USING A STRUCTURED APPROACH TO EVALUATE ICT4D: HEALTHCARE DELIVERY IN UGANDA

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ABSTRACT
Using a case from the healthcare delivery sector, we demonstrate how a structured evaluation approach can facilitate the measurement of actual ICT contributions in various contexts. Typically, such are intricate due to the complexities inherent in the environments, making it difficult to evaluate the relationship between ICT and the benefits it intends to achieve to a reasonable degree. The approach suggested in this paper tries to partly remedy some of these complications, by facilitating qualitative data elicitations, aggregation, analysis and evaluation. To make this computationally meaningful, a decision support tool for handling numerically imprecise information is used for the data analysis and evaluation details. The results of this indicate that such an approach makes at least some meaningful input for practitioners and policymakers. In comparison to the qualitative in-depth approaches this approach facilitates a one-point in time assessment, which is less resource intensive, but provides prompt and substantial insight on the development performance of ICT4D initiatives. A similar approach would also be applicable to different sectors, and can utilize a broader scope of criteria, as well as incorporate views from several categories of stakeholders.

Keywords: ICT4D, Evaluation, Impact, Healthcare delivery, decision analysis, MCDA

1. INTRODUCTION

Practitioners and policy makers in developing countries are increasingly relying on the evidence of acquired benefits to prioritize and allocate health care resources. In this respect, evidence regarding the contribution Information and Communication Technology (ICT) makes towards improved healthcare delivery is a vital input to this decision process. There has been a proliferation in approaches seeking to establish whether and how ICT contributes to healthcare delivery. However, there are limitations in obtaining reliable information due to challenges inherent in the existing approaches. For instance, Verbeke et al. (2013) note that explicit approaches against which outcomes can be judged and performance measured are still limited. Similarly, Piette et al. (2012) reiterate the need for more information regarding the impact of e-health in developing countries.

More generally, some of the challenges facing the evaluation of the ICT contribution to development which are also pertinent to improved healthcare delivery include: the fact that there is no direct relationship between ICT and development (Grunfeld, 2011), the lack of clarity on what constitutes such an impact evaluation (Roberts, 2008), and various methodological challenges such as limited financial resources or the lack of relevant data to facilitate such evaluations. Furthermore, even when data is available, the selection of measures is often dictated by the information needs of international or local organizations, which results in data collection which is rarely useful for making improvements to the existing health care system. See e.g., Verbeke et al. (2013).

In this article, we suggest a structured approach that relies on qualitative criteria to facilitate the evaluation of the ICT contribution in different sectors particularly from a developing country perspective. We also exemplify this in a comparative evaluation of the ICT contribution to improved healthcare delivery in rural healthcare facilities in Uganda. The actual ICT here ranged from the most basic personal mobile phones to the more sophisticated tele-medicine applications. We show how a systematic one point in time evaluation of ICT benefits in terms of outputs and outcomes can be conducted. Our approach complements the predominantly qualitative, descriptive evaluations when handling multi-dimensional, multiple stakeholders' views characterized by differences in goals for various development initiatives.

In Section 2, we review studies applying similar evaluation techniques on healthcare delivery and position our own approach. Section 3 presents our evaluation approach, while section 4 puts this in context and provides some concluding remarks.

2. EVALUATING THE ICT BENEFITS TO HEALTHCARE DELIVERY

In general, interactions in ICT for development (ICT4D) involve: 1) multiple dimensions within the restrictions of various contextual factors (Blake & Garzon, 2012 pp.10); 2) multiple stakeholders typically with conflicting objectives; and 3) uncertainty arising from the unavailability of data about the interactions and performance of the various elements

Given the central role information regarding benefits or impact plays in decision making, various approaches have been devised to evaluate ICT benefits in improved healthcare delivery. Most significant are the longitudinal evaluation approaches, and the randomized control trials. Longitudinal approaches involve the establishment of a baseline status before the intervention, and then the performance of an evaluation after an agreed period of adoption and use. These may employ either quantitative indicators, or qualitative assessment, or both. For example Verbeke et al. (2013) performed a pre- and post-implementation comparison of *OpenClinic*, a patient records management system, from 2007 to 2011. They evaluated indicators such as *outpatient caseload, user-fee based hospital income* and *technical efficiency*. Kiberu et al. (2014) also measured the performance of the District Health Management Information Software System version 2 (DHIS2) in Uganda in terms of *completeness* and *timeliness* of outpatient and inpatient reporting between 2011 and 2013. Li (2010) proposed a multi-method longitudinal evaluation process to explore the impact of ICT with an appreciation of the relationship between the social and technical systems within a clinical department. The study employed both quantitative and qualitative research methods, incorporating the measurement of safety and workflow efficiency indicators. However, the challenge in conducting such longitudinal evaluations is the prerequisite for baseline data, which might be non-existent in certain situations, as well as the resources required to run such a study, especially in resource constrained contexts.

The randomized control trial (RCT) or randomized impact evaluation involves the evaluation and comparison of groups that benefit from an intervention and those that do not. Piette et al. (2012) point out that although RCT, like Zurovac et al. (2011) provide strong evidence of the usefulness of e-health solutions and their potential impact on outcomes, they

exhibit various shortfalls. For example they fail to address concerns regarding the adoption, scaling up and maintenance of e-health services outside the environments in which they were originally studied. It is also non-ethical to randomize some medical services, while large, multi-site trials are expensive and can take years to produce information. Additionally the random control trial approach to some extent isolates the technology from the social context that surrounds and presumably affects it (Li, 2010).

There is also a growing trend that is applying the more flexible systems-oriented and modeling techniques in healthcare evaluation. For instance, Royston (2011) proposes that modeling decision trees can give prompt insights into the operational and cost effectiveness of initiatives. These are mostly qualitative approaches particularly suitable when the background information is insufficient for the intended purposes, or when dealing with complex, ill-defined problems for which quantitative approaches may be difficult or even inappropriate. In addition to analytical rigor these approaches are simple and transparent (Royston, 2011). Merrill et al. (2013) apply a system dynamics model to evaluate the complexities involved in implementing electronic health information exchange for public health reporting at a state health department, which enables the identification of policy implications to inform similar implementations.

