Systems Engineering Perspective on eHealth Implementations: Case Study of users

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Abstract

The expected outputs and outcomes for healthcare services delivery were not realized by the implemented eHealth systems in South Africa. This paper investigates the impact of system engineering management (SEM) practices on the efficiency and effectiveness of eHealth systems in a South African institution in Gauteng Province. The System Engineering Capability Model (SECM) is combined with the four major outcomes for eHealth systems as concepts in designing open ended questions for narrative enquiry addressing efficiency and effectiveness as part in the context of a result based development framework to collect stories from multidisciplinary teams in healthcare having no knowledge of SEM and limited knowledge of Information and Communications Technologies (ICT). Two eHealth projects implemented in the applicable facility show indications that the efficiency of eHealth projects is directly influenced by how well SEM is implemented. For this study, the environment category was the strongest contributor to efficiency of the Mobile application and the Electronic Medical Record (EMR) system. Users of both systems perceived that SEM was performed by both projects without proper proof of being managed through documented processes. The two projects were in the pilot phase and the Mobile application was perceived by users to demonstrate a higher outcome level than the EMR system.

Introduction

The burden of disease is a major challenge in Africa and South Africa (WHO, 2010). In order to improve the quality, access and efficacy of healthcare services for all South African citizens, eHealth-systems implementation initiatives were launched by the National Department of Health (Department of Health, 2012).

eHealth is defined as the use of ICT in healthcare (WHO, 2010). eHealth systems comprise, among others, of Electronic Medical Records (EMR), Telemedicine and mHealth (DeNardis, 2011). eHealth systems have several expected benefits, e.g. extending geographic access, improving diagnosis and treatment, improving data management, streamlining financial transactions, and mitigating fraud and abuse (Lewis, Synowiec, Lagomarsino and Schweitzer, 2012).

eHealth projects have various degree of implementation success. Different reasons for the failure of eHealth projects were reported (Department of Health, 2012; Gulube & Wynchank, 2001; Mars & Seebregts, 2008):

- some projects could not proceed beyond the pilot phase,
- the poor ICT infrastructure of the country contributes to the failure of projects,
- a lack of policy and guidance for eHealth systems integration and coordination, and

- the organization and workforce readiness to manage the required changes during implementation.

The national eHealth vision should guide eHealth system and product development processes for the stakeholders requirements analysis in the systems engineering (SE) process. The SE process is applicable throughout the eHealth system life cycle.

Objectives

Some of the challenges with eHealth system implementations in South Africa identified during the preliminary investigation for this study indicate (Gulube & Wynchank, 2001; Mars & Seebregts, 2008):

- Lack of a national eHealth strategy.
- Limited capacity and/or capability within the public sector to implement eHealth.
- High connectivity price.
- Absence of a national master patient index.
- Lack of coordination and interoperability.

This study intends to contribute to the knowledge base of eHealth systems implementation in South Africa from a user perspective. The associated research questions are (Fanta & Erasmus, 2014):

- Does a relationship exist between eHealth system efficiency and the execution of SEM principles?
- Do SEM practices have an impact on the implementation outcome of eHealth systems?

By answering the above research questions, the objective of this study is to determine how well SEM practices are applied in the implementation of eHealth systems in South Africa (Fanta & Erasmus, 2014). The study also assesses the influence of effective execution of SEM practices on successful implementation of eHealth systems. The related objectives are:

1. To determine the maturity level of SEM practices during eHealth systems implementation as perceived by the users.
2. To assess the influence of effective execution of SEM principles on the implementation outcomes of eHealth systems as perceived by the users.

eHealth Systems Background

The primary focus in evaluating healthcare technologies should be the ability of technologies to increase throughput (Fanta & Erasmus, 2014), i.e. the ability of an organization to achieve its goals, and the ease of implementing accompanying process changes (Goldratt & Cox, 2004). The improvement of a system through the application of The Theory of Constraints (TOC) can be done by strengthening the weakest link where these constraints can be physical, policy, operational procedure, or management policy constraints (Goldratt & Cox, 2004). The success determinants of telemedicine implementation can be classified into five major categories (Broens, Veld, Vollenbroek-Hutten, Hermens, Halteren & Nieuwenhuis, 2007):

- Technology.
- Acceptance.
- Finance.
- Organization.
- Policy and legislation.

Technology and Acceptance were the most reported determinants (Broens *et al.*, 2007). Fanta & Erasmus (2014) points out that the above five categories have similarities with the attributes of the healthcare services-support system in the healthcare services-science model (Weeks, 2012).

eHealth is a promising solution that facilitates health consultation in rural communities of developing countries with less cost, minimum travel time and short traveling distances (Sudhahar, Vatsalan, Wijethilake, Wickramasinghe, Arunathilake, Chapman & Seneviratna, 2010). However, Broens *et al.* (2007) discussed that the focus of success determinants shifts from technology acceptance to financial and organizational factors as the implementation progresses from pilot to large-scale implementation phase. Thus, the financial gain of the above mentioned eHealth system is determined by considering the large-scale system implementation cost of operations, maintenance and support phases (Fanta & Erasmus, 2014).

