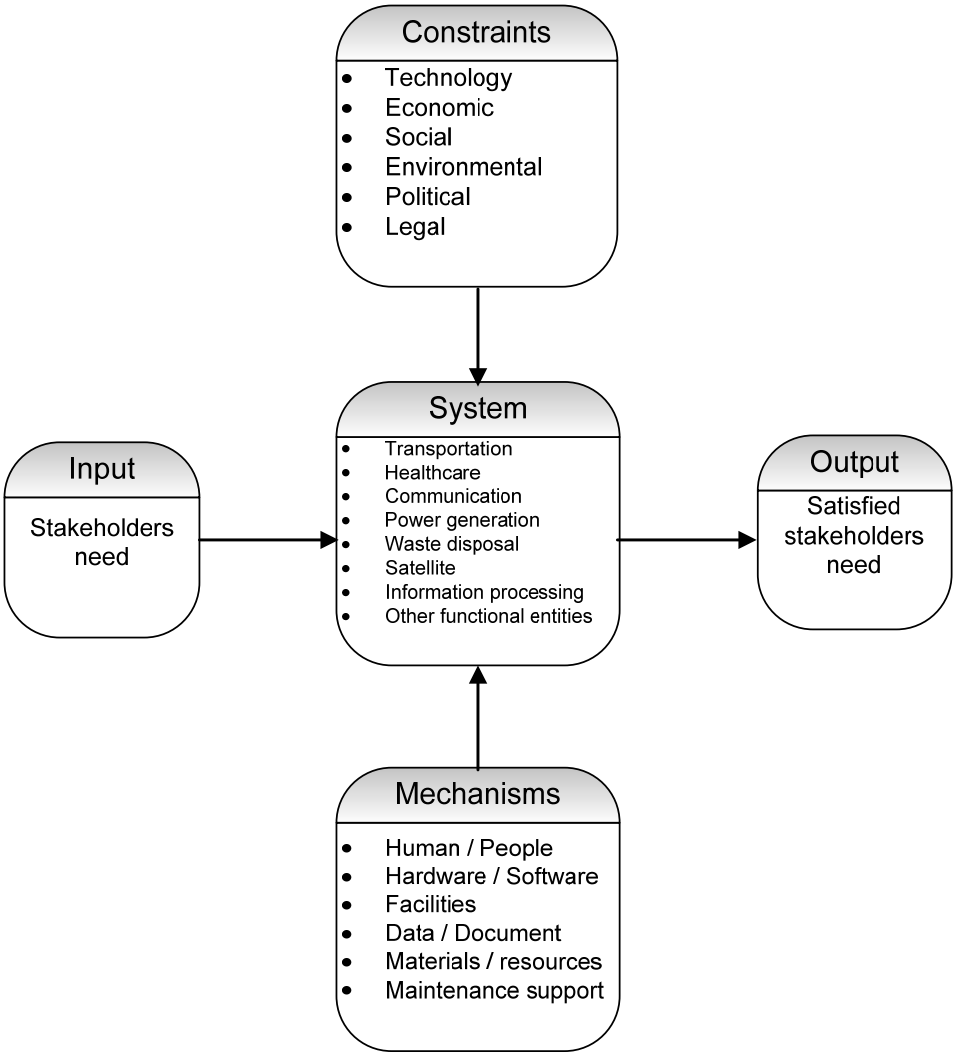

Figure 2: The System, Source: Blanchard, 2008:6

A system converts an *input* (stakeholders' needs) into an *output* (response to stakeholders' needs). This is done by considering the *constraints* imposed on the system and using the *mechanisms* required to realise the desired result as shown in Figure 2 above.

A system interacts with its environment and with other systems to satisfy the needs of its stakeholders. The three sustainability measures discussed above are mentioned in the NRI framework and are also indicated as part of the constraints to the system of choice (Blanchard, 2008). The system constraints specify the operational environment in which the system of interest operates, and the mechanisms are the capacities and capabilities required to satisfy the needs of the stakeholders.

CONCEPTUAL FRAMEWORK TO EVALUATE SUSTAINABILITY OF EHEALTH SYSTEMS

Based on the literature survey, four major factors are selected, namely *social*, *environmental*, *economic* and *technological*, to evaluate the contribution frameworks make to ensure sustainability of eHealth systems. The conceptual framework for eHealth sustainability aims to realise the fit among the social, environmental, economic and technological factors.