Other approaches are based on Multi-criteria Decision Making and Multi-criteria Decision Aid (MCDM/MCDA), i.e., decision approaches facilitating the decomposition of complex decision problems. For example Güney et al. (2014) propose an evaluation framework that applies fuzzy logic techniques to facilitate the appraisal of the extent to which a hospital information system meets the user expectations. While promising, the actual use of MCDA structured techniques to facilitate evaluation of ICT initiatives in developing countries is still very limited, an aspect this paper contributes to.

3. METHODOLOGY

In the study presented herein, we utilize the Analytical Decision Layer model suggested in Danielson et al. (2010) for handling the stakeholders, criteria and alternatives involved. This is designed for handling imprecise and vague information, facilitating multidimensional and multi-stakeholder assessment processes and evaluations, when the handling of uncertainty attributed to incomplete and vague information is necessary. This as a more instrumental alternative to the predominately descriptive ICT4D evaluation approaches. The process itself basically follows normal procedures and has been adapted to three main stages in this context: 1) Problem structuring; 2) Elicitation and aggregation of data; and 3) Analysis and evaluation.

The case study strategy (Yin, 2003) was adopted to guide the research process in demonstrating how a structured approach can facilitate the evaluation of ICT4D initiatives. According to Denscombe (2011) the case study strategy is appropriate if the research is undertaken in its unaltered natural setting, and seeks to gain insights from one or more relevant instances which will advise subsequent studies, which was typical of our study sites. Additionally, the selection of study sites and respondents were deliberate as subsequent discussions show.

3.1. Problem Structuring

The study was conducted in two purposively selected healthcare facilities in Uganda, Alt 1: Nakaseke hospital – a rural hospital and Alt 2: Mukono Health Centre IV – a semi-urban strategically placed health centre facility. The study sites were selected based on whether: they had at some point benefited from the rural communications development fund (RCDF), a Universal services Fund in Uganda, had ICT implemented for some time and were still actively using it. RCDF staff in charge of overseeing the implementation and effective

operations of the facilities advised on the selection of study sites. An initial visit was undertaken to each of the health facilities in which discussions regarding the services offered, and the ICT facilities/systems in place to facilitate service delivery were held with top management.

Nakaseke hospital is a rural regional main hospital located about 60 Kilometers from the main capital. It was established in the 1960s to admit up to 100 patients at any one time. The services it offers include maternity, immunization, family planning, surgical operations, and rehabilitation, curative and preventive community health. It has over 20 units, and currently admits anywhere from 160 to 200 patients at any one time. Nakaseke hospital receives up to 7000 outpatients per month. It has eight clinical offices, five senior nursing officers and several other medical personnel.

Prior to obtaining ICT equipment through the RCDF in 2011, the hospital was one of the recipients of the EU-TeleInViVo, a UNESCO funded tele-medicine project, in the 1990s. However the equipment was damaged during shipping and was shipped back to the suppliers for repair since there was no skilled local support. The computers were however retained and were used in the day-to-day operations of the hospital. The 7 (seven) computers obtained through RCDF were distributed in various hospital departments with the aim of streamlining hospital operations. The hospital obtains Internet access through connectivity to Nakaseke Multipurpose Community Telecenter[1] in addition to personal 3G Internet modems. Other initiatives have been implemented since then, such as the Uganda mobile Vital Records System (VRS)[2], an online birth and death records system implemented in November 2012. Another was a pilot Act for birth project[3] that was initiated by Save the Children and run between July 2012 and July 2013. It involves taking birth records, as well as a community outreach program to set up and distribute mobile phones at the hospital and to the village health team (VHT). Finally Mildmay has set up an HIV disease monitoring service at the HIV outpatients' clinic.

Mukono Health Centre IV (HC4) is located approximately 21 Kilometers from Kampala. Although it is semi-urban, it was used in this study mainly because it serves a rural populace, and is an under-supported institution (Burrell & Toyama, 2009). Mukono HC4 offers the following services: maternity, immunization, family planning, operations, rehabilitation, curative and preventive community health. It receives 150-200 outpatients daily, 200-250 antenatal patients per day, immunizes 150 per day and delivers approximately 400 babies per month. It has 3 doctors and 4 clinical officers, a dispenser and nurses, as well as a records department.

Although Mukono HC4 also received equipment from the RCDF, this did not effectively take off. However in 2012 Mukono was the first beneficiary of ICT4mpower project. ICT4mpower[4] development team studied the manual/paper workflow process of the HC and used this to design an ICT application that directly fits the existing service delivery model to offer various services. Other ICT services include mTrack which tracks medical supplies and community radio.

It is important to note that the Ministry of health in Uganda has instituted the management of medical records through a Health Management Information System, (DHIS2) to which all public health facilities nation-wide are required to submit weekly reports (Kiberu et al., 2014).

[1] http://nakasekecmc.blogspot.com/
[2] http://mobilevrs.co.ug/home.php
[3] http://savinglivesatbirth.net/blog/13/04/30/act-birth-improving-quality-care-uganda
[4] http://www.ict4mpower.org

The evaluation involved two categories of respondents. The first category was the beneficiaries, the healthcare service providers who included the administrators, receptionists, doctors, clinicians, lab technicians and pharmacists involved in the delivery of healthcare services. The second category was decision-makers involved in the implementation of ICT for healthcare delivery. While the former evaluated the performance of the healthcare initiatives, the later assessed the relative importance of criteria discussed in the subsequent section.

The development of criteria drew from a combination of an earlier study that proposed and validated criteria for the evaluation of the ICT contribution to development (Kivunike et al., 2013) and an initial visit to the healthcare facilities. This initial visit was aimed at ascertaining that nature of ICT services that were in existence, and how they were utilized. The criteria consist of output and outcome indicators that characterize ICT use in healthcare services provision, as well as contextual factors that influence the ICT contribution to healthcare delivery. While outputs are the opportunities, the things people could do with ICT to facilitate healthcare delivery, the outcomes on the other hand are the effects of outputs. The following output categories with specific quality and usage indicators are evaluated:

- *Manage patient records*- creating or updating patient records, referrals, and statistical analysis;
- *Remote consultancy* diagnosing, giving prescriptions or performing medical procedures remotely through phones or tele-medicine applications and
- *Perform health management transactions* – doing prescriptions online, requesting and reporting laboratory examinations, and tracking and placing orders for medical supplies.