The barriers identified during the implementation of eHealth are (Lewis *et al.*, 2012; Mars, 2012; Monda *et al.*, 2012; Ruxwana *et al.*, 2010):

- Lack of necessary infrastructure.
- Initial and lifecycle cost of technology.
- Lack of ICT skill and knowledge.
- Lack of cultural appropriateness.
- Lack of incentives to adopt new tools.
- Inadequate technical support and maintenance.
- Ensuring the data quality.

Evaluating eHealth Systems

Engineering defines efficiency as the measured ratio between the output and input of a system (Fanta & Erasmus, 2014). The capability maturity measurement of the SE process creating system or product can estimate the efficiency of that system or product (Elm, Goldenson, El Emam, Donatelli & Neisa, 2007) and is the basis for the efficiency parameter shown in Figure 1 (Fanta & Erasmus, 2014). The first step in capability development is to define the goals and objectives of an organization (Blanchard, 2008). The SECM can be categorised into the following focus areas (Blanchard, 2008:404):

- Technical.
- Management.
- Environment.

Technical aspects of systems engineering falls into the Technical category of the SECM (Blanchard, 2008:403). The Management category of the SECM addresses the cost-effective execution of the systems engineering processes by evaluating (GEIA, 2002):

- Planning.
- Control.
- Information management.

The Environment category of the SECM supports the Technical and Management Focus Areas by ensuring the alignment of business goals with technology and process development processes (GEIA, 2002).

The capability levels of the three SEM categories are measured by the levels of maturity ranging from 0-5, namely initial, performed, managed, defined, measured and optimized

respectively (GEIA, 2002). Integer numbers are used to designate the criteria for each capability level and the decimal number measurements indicate the progress to reach the next level of maturity.

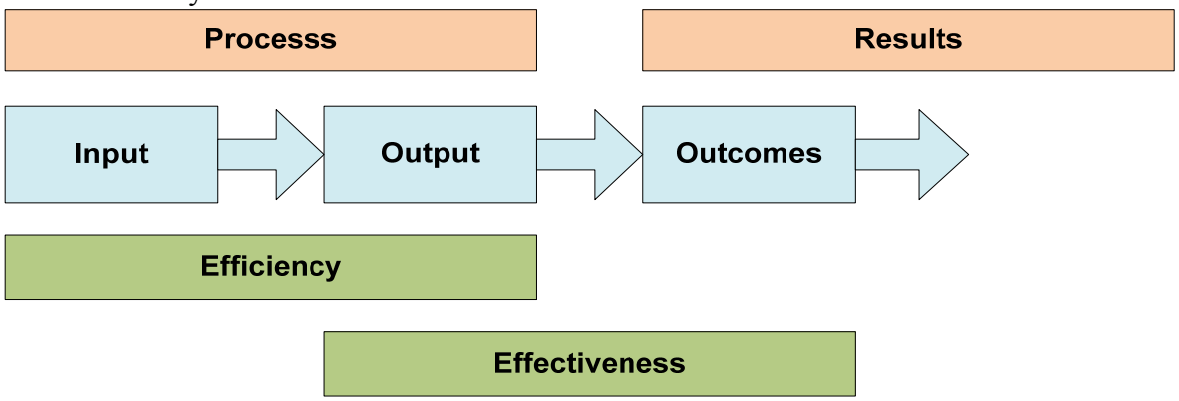

Figure 1: Efficiency and Effectiveness context (Based on Nagel & Remmelzwaal (2010) in Erasmus, Poluta & Weeks, 2012:26)

A system is sustainable when the combination of the system's input, output, outcome and impact is meeting favorable criteria (Nagel & Remmelzwaal (2010) in Erasmus, Poluta & Weeks, 2012). System efficiency is achieved by a process that produces the intended output from the given inputs. An estimate for system efficiency is the capability measures of the process and the organization executing it. The SECM is an operative tool used to conduct assessments of SE capability (GEIA, 2002) and it is adapted for measuring the efficiency of eHealth systems. The efficiency and effectiveness of healthcare services are expected to be improved by the four major eHealth systems outcomes (Gruber, Cummings, Leblanc & Smith, 2009):

- System outcome,
- Users/Providers outcome,
- Management outcome, and
- Patient outcome.

These four outcome categories are adapted to measure the outcomes of eHealth systems (Fanta & Erasmus, 2014). The system effectiveness measures the achievement of the general objectives of the introduced system or the system outcome as depicted in Figure 1.

Research Methodology

There are not a large number of eHealth systems operational (including those still in the pilot phase) in the South African public health sector. Moreover, the ethical constraints in healthcare and people who have the time and technical knowledge about eHealth technologies are constricting the use of normal qualitative techniques to deliver reliable research results.

The combination of both quantitative and qualitative methods is used to enhance the research studies (Leedy & Ormrod, 2010). In light of the above constraints and to increase the ability to interpreted the research finding, triangulation is used that combines two or more theoretical perspectives, methodological approaches, data sources, investigators or data analysis methods within the same study with the intent to decrease, negate, or counterbalance the deficiency of a single strategy (Thurmond, 2001).

The assumption is that most people in the healthcare services have limited or no technical knowledge and understanding of ICT and SE processes (Fanta & Erasmus, 2014), thus, a narrative enquiry with open ended guiding questions was used to collect data from eHealth users.

A qualitative (interpretations) and quantitative (statistical description) research approach was used in analyzing the data and reporting the results from a mixed-method or triangulation research methodology as shown in Figure 2. Quantitative data was derived from the qualitative data by filling out SECM evaluation sheets based on the collected narratives (Fanta & Erasmus, 2014).