The first three indicators (social, environmental and economic) focus on the system environment, i.e, the environment in which the system of interest operates. The last one (technological) focuses on the quality of the system of interest (eHealth system) to address stakeholders' needs. The framework uses the sustainability theory and applies the system's approach to divide indicators into system of interest and system environment. The sustainability pillars are adopted to ensure the sustainability of a system, whereas the systems approach is applied to logically structure the eHealth system's sustainability factors.

Social factors: in the context of eHealth systems, social factors represent the eHealth framework's ability to address the ethical, behavioural, cultural, and stakeholder related issues in the process of eHealth systems development, implementation, operation and improvement. It aims at improving clinical safety, quality of care, equity of healthcare services, decision making, and speed of service delivery to all stakeholders (refer Table 1).

Environmental factors: from the sustainability of eHealth systems perspective, the environmental factors address legal, organisational and individual readiness; technical, management and political supports; policy and capacity building aspects of the system operational environment, as shown in Table 2 below.

Economic factors: In the context of the sustainability of eHealth systems, it refers to financial issues such as the availability of sustainable funding, affordability of technology, cost effectiveness and return on investment (ROI). The economic factors aim to improve profits; reduce costs and deliver affordable healthcare service (see Table 3).

Technological factors: focus on the technical capability of the eHealth system to meet the users' expectation where it is deployed. They also addresses technical indicators such as user-friendliness, flexibility, reliability, availability, accuracy, efficiency, data quality, scalability and adaptability (see Table 4).

Table 1: Social factors for eHealth Sustainability, Source: Bilbao-Osorio et al., 2014; Khoja, Scott, Casebeer, Mohsin, Ishaq, and Gilani, 2007; Khoja, Durrani, Scott, Sajwani and Piryani, 2013; Leon, Schneider and Daviaud, 2012 and WHO, 2011.

Social Factors				
Ethical	**Social outcome**	**Behavioural**	**Stakeholders**	**Culture**
• Sharing health-related data within the same healthcare facility; with different healthcare entities within the country; with healthcare entities in other countries) • Securing identity and maintaining confidentiality of patient info • Sensitivity to sociocultural issues	• Better clinically • Safety Improved • Quality of care • Acceptability of eHealth • Stability of service • Equity of healthcare service • Fast healthcare service • Affordable healthcare service • Improved decision support, clinical care and health management	• Human-computer interaction • Trust in using eHealth • Satisfaction & willingness • Benefit in learning • Awareness about eHealth • Users' technology adoption • Readiness to make changes	• Direct benefit to users in routine work • Stakeholders involvement	• Individual's culture of electronic information use • Organisational culture of electronic information use • Societal culture of electronic information use

Despite the large number of eHealth technologies in the market place, the implementation success rate is limited. Three of the four eHealth system's sustainability factors listed above are linked to the system's operational environment. This proves the importance of system environment to the successful implementation of eHealth systems.

The social, environmental and economic conditions are significantly different within developing and developed worlds. It is also observed that most of the eHealth success challenges reported in literatures are associated with the system environment. Environmental factors like regulations, ICT infrastructure and ICT skills in developing countries are significantly weak compared to the developed world (Bilbao-Osorio *et al.*, 2014). These environmental indictors are reported to be some of the major challenges in eHealth implementation (WHO and ITU, 2012).

Similarly, one of the most reported eHealth sustainability challenges, lack of sustainable funding (Leon *et al.*, 2012; WHO, 2010a), falls into the economic factors category. The developing world often suffer shortage of funds, resulting in the failure of eHealth systems, compared to the developed world (Molefi, 2010). The conceptual framework for eHealth sustainability can support the efforts of developers, researchers, managers and policy makers to ensure the implementation of sustainable eHealth systems in resource constrained settings.

Table 2: Environmental factors for eHealth Sustainability, Source: Bilbao-Osorio et al., 2014; Khoja et al., 2007; Khoja et al,. 2013; Leon et al., 2012 and WHO, 2011.