The quality indicator is further granulated to specific measures of ease of use, and usefulness which have been extensively validated in other studies (Urbach & Müller, 2012). While ease of use refers to the "perception of ease associated with using the service" (Venkatesh et al., 2003 pp. 450), usefulness refers to "degree by which the information service serves its purpose" (Akter et al., 2013 pp. 185). Usage on the other hand was assessed in terms of a qualitative measure of frequency of use, and the nature of use. Delone and McLean (2003) point out that the nature of use – what a system is used for is an important indication of its benefits. Given the increased dependency on remote medical consultancy through phone calls and telemedicine, this study also considered interaction quality in terms of cooperation (Akter et al., 2013). Cooperation is "the willingness of the service provider to help users and deliver prompt service" (Akter et al., 2013 pp. 185). This specifically focused on the willingness of the healthcare providers to offer services remotely through phone calls for example. All output criteria are summarized in Table 1.

Table 1: Outputs indicators

Output indicator category		**Indicators**
Managing patient records		
Quality	Efficient, ease of use	Managing patient records using ICT sufficiently meets our work requirements
	Usefulness	Managing patient information through ICT is very useful in our day to day activities as healthcare providers
		Managing patient information using ICT is relevant to the healthcare delivery goals
Usage	Frequency	Frequently use of ICT to manage patient information when

	of use	delivering healthcare services
	Nature of use	Managing patient records through ICT than the traditional paper-based approach
Remote consultancy		
Quality	Usefulness	I think medical consultancy e.g. through phone calls is extremely significant in our delivery of healthcare
	Cooperation	It is normally an inconvenience to receive phone calls seeking to diagnose or prescribe medication for a patient
	Ease of use	I find it easy to offer remote medical consultancy/assistance e.g. diagnosis and prescription through a phone call
Usage	Frequency of use	We frequently offer medical advice on various conditions through phone calls or messaging
	Nature of use	We sometimes use the phone to follow-up on patients who visit the facility
Performing health management transactions		
Quality	Relevant	Transactions provided by ICT are extremely relevant for our delivery of healthcare
	Ease of use	I find the health delivery transaction features provided through ICT easy to use
	Usefulness	Transactions provided by ICT are useful in our day to day delivery of healthcare services
Usage	Frequency of use	We frequently perform transactions e.g. order or report lab exams, prescriptions or medical requisitions using ICT
	Nature of use	It is more burdensome to perform health management transactions using ICT than the traditional paper-based methods

Outcome indicators (Table 2) were also defined in terms of improvement in various outcomes including patient records management, medical supplies management, managing patient queues, facilitating remote medical consultation, effect on individual workload, effect on overall delivery of healthcare and personal wellbeing. The details of the criteria development process are discussed in (Kivunike et al., 2013).

Table 2: Outcomes Indicators

Outcomes	Outcome Indicators
Improved patient records management	The use of the ICT in records management has enabled efficient production of reports
	The patient records management system has enabled better management and follow-up of patients
Improved medical supplies management	I think the use of ICT in stock management facilitates better accountability of medical supplies
	The use of ICT in medical stock management has reduced supplies running out of stock
Improved patients queue management	Using the queue management system to handle patients treatment flows has reduced the patient waiting times
	Using the queue management system has led to greater transparency in handling patients on the waiting list
Benefits of remote consultancy	The adoption and use of remote consultancy e.g. through phone calls has enabled the timely delivery of medical interventions
	I feel the use of ICT to deliver healthcare has improved medical

	emergency management
Effect on individual workload	I feel the use of ICT to deliver healthcare has increased my responsibilities and workload as a healthcare provider
	I feel the use of ICT to deliver healthcare has made me a more efficient and diligent health worker
Personal wellbeing	I have obtained advanced ICT skills
	Using the ICT services to facilitate my healthcare delivery activities has improved my levels of self-confidence
	I now feel more valued and respected by my peers because of the skills I have obtained through the use of ICT
	Using ICT in my day-to-day work activities has had a positive influence on my decision-making capabilities
Overall delivery of healthcare	I believe the use of ICT has reduced the overall cost of healthcare delivery
	I believe this healthcare facility is gaining (national and/or international) recognition because it embraced the use of ICT in healthcare delivery
	Overall ICT has had a positive influence on the quality of care delivered to the patients

The contextual factors (Table 3) were defined in various categories including personal and social, technical as well as political and economic factors based on an earlier study (Talantsev et al., 2014).

Table 3: Contextual Factors

Factor	Indicators
Personal & Social Factors	
Relevant skills	I lacked the relevant skills to use the ICT facilities
Personal interest	I was personally interested in using ICT to facilitate my day to day work in healthcare delivery
Perceived added-value	I think that the use of ICT adds no value to my day to day work in healthcare delivery The existing (paper-based) systems are sufficient in meeting our healthcare delivery goals
Awareness	Being aware of the potential benefits played a central role in the adoption and use of ICT to deliver healthcare
Mandatory to use ICT	It is mandatory (a basic requirement) to use ICT in delivering healthcare services at the medical facility
Technical Factors	
Availability of PCs	The healthcare facility has sufficient computers which has contributed to the adoption of the ICT in healthcare delivery
Electricity	The unreliable electricity frustrates the use/total dependence on ICT to facilitate healthcare delivery.
Skilled technical support	The lack of skilled technical support frustrates the use of ICT to deliver healthcare
Political & Economic Factors	
Bureaucracy	National inefficiencies frustrate the effective application of ICT to facilitate healthcare delivery in the public
Affordability of	The medical facility does not have sufficient funds to run ICT to facilitate

ICT/IT	its service delivery

Besides the validation undertaken in Kivunike et al. (2013), the validity of the proposed criteria was further checked with the experts who ranked the importance of the various indicators.

3.2. Elicitation

At elicitation, the criteria weights - the relative importance of the proposed criteria; and the scores on each criterion - the performance of the initiatives against the criteria were obtained from the decision-makers and healthcare delivery service providers respectively. Both criteria weights and performance scores are the required inputs for modeling in the decision support tool. Criteria weight elicitation basically involved assigning of weights to reflect the relative importance of criteria relative to others. Due to the difficulties involved in eliciting numerical information; we applied a rank-order approach (Riabacke, 2012). This provides for better explanation of the results.