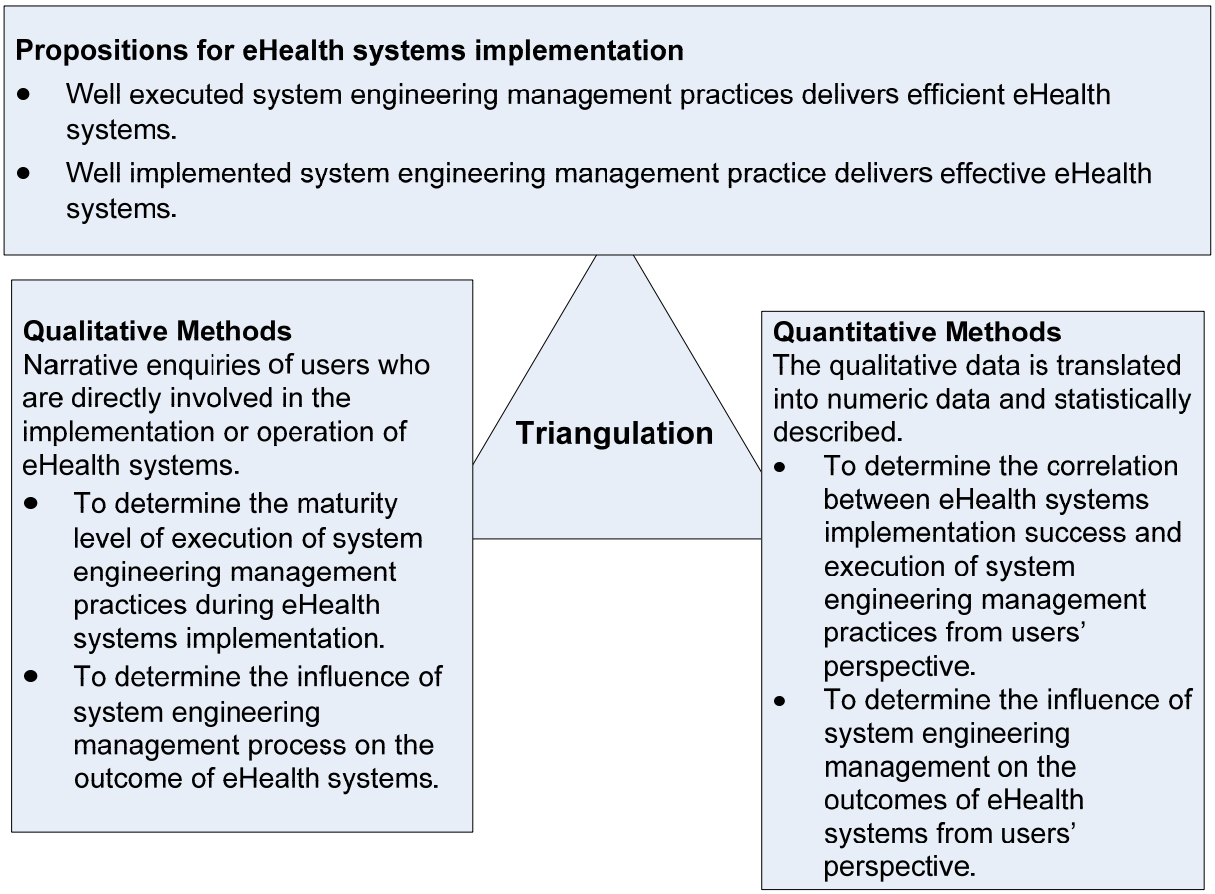

Figure 2: Research approach to investigate efficiency and effectiveness of eHealth systems (Based on Fanta & Erasmus, 2014)

Accidental sampling was used because the sensitivity of healthcare information made access to research data difficult. Thus, eHealth projects were selected based on the accessibility of the research data (Fanta & Erasmus, 2014). The eHealth-system users are summarized in Table 1.

Table 1: Clinical and nonclinical eHealth System users

Health Facilities	Locations	eHealth Systems	Technology Users
Clinic	Gauteng	Electronic Medical Record (EMR)	Clinical users Nonclinical users
		Mobile Application	Nonclinical users

Four clinical and two nonclinical users of EMR systems were interviewed in on-to-one session. Additionally, eight community healthcare workers that use mobile technology for their daily work activities were interviewed in a group panel.

Users Perception on SEM practices during implementation

This section evaluates objective 1 to determine the maturity level of SEM practices during eHealth systems implementation as perceived by the users, by analyzing the stories obtained during the interviews for emerging themes through the three focus area categories of SEM tasks of the SECM, namely technical, management and environment outputs.

Technical Outputs:

Requirements, defining solutions, verification and validation. All the clinical members of staff wanted to have input into the design of the EMR system which they will be using in their day to day activities. They also needed the system to incorporate the multidisciplinary team within the facility and to facilitate the learning process. One clinician wanted to have part in testing the technology and also wanted communication to be improved on the process of the system implementations. Nonclinical member of staff also indicated that there was no platform to address her input during the system design.