Environmental Factors				
Legal	**Policy**	**Capability and Capacity Building**	**User and Organisational Readiness**	**Technical, Management and Political Support**
• Privacy of personal and health related data • Laws related to ICT and eHealth • Efficiency of legal systems in settling disputes • Intellectual property protection • Procedures to enforce contracts • Software piracy	• eHealth policy • ICT procurement policy • eGovernment policy • Change management policy	• Availability of ICT training to technology users • Availability of training for technical support team	• Infrastructure and digital content • Availability of electric power • Availability of mobile network coverage • Speed and quality of internet • Security of internet servers • Accessibility of digital content • eHealth standards • Availability of latest technologies • Users' skill to use computers • Availability of hardware and software	• Technical (ICT service and technical support) • Management Support (Learning environment; Leadership and coordination; Collaboration and partnership; Effective change management) • Political Support (Awareness and support of eHealth among politicians and policy makers; Ownership and Commitment)

Table 3: Economic factors for eHealth sustainability, Source: Bilbao-Osorio et al., 2014 and Leon et al., 2012.

Economic Factors		
Financial/Funding	**Affordability of connectivity**	**Economic outcome**
• Availability of sustainable funding • Cost-effectiveness/cost minimisation • Return on Investment (ROI)	• Mobile cellular tariffs • Broadband internet tariffs • eHealth system procurement prices	• Reducing healthcare expenses • Improving profit

Table 4: Technological factors for eHealth Sustainability, Source: Khoja et al., 2013 and Leon et al., 2012

Technological Factors			
• User friendliness • Reliability of hardware, software, networking • Availability of eHealth system • Technical support to eHealth system	• Interoperability and standardisation • Flexibility to suit local, cultural or social needs • Scalability	• Data privacy and security • Data quality • Accuracy • Adaptability to different settings	• Technical efficiency • Appropriateness in a variety of conditions • Relevance to existing and growing needs • Timeliness

The context diagram for the eHealth system (Figure 3) summarises the system environment under social, environmental and economic categories and shows their interaction with the eHealth system (technology) at the centre. In summary, eHealth systems sustainability factors analyse the system and its system environment's ability to ensure the sustainability of eHealth systems implementation in resource constrained settings.