In this study interval based verbal-numerical scales and the binary (yes/no) scales were applied for the score elicitation. The verbal-numerical scale is a combination of verbal expressions and their corresponding numerical values for extraction (data collection) and representation in the decision analysis tool respectively. The verbal-numerical scale combined verbal expressions and their corresponding numerical values for extraction (data collection) as well as representation in the decision analysis tool. The numerical intervals (ranges) maintain the vagueness and imprecise nature of the assessments being made. On the other hand the use of verbal expressions is especially beneficial in contexts involving stakeholders with diverse levels of expertise; e.g. the numerically less literate who find it easier to work with words such as the respondents in the current study (Witteman & Renooij, 2003). This study opted for a separate use of the verbal expressions to facilitate the extraction (data collection), which were translated into the corresponding numerical values during aggregation. Table 4 below shows the particular scales applied in this study. The binary scales facilitated the elicitation of stakeholder perceptions on whether or not various contextual factors had some influence in their use of ICT to deliver healthcare services.

Table 4. Agreement and Likelihood Interval-based Scales

Agreement		Likelihood	
Verbal Expressions	**Numerical Ranges**	**Verbal Expressions**	**Numerical Ranges**
Strongly Disagree	0 -10	Exceptionally unlikely	0 - 10
Disagree	10 - 30	Very unlikely	10 - 30
Somewhat Disagree	20 - 40	Unlikely	20 - 40
Average	40 - 60	Fifty-Fifty	40 - 50
Somewhat Agree	50 - 70	Likely	50 - 70
Strongly Agree	80 - 100	Certain	80 - 100

The elicitation data was collected between January and February 2014 using two questionnaires; the first sought to elicit the criteria weights, and the second to evaluate performance of each alternative on different scores. The questionnaire was the most appropriate data collection approach in both instances since the data being collected was standardized data regarding expert rankings and perceptions of ICT performance on various aspects. The first questionnaire was reviewed with both ICT4D practitioners and medical professionals on language to ascertain that it was easy to comprehend. The respondents in

this case were various decision makers, including staff of RCDF, practitioners involved in e-health initiatives, and medical personnel in decision-making positions at the visited healthcare facilities.

Besides eliciting scores, the second questionnaire also sought to establish the different technologies and applications that healthcare providers had used in facilitating their service delivery, the overall period for which they had used ICT for this purpose, and the functions of use. This aimed to further confirm that the respondents were appropriate for the study. ICT4D practitioners and medical professionals also reviewed this questionnaire to ensure appropriate medical terms had been used. It was then piloted with personnel at the two facilities, to facilitate its improvement more so in relation to the medical terms healthcare service providers are most conversant with. The respondents were also purposively selected (with the help of the facilities' top management) as those healthcare providers at the two facilities, who had used ICT to facilitate their work. This was especially appropriate for the rather small-scale study, which specifically sought to investigate the ICT benefits resulting from ICT use in healthcare delivery.

One of the authors and two trained research assistants administered the questionnaire. This addressed three concerns: 1) ensuring meaningful feedback since the evaluations were being conducted with personnel in rural settings (who might have problems comprehending some aspects); 2) avoiding cases of non-response since the medical personnel were very busy, and it was envisaged that they would not find the time to provide feedback; and 3) offering explanations on the various aspects being evaluated. However respondents were not coerced into participating in the study and data was obtained from only those who were approached and agreed to be a part of the study.

The data aggregation was required for both weights and score data in preparation for input into the decision analysis software as the data had been elicited from multiple respondents. The response scale used determined the choice of aggregation approach. For instance since the ranking scales (used to elicit expert opinions of the criteria) and binary (yes/no – part of the second questionnaire) scales were ordinal, the mode was applied to obtain the aggregate value(s) (Manikandan, 2011). The output of the aggregation in the former was a ranking of the different criteria, while for the latter it was the most frequent score of the evaluation. The simple weighted sum approach was applied for the aggregation of the responses obtained through the verbal-numerical scale (Clemen & Reilly, 2001). This involved assuming equal weights for each stakeholder and calculating the expected value for the minimum and maximum interval values to obtain a group interval. The simplicity and effectiveness of the simple weighted sum approach in the aggregation of imprecise values motivated its use in this study (Clemen & Reilly, 2001).

4. RESULTS & DISCUSSION

At the analysis and evaluation stage all obtained structured decision information including the alternatives, criteria and aggregated data i.e. criteria weights and interval scores on alternatives are modelled as input into the decision support tool. This creates a hierarchical decision model, preferably using a decision support tool. In this study the DecideIT decision support tool (Danielson et al., 2007a; Danielson et al., 2003; Hansson et al., 2008) was used to analyse and evaluate the decision problem. DecideIT is based on multi attribute value theory (Dyer, 2005) and supports both precise and imprecise information. It is based on the standard and well-established concepts of probability, value, and criteria weights, which have been more easily accepted by decision-makers. It also incorporates various types of sensitivity analysis into the evaluation process to ensure stability and validity of the assessment. The elicited information is represented in so called information frames. The criteria weights were modelled as comparative weight relations; while the score or

performance information obtained through the verbal-numerical scales was modelled as value intervals. Figure 1 illustrates how the data modelling is performed for one of the criteria. The [0,100] scale was converted to [0, 1] at modelling. Two MCDA hierarchical models were created, the outputs (illustrated in Figure 2) and outcomes models. Evaluations were performed for each model, and results are presented and discussed after the descriptive analysis of the respondents.