Although some clinical users have been involved in the design process of the Mobile application, the limited users' involvement in the design of the EMR system was one of the limitations in the process of health technology design and implementation. Most of the clinical and nonclinical users of the EMR system indicated that there was no available platform for users to provide feedback. Blanchard (2008:21) states that "the SE process is continuous, iterative and incorporates the necessary feedback provisions to ensure convergence". Fanta & Erasmus (2014) concluded from the suppliers' perspective that "the limited involvement of stakeholders and lack of feedback incorporation methods were the two key observed weakness of the solution defining process in the EMR system". These observed weaknesses were also confirmed by the users.

The SE process starts from the challenges of stakeholders who are the main actors in the process (Erasmus & Doeben-Henisch, 2011a). Feedback and verification are important elements in defining solutions (GEIA, 2002).

Technology assessment and selection. The EMR technology supplier was never formally contracted for delivering the solution; as a result clinical users appeared to be of the opinion that the technology assessment and selection process was not based on documented procedures.

Integration. All clinical users described that the EMR system lacks technical integration with other legacy systems in the facility, as well as it lacks interdisciplinary integration because of insufficient communication among stakeholders. Nonclinical respondents also appeared to indicate that the integration of multidisciplinary teams into the design and implementation process was limited.

Integration requires an interaction of interfaces that could be between users, environment or other systems (Erasmus & Doeben-Henisch, 2011b). As discussed by Erasmus & Doeben-Henisch (2011b), the user interface represents the required behaviours of the users. The users clearly indicated the disconnect between the multidisciplinary users and the EMR system.

Stakeholders' engagement is part of the eHealth strategies' priorities (Department of Health, 2012:6); but clinical and nonclinical eHealth users indicated limited involvement of stakeholders in the design process. Interdisciplinary teams have a significant role during system design to consider the system life cycle needs of stakeholders (Erasmus & Doeben-Henisch, 2011b). According to the respondents, one of the missing pieces during the eHealth systems implementation seemed to be the involvement of interdisciplinary teams. Ludwick & Doucette (2009) discussed the importance of an interdisciplinary approach in the implementation of eHealth system which was also supported by the responses of most clinician respondents

Management Outputs:

Change management. Three clinician respondents described the system as impractical because it did not consider the work burden of clinicians within the facility. They explained that the large number of patients and the supervision of a significant number of medical students put an extra burden on their work so the system should be planned in such a way to fit to the actual situation on the ground. The respondents indicated the following as challenges in the technology acceptance:

- Lack of proper training.
- High work burden.
- Fear of failure based on past experience with a failed electronic system.
- Weak communication.

Ludwick & Doucette (2009) discuss the importance of proactive management in dealing with staff's resistance to change. The clinician respondents made an interesting comment that better communication could facilitate the technology introduction and rollout process. The users, both clinical and nonclinical members of staff, commented on the need of technologies to fit into the practical work condition of the healthcare facility. Cultural appropriateness of new electronic tools could be one of the possible impediments of successful eHealth systems implementation (Mengistu, 2010).

Risk Management. All the clinician respondents appeared to agree that some of the major factors contributing to the huge resistances from then clinical team are:

- impractical to the clinicians work situation in the health facility,
- time consuming to enter data,
- the workload on clinical staff,
- duplication of the system (paper and electronic),
- a negative connotation to electronics systems because of a previously failure, and
- communication gaps.

Nonclinical members of staff also echoed clinician respondents' concerns that the system is not practical to be used by overloaded clinical staff who consult many patients and supervise a significant number of students.

Strong leadership through the using of project management techniques, establishing standards and training staff helps to prevent or mitigate possible risks that can challenge implementation success (Ludwick & Doucette, 2009).

Both clinical and nonclinical technology users described the usability of the technology in the actual work environment as the major risk associated with the adoption of the EMR solution in the healthcare facility. Communication gaps and a fear of failure were also risks mentioned by the users which they believe were not mitigated sufficiently. Well-designed risk management commences early in the project and proceeds as a monitor and follow-up effort throughout the project (Smith & Merritt, 2002). However most of the risks mentioned by the respondents appeared not to be addressed appropriately or proactively.

Data Management. Generally, the clinical staff appeared to have little knowledge about the data management process and almost all pointed out that it should be the task of the technology provider to do it. The promised improved and an efficient healthcare service delivery cannot be achieved without a high level of data quality (Monda *et al.*, 2012).

Environment Outputs:

Competency. The clinical staff appeared to be comfortable in using the EMR system if the applications were easy and comfortable to use. The respondents believed that some skill shortages can be addressed through training.

Time and cost of training is regarded as a measure of system effectiveness (US Department of Defense, 2001). Both the EMR system and the Mobile application appear to be effective in terms of training as they only take a short time in training users.

Technology and Organizational Support. The clinical staff members were aware of available technical support for both systems; however, they demanded more intensive support, especially, for those who are slow to learn the technology. The nonclinical group of users appeared to be satisfied with the technical support provided by the technology providers.

A clinical member of staff's concern was the absence of formal technical support agreements between the facility and the technology providers; this seemed to be a shortcoming of the technical support structure.

The eHealth Implementation Outcomes

The second objective, to assess the influence of effective execution of SEM principles on the implementation outcomes of eHealth systems as perceived by the users, was addressed by analyzing the stories obtained during the interviews for emerging themes through the use of four outcomes of Clinical Information Systems (CIS) (Gruber *et al.* 2009):

- *System outcomes:* the results of a CIS implementation such as documentation.
- *User outcomes:* the end-users of a CIS who have interaction with the system in the course of providing patient care.
- *Management outcomes:* aspects of a CIS that assist in managerial decision-making, operational management, meeting government regulations, benchmarking organizational performance, funding decisions within and external to the organization.
- *Patient outcomes:* aspects of a CIS that are directly affected by the system's implementation for patients.