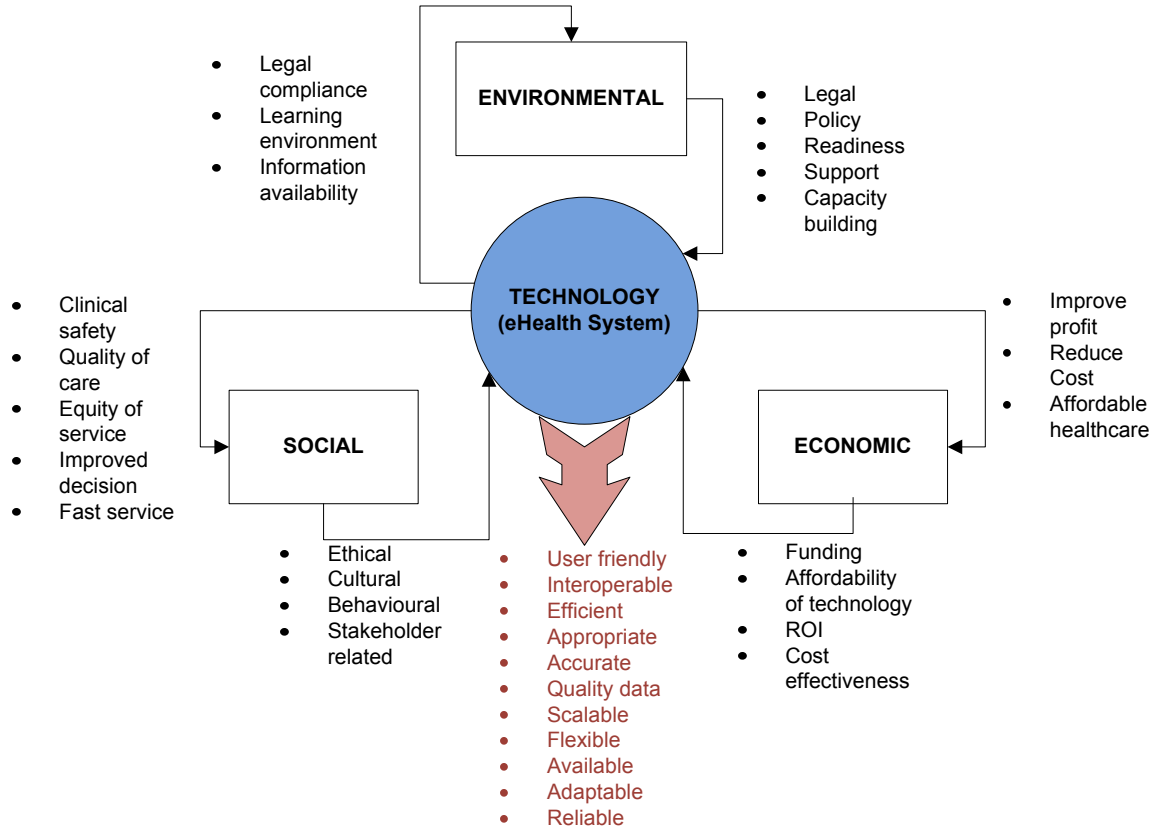

Figure 3: Context diagram for eHealth system, Source: Own research

EVALUATION OF EHEALTH FRAMEWORKS

eHealth framework 1

After reviewing nine published articles that reported on eHealth frameworks, van Dyk (2014) confirmed the importance of a holistic approach for the implementation of a telehealth service that considers the following themes: technology, organisational structures, change management, economic feasibility, societal impacts, perceptions, user-friendliness, evaluation and evidence, legislation, policy and governance.

The themes mentioned above address both the system of interest and its operating environment to ensure sustainability under all four factors of eHealth sustainability. However, the attributes of the themes are not discussed in detail. The economic feasibility addresses the economic factors, and technology addresses the technological factors. Themes such as organisational structure, change management, legislation, policy and governance cover environmental factors, whereas societal impact and perceptions can be grouped under social factors of eHealth sustainability.

eHealth framework 2

The study combined 19 key informant interviews, site visits to three mobile health (mHealth) projects and document reviews, to propose a health systems framework that addresses the four major health system dimensions required for scaling up mHealth systems and the associated capacity requirements for each dimension (Leon *et al.*, 2012).

- *Government stewardship:* policy environment supportive of mHealth
- *Organisational:* culture and capacity to use information technology for management
- *Technological:* usability, integration and sustainability of the chosen technology
- *Financial:* adequacy of finance for the medium to long term use of mHealth

The strength of the framework is its ability to address all four eHealth sustainability factors, covering both the eHealth system and its operating environment. The economic and technological factors appear to be addressed in more depth compared to the other two factors. The ethical, behavioural and stakeholders' related issues are missing under the social factors. Moreover, legal and change management are also not considered under the environmental factors.

eHealth framework 3

The four components of the eHealth Architectural Maturity Model (eHAMM), which can be used for systems analysis and development of strategy, as described on ISO/TR 14639-1 (ISO, 2012), are:

- *Governance and National Ownership:* executive sponsorship; national leadership of the eHealth program; adoption and implementation of eHealth standards; development of eHealth capacity and capability; eHealth financing and performance management; eHealth planning; architectural maintenance.
- *Foundation – eHealth Infostructure:* EHR and health information repositories; identification registries and directories; clinical terminology and classifications; data interchange interoperability and accessibility; consent/access control and workflow management; privacy; security and safety regimes; census and population information; data warehouse.

- *Foundation – ICT Infrastructure:* local access to ICT equipment and facilities; electronic communication infrastructure; ICT processing and storage services; ICT professional and technical support; standards, methods, guidelines and frameworks.
- *Health Process Domain Components:* community based; primary care; hospital/institutional; public health and disease surveillance; diagnostic; emergency response; pharmacy; healthcare supply chain services; human resources in health; health finance and insurance; vital records collection and management; environmental monitoring; and knowledge management and eLearning.