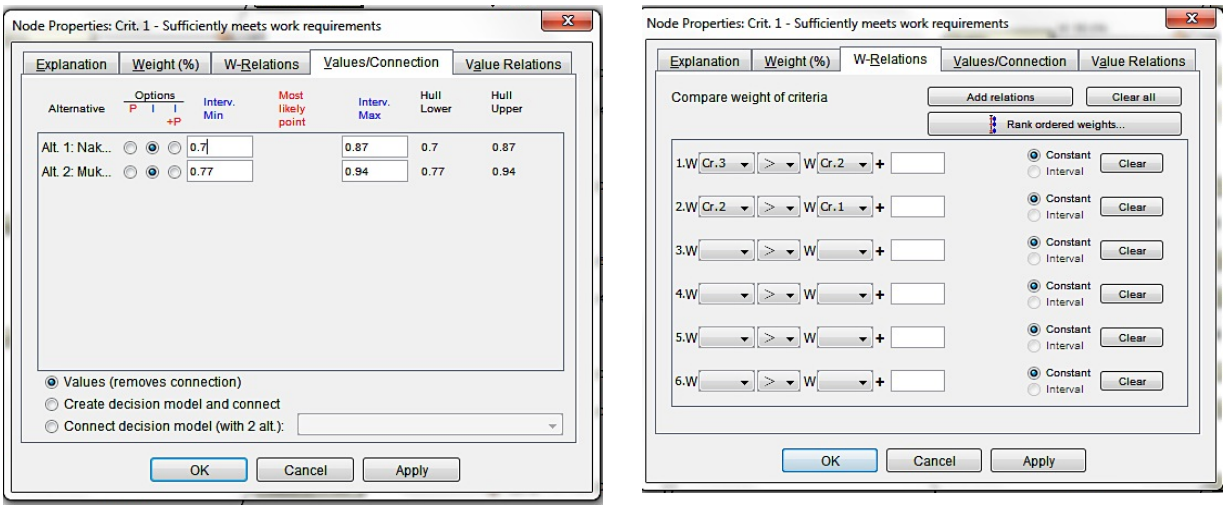


Figure 1: Modeling data input

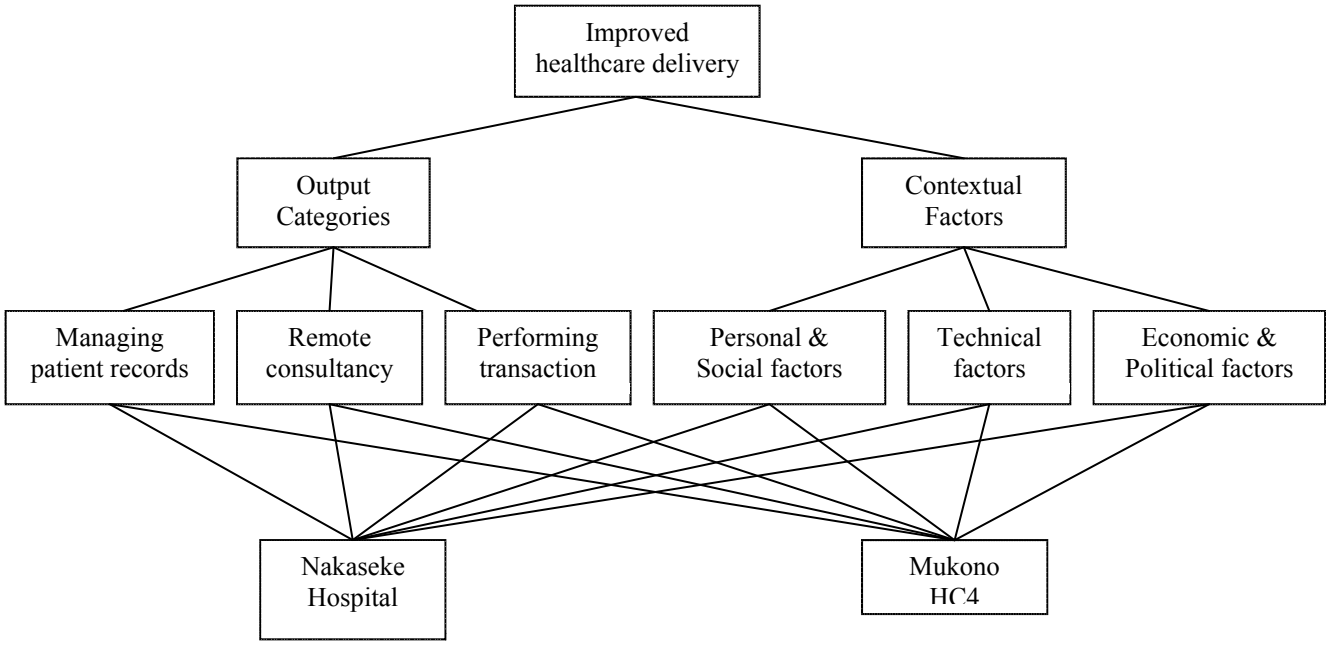


Figure 2: Outputs evaluation model

Twelve respondents (experts) were consulted on the ranking of importance of criteria used to evaluate the ICT contribution to improved healthcare delivery. Four were staff of RCDF; three were medical officers while five were practitioners involved in implementing ICT to facilitate healthcare delivery. On the other hand twenty-two healthcare service providers, thirteen from Nakaseke hospital and nine from Mukono HC4 participated in the evaluation. Of these, five were clinical officers, seven were nursing officers, two were pharmacists, two were laboratory technicians, two were records officers and three were social workers. One of

the respondents did not provide his/her affiliation. The period of ICT use in delivering healthcare ranged from six months for the most recent technologies, to ten years for the mobile phone. In addition to these, Tables 5 and 6 also provide a summary of which technologies respondents reported using, as well as the purpose of use respectively.

Table 5. Healthcare service providers' demographics

Variable		No.	Variable		No.
Age	20 to 29	11	**Gender**	Female	12
	30 to 49	6		Male	10
	Above 50	3	**ICT Tools and Applications**	Microsoft word	15
Level of Education	Professional certificate	4		Microsoft Excel	12
	Diploma	12		SMS	21
	Bachelor	3		OpenMRS	5
	MSc	1		ICT4Mpower	5
				Telemedicine application	3

Table 6. Purpose of ICT use

Healthcare delivery functions	No. of users
Creating and updating digital patient records e.g. outpatient visits, child births, immunization	12
Managing treatment flows (with a triage queue management system)	10
Enter diagnosis directly in the digital patient record	14
Handling patient referrals	14
Statistical tracking and information management	11
Performing remote diagnosis &/or medical procedures e.g. through telemedicine or phone consultancy	13
Performing remote prescriptions e.g. through telemedicine or phone consultancy	14
Requesting & reporting laboratory examinations	14
Tracking and placing orders for medical supplies	13