System and Users Outcomes of eHealth Implementations

The users claimed that the EMR system that runs in parallel with the paper system is resulting in a duplication of effort. The EMR system appeared to be easy to use and accessible from all computers, but it missed some key functionality, consumed time to register patients and was slow in the morning.

Management and Patients Outcomes of eHealth Implementations

The clinical members of staff mentioned the following benefits of the EMR system to the patient and management:

- Creation of the funding model for the National Health Insurance (NHI) system.
- Linking the patient risk profile and protocol to the diagnosis.
- Improving the data management and classification process.

The nonclinical members of staff also described the benefits of the EMR system as:

- Replacing of the paper system in the future.
- Recovering of misplaced patient files.

Descriptive Statistical Analysis

The users perceived the same level of system output for both the Mobile application and the EMR system; however the Mobile application exhibited a higher system outcome level (Figure 3). The result indicated that the system output was not the only factor that influenced the system outcome. The study conducted by Fanta & Erasmus (2014) on eHealth system suppliers also indicated that SEM practice might not necessarily ensure a successful eHealth system's outcome. The relationship between the system output and system outcome needs to be confirmed by a bigger set of sample data from all stakeholders' perspective.

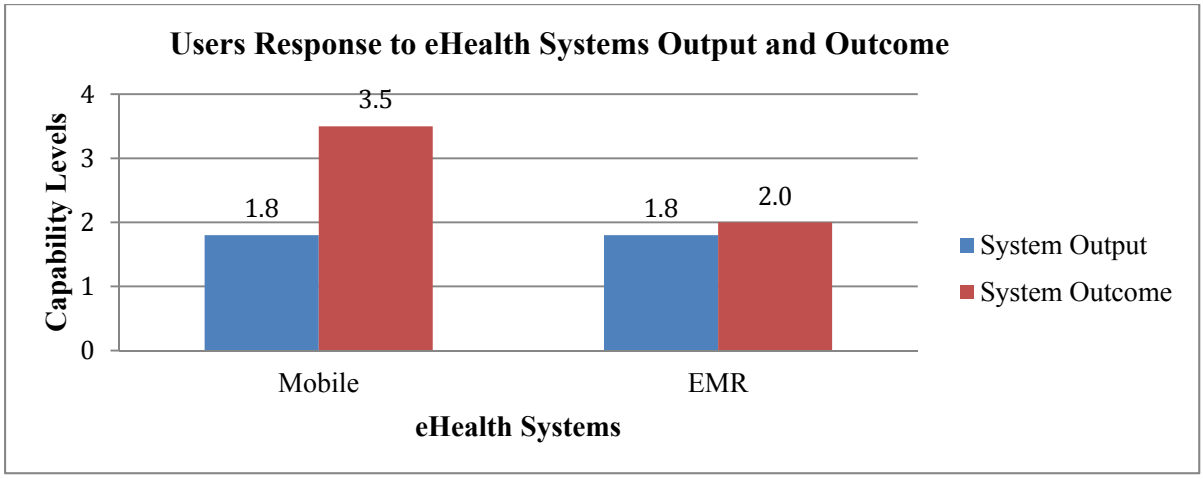

Figure 3: Users response to SE capability of eHealth systems output and outcome

The Mobile application demonstrated higher SE capability levels in the management and environment categories; whereas the EMR system showed a better capability in the technical category as perceived by users (Figure 4). The users rated the overall SE capability level of both systems the same, indicating the systems were partially planned, tracked and verified but some of the processes were not well defined.