The health process domain of the model deals with different components of the healthcare dimension that can be supported by eHealth systems. The eHealth infostructure relates to the technological aspect of eHealth sustainability factors, whereas the ICT infrastructure and governance and national ownership mainly associate with the environmental factors. The model of eHealth architecture covers the environmental and technological factors of eHealth sustainability in detail, and the economic factors, to some extent, fall under its governance and national ownership. However, this model does not seem to address the social dimension of eHealth system's implementation.

eHealth framework 4

The Khoja-Durrani-Scott (KDS) framework covers a wide range of areas influenced by eHealth interventions, including (Khoja *et al.,* 2013):

- Health services outcomes
- Behavioural and sociotechnical outcomes
- Technological outcomes
- Economic outcomes
- Ethical outcomes
- Policy outcomes
- Readiness and change outcomes

The KDS framework aims at evaluating eHealth programs at the development, implementation, integration and sustained operation stages of the eHealth lifecycle (Khoja *et al.*, 2013). The KDS framework is comprehensive in covering the four eHealth sustainability factors. The economic factors are covered under economic outcomes of the KDS framework, while the technological factors are addressed under the technology outcomes of the KDS framework. The social factors are indicated under ethical, behavioural, sociotechnical and health service outcomes. The environmental factors are also addressed in the policy and readiness and change aspects of eHealth programs. The weakness of the KDS framework is not covering the legal aspect, as well as the technical, management and political support issues in detail in the environmental dimension when compared to the other three dimensions (economic, social and technological).

Table 5 summarises the four frameworks evaluated in this paper, using the eHealth sustainability framework.

Table 5: Summary of eHealth frameworks evaluation

	Social	Environmental	Economic	Technological
Framework 1	• Societal impact • Perceptions	• Organisational structure • Change management • Legislation • Policy and governance	• Economic feasibility	• Technology
Framework 2	• Organisational	• Government stewardship • Organisational	• Financial	• Technological
Framework 3		• Foundation – ICT Infrastructure • Governance and national ownership	• Governance and national ownership: eHealth financing	• Foundation – eHealth Infostructure
Framework 4	• Ethical • Behavioural & sociotechnical • Health service outcomes	• Policy and readiness • Change aspects	• Economic outcomes	• Technology outcomes

Key: Missing Undetailed Detailed

This study is not without limitations. The eHealth system sustainability factors described in this paper are derived from the literatures report. However, they are neither validated by experts in the field of eHealth, nor confirmed with objective evidence. Nonetheless, the factors are comprehensive in addressing sustainability factors of the eHealth system, covering not only the system of interest, but also the operational environment. Future studies need to validate the ability of the framework to ensure sustainability of eHealth systems in resource constrained environments.

CONCLUSION

The health related challenges are well recognised and are also addressed in the MDGs. Despite several efforts to improve healthcare delivery, developing regions still experience huge burdens of disease, shortage of skilled healthcare professionals and inequity in healthcare service delivery between rural and urban areas.

Following the impact of ICT in different organisations to improve productivity, eHealth emerged as a promising solution to improve the quality, safety and to reduce the cost of healthcare services. However eHealth systems struggled to deliver the promised result, because of weak ICT infrastructure, inadequate funding and lack of ICT skills. To address these eHealth implementation challenges, several frameworks have been developed, aiming to improve the success of eHealth implementation.

The three pillars of sustainability are widely used to measure the sustainability of a system. The indicators under each dimension of sustainability vary significantly, based on the system of interest. Four eHealth sustainability factors are selected, namely social, economic, environmental and technological, to assess the ability of eHealth frameworks to address sustainability of eHealth systems.

One of the factors (technological) focuses on the technical quality of the system of interest, while the other three factors focus on the system environment, namely the environment in which the system of interest operates. The framework uses the sustainability theory to ensure the sustainability of a system. It also applies the systems approach to logically structure the eHealth system's sustainability factors into system of interest and system environment.

The eHealth operational environment within the developing and developed world is significantly different. The majority of the eHealth system's sustainability factors link to system environment. This depicts the influence of system environment on the success of the eHealth system.

Moreover, it is also observed that most of the eHealth success challenges reported in literatures are associated with system environment. The conceptual framework for the sustainability of eHealth systems is a valuable tool to address eHealth implementation challenges in resource constrained settings. The indicators of the framework address not only the technological factors but also the system environment challenges, which differ significantly between developed and developing countries, yet are very important factors to the success of eHealth systems.

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