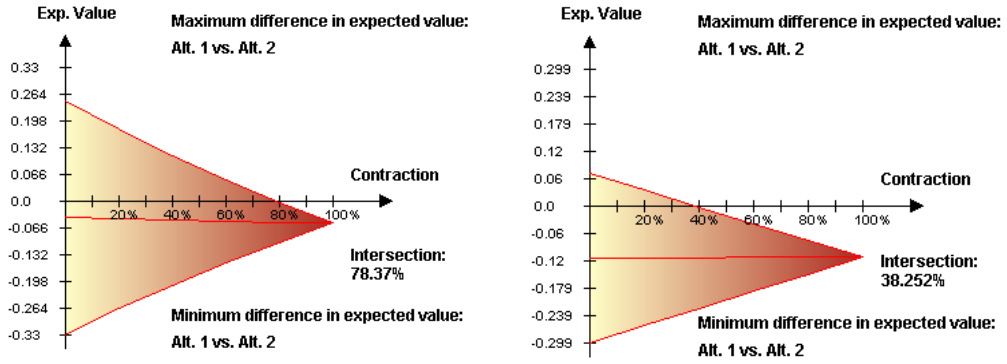
4.1. Output and Outcome Model Evaluation

Two forms of evaluations were undertaken; one that focused on the outputs and another that focused on the outcomes. The outputs evaluation will shows which of the two facilities (alternatives) uses ICT the most in its healthcare functions, while the outcomes analysis suggests the alternative that accrued the most benefits as a result of the ICT use. DecideIT offers various forms of evaluation to explain the model results (Danielson et al., 2007a; Danielson et al., 2010). This study specifically relied on ordinal ranking, expected value graphs and tornado graphs.

An *Expected value graph* shows the aggregated weighted sum for all outputs (Figure 3 a) and outcomes (Figure 3 b) criteria. The upper and lower graph show the minimum and maximum expected values when performing a systematic sensitivity analysis regarding the stability of the solution.[5] It basically involves establishing the strength of the alternatives through pairwise comparisons. For the output model, the expected value interval [-0.33, 0.26]

[5]Described in further details in Danielson & Ekenberg (2007) and Danielson et al. (2007b)

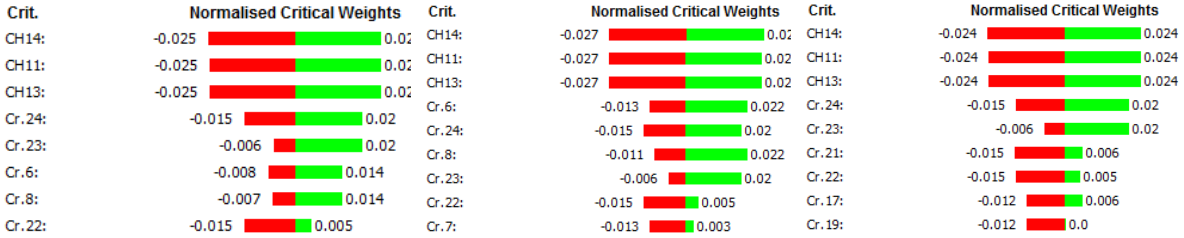
on the vertical scale implies a moderate variability between the two alternatives. The almost equal distribution below and above the horizontal line implies that ICT use in terms of managing patient records, remote consultancy and performing transactions moderately facilitates healthcare delivery at both sites. The overall result is that Mukono HC4 had an upper hand over Nakaseke hospital in terms of exploiting ICT to facilitate healthcare delivery, as well as eventually accruing benefits. When reducing the information frame to 78.4% and above, the model is in full support of alternative 2, implying that ICT is used more at Mukono HC4 (Alt. 2) than Nakaseke hospital (Alt. 1). This is in full support of the outcome model, given undisturbed user inputs, the expected value interval is [-0.3, 0.07] and the graph is mostly below the horizontal line. When reduced to 38.3% and above it is clear that of the two facilities, Mukono HC4 obtained the most benefits from ICT in as far as improved healthcare delivery is concerned.



a) Outputs **b) Outcomes**

Figure 3.Expected value graph evaluating performance of both healthcare facilities

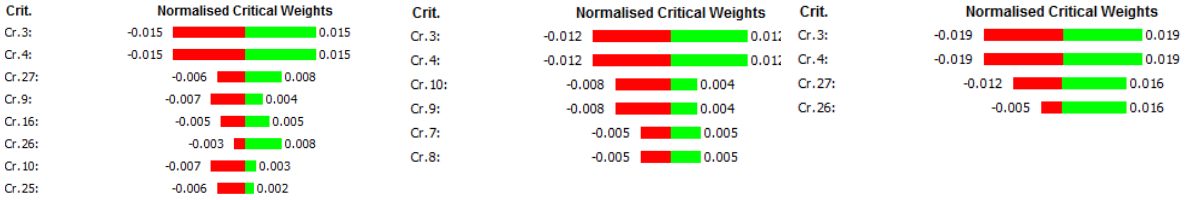
The *Tornado diagrams* facilitate the identification of the variables that have the greatest impact on the expected value. Each bar shows the variation of the expected value of the criterion, when that specific criterion is adjusted within its interval boundaries. By this the aspects that had the most significant influence can be identified. The result regarding ICT use in delivering healthcare services can be seen below. Figure 4 (a) shows this for both facilities and (Figure 4 b and c) show this for the individual facilities. In all instances the contextual factors i.e. CH14-political and economic factors, CH11-personal and social factors and CH13-technical factors had the most significant influence on ICT use for various functions in healthcare delivery. Additionally Cr.24 - electricity and Cr.23 – skilled technical support had a significant influence both generally (Figure 3 a) and at Mukono HC4 (Figure 3 c). Criteria Cr.6 - the significance of remote consultancy, Cr.24 – electricity and Cr.8 - the ease of use of remote consultancy had a substantial contribution to the use of ICT to deliver services in Nakaseke hospital.