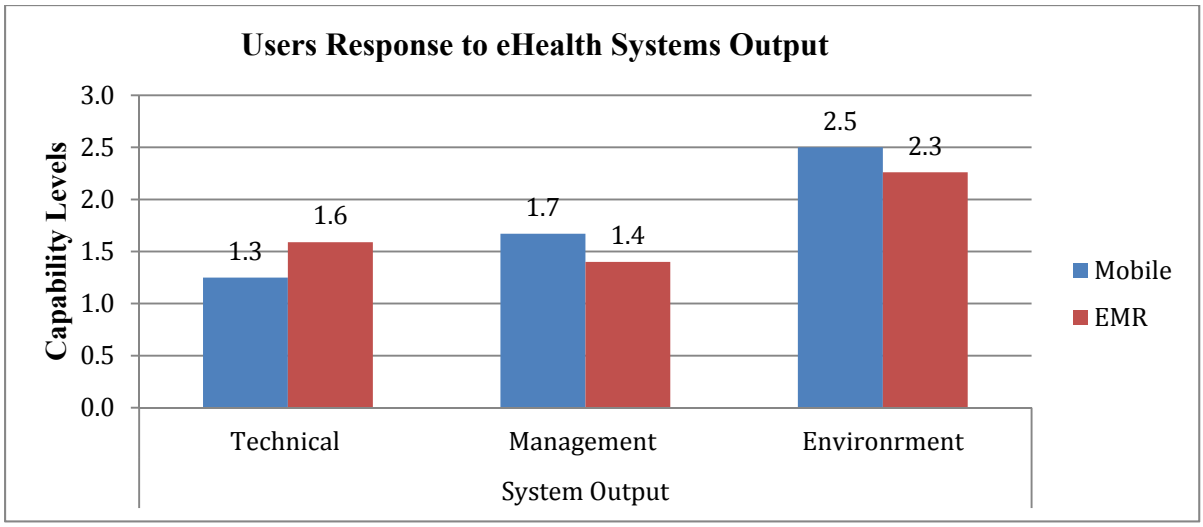

Figure 4: Users Response to the Output of eHealth Systems

The clinical and nonclinical users of both systems specified the environment category as a more dominant SE capability than the technical and management categories (Figure 5). In all three categories of SE capabilities for the EMR system (Figure 5), the clinical users perceived lower SE capability levels than the nonclinical users.

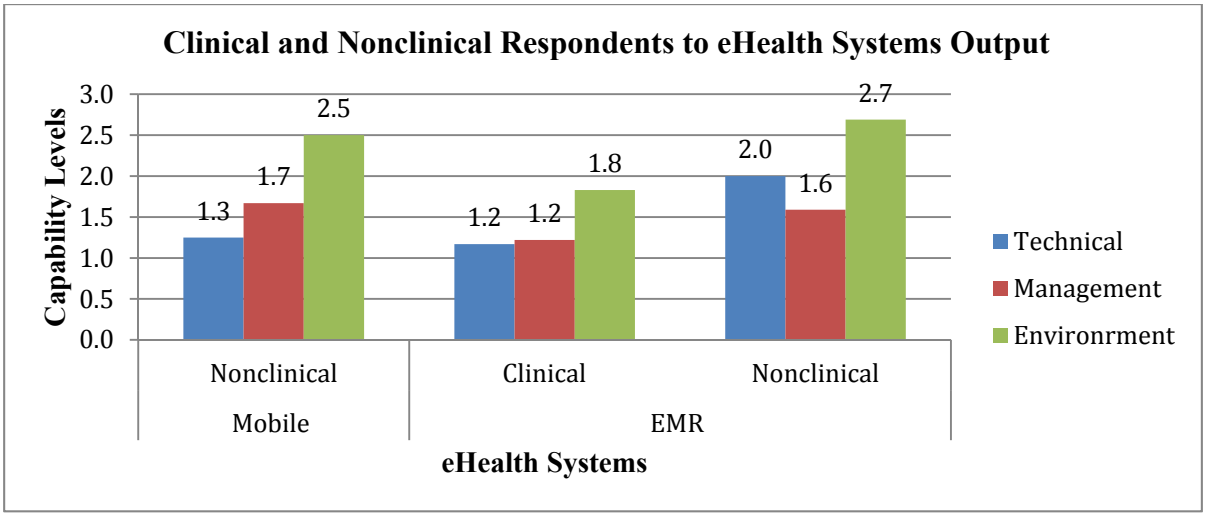

Figure 5: Clinical and Nonclinical Users Response to the Output of eHealth Systems