(a) Combined (b) Nakaseke (c) Mukono

Figure 4.Outputs Tornado graphs for improved healthcare delivery

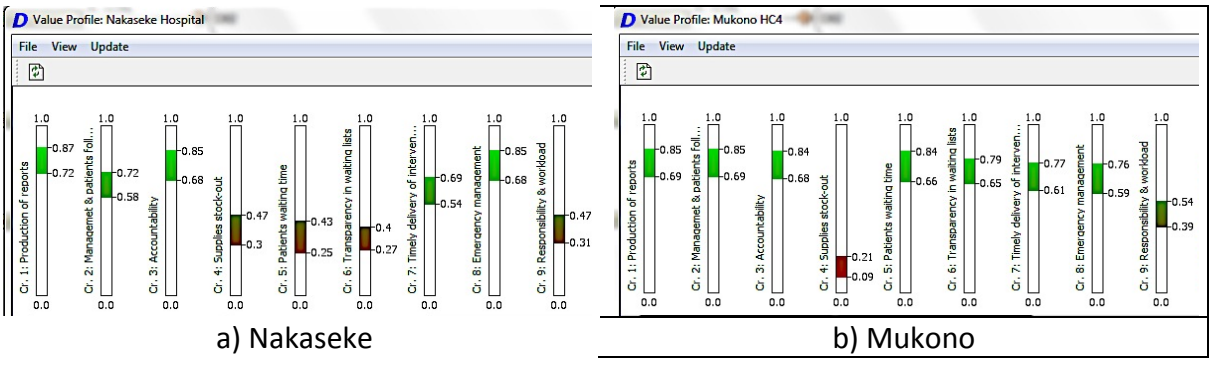
The tornado graph outcomes analysis (Figure 5) aims to identify the factors that contributed the most to the outcomes obtained in improved healthcare delivery. Aspects regarding managing medical supplies Cr.3 - accountability and Cr.4 – stock outs in all cases, as well as Cr.27 – skilled technical support for the combined assessment (Figure 5 a) and Mukono (Figure 5 b) had the most significant influence on the ICT contribution to improved healthcare delivery. Notably Cr.10 – being more diligent, Cr.9 – being more efficient, Cr.7 timely delivery of health through remote consultancy and Cr.8 improved medical emergency management were significant aspects in Nakaseke hospital (Figure 5 b).



(a) Combined (b) Nakaseke (c) Mukono

Figure 5.Outcomes Tornado graphs for improved healthcare delivery

The value profiles in Figure 6 provide the disaggregate performance of a selection of low-level outcome criteria for both Nakaseke hospital and Mukono HC4 (A similar one can also be done for the outputs model criteria). This offers more details on how the different alternatives perform in as far as achieving the different aspects being evaluated is concerned. For example for the outcome assessment, both alternatives satisfactorily enabled the production of reports, managing patients follow-up, accountability, timely delivery of services and the management of emergency cases. Furthermore ICTs had only averagely affected people's responsibilities and workload at both sites. Both sites acknowledged that the use of ICT had little impact on supplies running out of stock. And finally while practitioners at Mukono HC4 attest to ICT decreasing patient waiting time and promoting transparency in the management of patients on waiting lists, practitioners at Nakaseke had a totally contrary view. This may be attributed to the fact that Unlike Mukono HC4, ICT was seldom used for managing patient queues at Nakaseke hospital.



a) Nakaseke b) Mukono

Figure 6. Value Profiles for the Outcome Criteria

The results obtained in this study provide insights into the performance of e-health initiatives in rural healthcare facilities in Uganda, both in terms of ICT use, as well as the realized benefits. The evaluation also facilitates an assessment of how ICT contributes to specific benefits, as well as the contextual factors that influence the nature of benefits. Thus results range from the more general comparative assessment of the alternatives, to the

specific performance. For instance results generally show that ICT was more used and therefore offered more benefits at Mukono HC4 than it did at Nakaseke hospital. Since use determines the resultant benefit, the implication here is that efforts should go into promoting more ICT use in delivering healthcare especially in areas where use is still limited. For instance in Nakaseke hospital ICT use to manage patient queues would ensure benefits in this area. This is in agreement with studies which note that ICT can do much more than what it is currently doing to deliver development benefits such as Rabin et al. (2009). There is also need to address the contextual factors but more specifically issues such as having skilled personnel as well as electricity which had a significant influence on use. A possible solution is the integration of ICT in all professional training courses e.g. medical training in this case so that it is perceived as one of the requirement for effective and efficient healthcare delivery instead of being perceived as a tool that one can do away with. Another potential solution would be implementing and integrating relevant ICT systems in healthcare delivery at all facilities, this will presumably encourage use.

Furthermore the significance of remote medical consultancy towards improved healthcare delivery in Nakaseke hospital attests to the contributions mobile phones are making in the more resource (financial and infrastructural) constrained contexts. To practitioners and policymakers this finding suggests the need to exploit such avenues to increase ICT benefits in healthcare delivery.

It is important to note that at the time of the study one of the healthcare facilities had run out of drugs although requisitions were made in time. This could explain the significant influence the use of ICT to facilitate medical supplies management had on the overall ICT contribution on improved healthcare delivery in this context. However this aspect could benefit from further investigation.

5. CONCLUDING REMARKS

In this paper, we have demonstrated the use of a structured, MCDA, evaluation approach in the appraisal of the ICT contribution to healthcare delivery. The method relies on sound computational approaches to facilitate the elicitation, aggregation, evaluation and reporting of vague and imprecise information, which could otherwise require in-depth descriptive approaches. In comparison to these more resources intensive (both financial and time) in-depth approaches, this approach facilitated a one point in time appraisal of the ICT contribution to healthcare delivery. This is presumably less time consuming, and as Royston (2011) suggests provides prompt insights into the performance of development initiatives, as well as advising on improvements or future implementation. The analytical rigor in terms of the reliability and validity of the results are further ensured by the sensitivity analysis mechanisms inbuilt in the evaluation tool.

This research can be extended in a number of ways to benefit both research and practice in the evaluation of ICT4D initiatives. For instance, while only qualitative imprecise indicators were employed in this context, the approach can incorporate precise data as well when such is available. This evaluation could also be extended to facilitate the evaluation of multiple healthcare cases, as well as incorporate opinions from the target beneficiaries (patients) in future studies. This would provide a holistic view of the ICT benefits to healthcare delivery. What has been done is also applicable to different sectors, and can utilize a broader scope of criteria, as well as incorporate views from several categories of stakeholders.

6. REFERENCES

Akter, S., D'Ambra, J., & Ray, P. (2013). Development and validation of an instrument to measure user perceived service quality of mHealth. *Information and Management,* 50, 4, 181-195.

Blake, A., & Garzon, M.Q. (2012). Boundary Objects to Guide Sustainable Technology-Supported Participatory Development for Poverty Alleviation in the Context of Digital Divides. *The Electronic Journal of Information Systems in Developing Countries,* 51, 1, 1-25.

Burrell, J., & Toyama, K. (2009). What Constitutes Good ICTD Research? *Information Technologies & International Development,* 5, 3, 82-94.