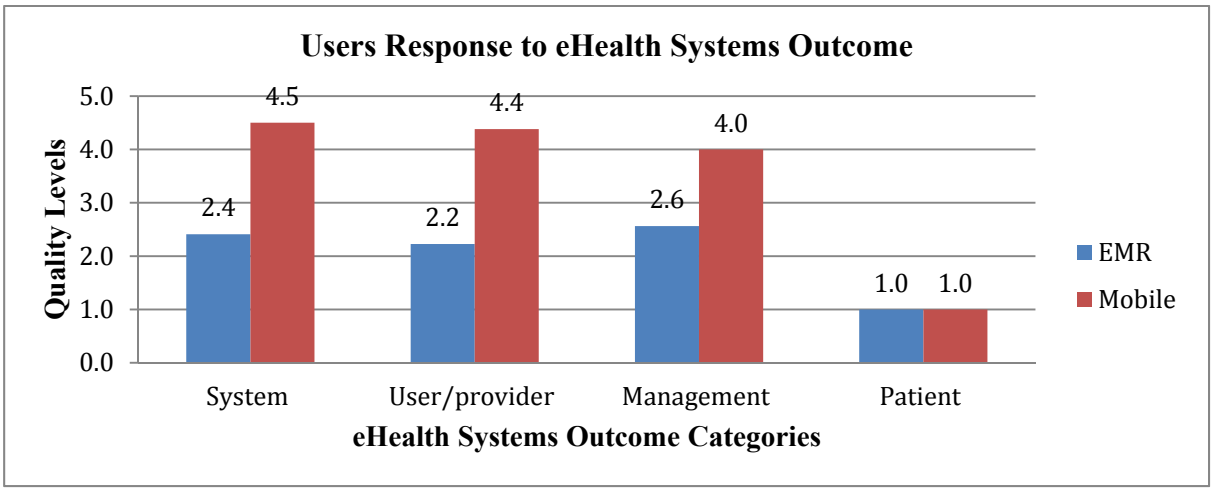

Figure 6: Users Response to the Outcomes of eHealth Systems

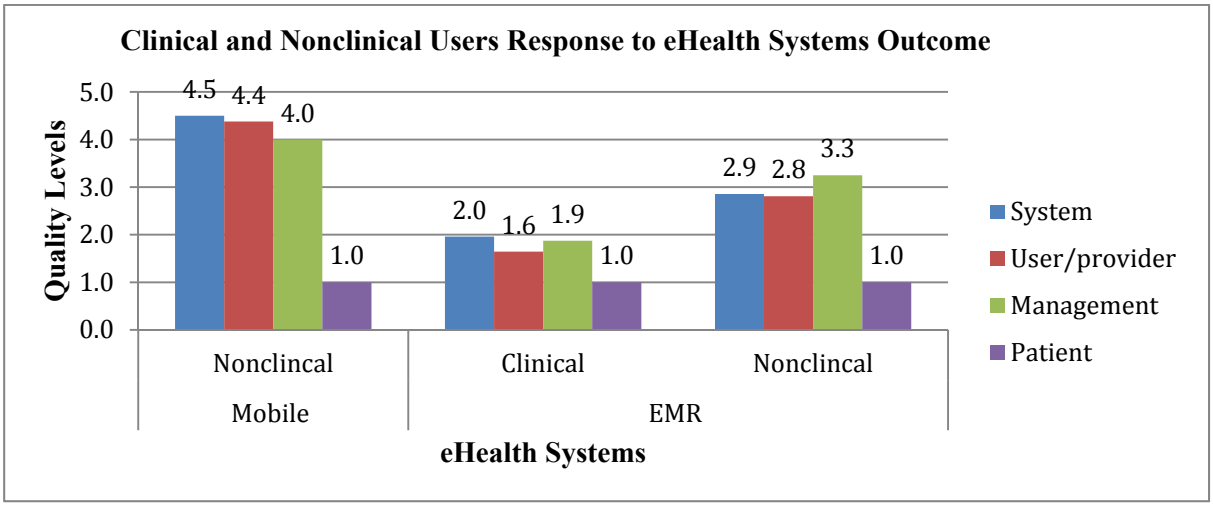

Figure 7: Clinical and Nonclinical Users Response to the Outcomes of eHealth Systems

The patient outcome was the lowest outcome category for both systems as described by the users of both systems (Figure 6). This showed that the clinical and nonclinical users assumed that the benefit of the system to patients was limited. The Mobile application users indicated

higher outcome levels for the system, user/provider and management categories compared to the outcome levels rated by both clinical and nonclinical users of the EMR system (Figure 7).

Conclusions and recommendations

The qualitative study showed the lack of technical integration and limited engagement of a multidisciplinary team as the two major technical category challenges as indicated by the users. These challenges could reduce project success if it is not mitigated proactively (Ruxwana *et al.*, 2010). The quantitative study shows a low technical capability level for the Mobile application.

The management category was challenged by the lack of a poor change management approach, lack of proper training, weak communication and risk management. In the quantitative analysis, the EMR system showed the lowest capability level in the management category.

The qualitative and quantitative analyses of users' responses indicated high capability levels in the environment category for both the Mobile application and the EMR system. One of the challenges in the environmental category as mentioned by users was the absence of formal technical support agreements between the facility and technology providers. Users were satisfied with eHealth systems that exhibited better system-engineering capabilities indicating a strong relationship between the implementation of an efficient eHealth system and the execution of SEM practices.

The first proposition, well executed SEM practice delivers efficient eHealth systems, appears to be supported by eHealth users in the course of carrying out this research study. In this case study, it is observed that efficient eHealth systems that satisfy user needs can be achieved by execution of SEM practices.

Since the Mobile application and the EMR system were both in the pilot phase, measuring the eHealth systems outcome was a challenge. Despite the same output level for both systems, the Mobile application demonstrated a better outcome level than that of the ECM system. The influence of SEM practices on the eHealth implementation outcome should be further studied when the two systems become fully operational.

The second proposition, well-implemented SEM practices ensures the success of eHealth system outcomes, could not be proven to be necessarily either true or false.

The data analyzed in this research study from users' perspective gives some indication that both the Mobile application and the EMR system have the same level of efficiency; however the Mobile application appeared to be more effective. Future research with a bigger sample size should confirm the efficiency and effectiveness of eHealth systems from users' perspective.

References

Blanchard, B. 2008. System Engineering Management. 4th edition. New Jersey: John Wiley & Sons Inc.

Broens, T.H.F., Veld, R.M.H A.H., Vollenbroek-Hutten, M.M.R., Hermens, H.J., Halteren, A.T.V. and Nieuwenhuis, L.J.M. 2007. "Determinants of successful telemedicine implementations: a literature study." Journal of Telemedicine and Telecare 13: 303 – 309.

DeNardis, L. 2011. *Standards and eHealth*. Geneva: ITU.

US Department of Defense. 2001. System Engineering Fundamentals. Virginia: Defense Acquisition University Press.

Department of Health. 2012. eHealth Strategy South Africa, 2012/13-2016/17. Pretoria: Department of Health.

Elm, J.P., Goldenson, D.R., El Emam, K., Donatelli and Neisa, A. 2007. A Survey of Systems Engineering Effectiveness. Pittsburgh: Carnegie Mellon University.