Clemen, R.T., & Reilly, T. (2001). *Making Hard Decisions with DecisionTools* (second ed.). Pacific Grove, CA: Duxbury Press.

Danielson, M., & Ekenberg, L. (2007). Computing upper and lower bounds in interval decision trees. *European Journal of Operational Research,* 181, 2, 808-816.

Danielson, M., Ekenberg, L., Idefeldt, J., & Larsson, A. (2007a). Using a Software Tool for Public Decision Analysis: The Case of Nacka Municipality. *Decision Analysis,* 4, 2, 76-90.

Danielson, M., Ekenberg, L., Johansson, J., & Larsson, A. (2003). *The DecideIT decision tool.* Paper presented at the 3rd International Symposium on Imprecise Probabilities and Their Applications, Lugano, Switzerland.

Danielson, M., Ekenberg, L., & Larsson, A. (2007b). Distribution of expected utility in decision trees. *International Journal of Approximate Reasoning,* 46, 2, 387-407.

Danielson, M., Ekenberg, L., Larsson, A., & Riabacke, M. (2010). Transparent Public Decision Making: Discussion and Case Study in Sweden. In D. Rios Insua & S. French (Eds.), *e-Democracy* (Vol. 5, pp. 263-281): Springer Netherlands.

Delone, W.H., & McLean, E.R. (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems,* 19, 4, 9-30.

Denscombe, M. (2011). *The Good Research Guide - For Small-Scale Social Research Projects* (4th Ed.). Berkshire, England: Open University Press.

Dyer, J.S. (2005). MAUT - Multiattribute Utility Theory In Figueira, J., Greco, S. & Ehrgott, M. (Eds.), *Multiple Criteria Decision Analysis - State of the Art Surveys* (3-24): Springer.

Grunfeld, H. (2011). *The Contribution of Information and CommunicationTechnologies for Development (ICT4D) Projects toCapabilities, Empowerment and Sustainability: A Case Study of iREACH in Cambodia.* (PhD), Victoria University Melbourne.

Güney, G., Neşe, Z., Hakan, G.K., Ali, A., & Osman, S. (2014). A New Approach in the Evaluation of Hospital Information Systems. *Turkish Journal of Electrical Engineering & Computer Sciences,* 22, 1, 214-222.

Hansson, K., Danielson, M., & Ekenberg, L. (2008). A Framework for Evaluation of Flood Management Strategies. *Journal of Environmental Management,* 86, 3, 465-480.

Kiberu, V. M., Matovu, J. K., Makumbi, F., Kyozira, C., Mukooyo, E., & Wanyenze, R. K. (2014). Strengthening District-based Health Reporting through the District Health Management Information Software System: The Ugandan Experience. *BMC Medical Informatics and Decision Making,* 14, 1, 40.

Kivunike, F.N., Ekenberg, L., Danielson, M., & Tusubira, F.F. (2013). *Developing Criteria for the Evaluation of the ICT Contribution to Social and Economic Development.* Paper presented at the Sixth Annual SIG GlobDev Pre-ICIS Workshop, Milan, Italy.

Li, J. (2010). A Sociotechnical Approach to Evaluating the Impact of ICT on Clinical Care Environments. *The Open Medical Informatics Journal,* 4, 202-205.

Manikandan, S. (2011). Measures of Central Tendency: Median and Mode. *Journal of Pharmacology & Pharmacotherapeutics*, 2, 3, 214-215.

Merrill, J.A., Deegan, M., Wilson, R.V., Kaushal, R., & Fredericks, K. (2013). A System Dynamics Evaluation Model: Implementation of Health Information Exchange for Public Health Reporting. *Journal of the American Medical Informatics Association,* 20, e1, e131-e138.

Piette, J.D., Lun, K., Moura L.A., Fraser, H.S., Mechael, P.N., Powellf, J., & Khojag, S.R. (2012). Impacts of e-Health on the Outcomes of Care in Low- and Middle-Income Countries: Where Do We Go from Here? *Bulletin of the World Health Organization,* 90, 365-372.

Rabin, P., Joyojeet, P., & Sergiu, N. (2009). *ICTD State of the Union: Where Have We Reached and Where Are We Headed.* Paper presented at the International Conference on Information and Communication Technologies and Development (ICTD).

Riabacke, M. (2012). *A Prescriptive Approach to Eliciting Decision Information.* (Doctor of Philosophy thesis), Stockholm University, Kista.

Roberts, S. (2008). The Global Information Society: A Statistical View. Santiago, Chile: United Nations.

Royston, G. (2011). Meeting Global Health Challenges through Operational Research and Management Science. *Bulletin of the World Health Organization,* 89, 683-688.

Talantsev, A., Larsson, A., Kivunike, F., & Sundgren, D. (2014). Quantitative Scenario-Based Assessment of Contextual Factors for ICT4D Projects: Design and Implementation in a Web Based Tool. In Rocha, Á., Correia, A.M., Tan, F.B. & Stroetmann, K.A. (Eds.), *New Perspectives in Information Systems and Technologies, Volume 1* (Vol. 275, 477-490): Springer International Publishing.

Urbach, N., & Müller, B. (2012). The Updated DeLone and McLean Model of Information Systems Success. In Dwivedi, Y.K. (Ed.), *Information Systems Theory: Explaining and Predicting Our Digital Society ...* (Vol. 1).

Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly,* 27, 3, 425-478.

Verbeke, F., Karara, G., & Nyssen, M. (2013). Evaluating the Impact of ICT-tools on Health Care Delivery in Sub-Saharan Hospitals. *Studies in Health Technologies and Informatics,* 192, 520-523.

Witteman, C., & Renooij, S. (2003). Evaluation of a Verbal - Numerical Probability Scale. *International Journal of Approximate Reasoning,* 33, 2, 117-131.

Yin, R. (2003). *Case Study Research: Design and Methods.* (3rd Edition ed. Vol. 5). Thousand Oaks, California: Sage Publications.

Zurovac, D., Sudoi, R.K., Akhwale, W.S., Ndiritu, M., Hamer, D.H., Rowe, A.K., & Snow, R.W. (2011). The Effect of Mobile Phone Text-Message Reminders on Kenyan Health Workers' Adherence to Malaria Treatment Guidelines: A Cluster Randomised Trial. *Lancet,* 378, 9793, 795–803.