Erasmus, L.D., and Doeben-Henisch, G. 2011a. "A Theory for the Systems Engineering Process," *IEEE AFRICON 2011*, Livingston, Zambia, doi: 10.1109/AFRCON.2011.6071989

Erasmus, L.D., and Doeben-Henisch, G. 2011b. "A Theory of the System Engineering Management." *ISEM*, Stellenbosch, South Africa. http://www.isem.org.za/index.php/isem/isem2011/paper/view/124/108

Erasmus, L., Poluta, M. and Weeks, R. 2012. Integrated Assessment and Management of Healthcare Infrastructure and Technology. Innovate. 07: 22-30.

Fanta, G.B. and Erasmus, L. 2014. A Systems Engineering Perspective on eHealth Implementations' Efficiency and Effectiveness: A Case Study involving suppliers. EMEASEC, Cape Town, ISBN: 978-0-620-58907-9.

GEIA (Government Electronics and Information Technology Association). 2002. *EIE Standard: EIA-731.1: System Engineering Capability Model (SECM)*. Washington, DC: GEIA.

Goldratt, E.M. and Cox, J. 2004. *The Goal: A Process of Ongoing Improvement.* 3rd Edition. Pretoria: Eli Goldratt.

Gruber, D., Cummings, G. G., Leblanc, L. and Smith, D. L. 2009. "Factors Influencing Outcomes of Clinical Information Systems Implementation." *Computers, Informatics, Nursing* 27(3):151-163.

Gulube, S. M. and Wynchank, S. 2001. "Telemedicine in South Africa: Success or failure?" *Journal of Telemedicine and Telecare* 7(Suppl. 2): S2:47-49.

Lee, T.W. 2012. *Using Qualitative Methods in Organizational Research*. London: Sage.

Leedy, P.D. and Ormrod, J.E. 2010. *Practical Research: Planning and Design*. 9th Edition. New Jersey: Pearson.

Lewis, T., Synowiec, C., Lagomarsino, G. and Schweitzer, J. 2012. "EHealth in low- and middle-income countries: findings from the Center for Health Market Innovations." *Bulletin of World Health Organization* 90:332–340.

Ludwick, D.A. and Doucette, J. 2009. "Adopting electronic medical records in primary care: Lessons learned from health information systems implementation experience in seven countries." *International Journal of Medical Informatics* 78, 22-31. http://www.intl.elsevierhealth.com/journals/ijmi

Mars, M. 2012. "Building the Capacity to Build Capacity in eHealth in Sub-Saharan Africa: The KwaZulu-Natal Experience." *Telemedicine and eHealth* 18(1).

Mars, M. and Seebregts, C. 2008. *Country case study for eHealth South Africa*. http://ehealth-connection.org/files/resources/County%20Case%20Study%20for%20eHealth%20South%20Africa.pdf

Mengistu, S.A. 2010. "Analyzing the challenges of IS implementation in public health institutions of a developing country: the need for flexible strategies." *Journal of Health Informatics in Developing Countries* 4(1):1-17. http://www.jhidc.org/index.php/jhidc/issue/view/9

Monda, J., Keipeer, J. and Were, M.C. 2012. "Data Integrity Module for Data Quality Assurance within an eHealth System in Sub-Saharan Africa." *Telemedicine and eHealth* 18(1): 5-10.

Ruxwana, N.L., Herselman, M.E. and Conradie, D.P. 2010. "ICT applications as eHealth solutions in rural healthcare in Eastern Cape Province of South Africa." *Health Information Management Journal* 39(1): 17-19.

Smith, P.G. and Merritt, G.M. 2002. *Proactive Risk Management: Controlling Uncertainty in Product Development*. A Productivity Press.

Sudhahar, S., Vatsalan, D., Wijethilake, D., Wickramasinghe, Y., Arunathilake, S.,Chapman, K. and Seneviratna, G. 2010. "Enhancing Rural Health in Emerging Countries through an eHeath Solution." *eTELEME* 11.

Weeks, R. V. 2012. Healthcare Services Management: Systems Perspective. *Journal of Contemporary Management.* 9:382-401.

World Health Organization (WHO), 2010. *Monitoring and evaluation of health systems strengthening: An operational framework*. Geneva: WHO Press.

World Health Organization (WHO) and International Telecommunication Union (ITU). 2012. *National eHealth Strategy Toolkit*. Geneva: WHO and ITU.

Biography

Getnet Bogale Fanta worked for 7 years in telecommunications and pharmaceutical supply chain management sectors on Management Information Systems for local and international organizations. He received the B.Sc. degree in Electrical Engineering from Addis Ababa University, graduated with Master Degree in Engineering Management and is a Ph.D. candidate at University of Pretoria. His interest is the application of systems engineering to ensure sustainability of projects; especially, to ICT projects in the healthcare sector.

Louwrence Erasmus worked for more than 20 years in academia, national and international industries on multi-disciplinary projects and is a Principal Systems Engineer at the CSIR since 2013 and an associated researcher with the Post Graduate Engineering Management, University of Johannesburg and a part-time senior lecturer and research associate at the Graduate School of Technology Management, University of Pretoria. He graduated from the Potchefstroom University with the B.Sc., B.Eng., and M.Sc. degrees in 1989, 1991 and 1993 and was awarded the Ph.D. degree in 2008 from North West University, Potchefstroom. He is a registered professional engineer with ECSA and a senior member of IEEE and SAIEE and a Lead Enterprise Architecture Expert. His interest is the underlying formal structures in enterprise and systems engineering using constructivist philosophy of science and their practical implications in the practice and management of engineering in complex environments.