Integrating Engagement Theory in Usability Evaluation Framework for the Design and Development of Health Information Systems.

By

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DECLARATION AND APPROVAL

Declaration

This thesis is my original work and has not been presented for an award of diploma, or conferment of degree in any other university of institution.

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Abstract

Usability is often ignored; many software developers focus on the functionalities and give little thought to the usability. This hinders the users and also damages the reputation of developers and the softwares. Such systems fail in use, scale up, and at times score very low when evaluated for usability. Users are not satisfied, systems are created ad hoc, and often abandoned, thus resulting in a waste of human and economic resources. Users many times describe the systems as complex, not intuitive and requiring a lot of training for successful use. There are a number of existing usability evaluation frameworks; however, they are suboptimal in providing health information systems (HIS) usability evaluation explicitly at the design and development stage. They each evaluate different aspects of HIS pertinent to human, organizational and technological factors. The frameworks differ in terms of generality and specificity, timing based on the system development phases, thus there exists a gap of an integrated evaluation framework that can merge critical usability constructs together and also be utilized at the design and development of HIS products. The objectives of the study were first to develop an integrated usability evaluation framework for the design and development of HIS, secondly to investigate the existing usability evaluation frameworks in HIS, thirdly to analyse the user involvement and satisfaction levels in HIS during the design and development phase using integrated software usability measurement tools and finally, to validate the developed integrated usability evaluation framework for the design of HIS. The study was conducted in selected public health facilities in western Kenya. The research study applied mixed methods research to gain detailed understanding of the entire HIS design and development processes. Simple random, and purposive sampling were used to select the health care workers i.e medical officers, clinicians, nurses, records staffs and patients who interact with the systems on a day today basis. Both survey questionnaires and focus group discussions tools were used to collect data. Data analysis was done using ordinal logistic regression and thematic analysis for qualitative data. Results showed that users were never involved in the process of development of the current HIS that they are using thus were never satisfied with the processes. User involvement and participation during the design and development positively influences user satisfaction levels therefore ease of use, efficiency, safety/errors of HIS has the potential to reduce the number of mortalities and readmissions in the health facilities. HIS developers need to consider utilizing the components, dimensions in the developed integrated usability evaluation framework as they provide a perfect opportunity to promote engagement and consider key constructs throughout the development life cycle. Health care providers need to provide real time feedback to the development team of any mis-alignment and emerging usability issues during the design and development process. There is need to capture the dynamics, processes, and interrelationships involved in technological change during the user engagement during the development of the health information systems.

Table of Contents

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LIST OF TABLES

LIST OF FIGURES

ACRONYMS/SYMBOLS/ABBREVIATIONS

ACA:	Affordable Care Act
API:	Application Program Interface
AUEMs:	Analytical Usability Evaluation Methods
CDSS:	Clinical Decision Support Systems
C-I-A	Confidentiality, integrity, availability
CMS:	Centers for Medicare and Medicaid Services
CPOE:	Computerized Provider Order Entry
DESIRE:	Decision-Support and Integrated Record-keeping
EUEMs:	Empirical Usability Evaluation Methods
GUI:	Graphical User Interphase
GUI:	Graphical User Interface
HCI:	Human-Computer Interaction
HER:	Electronic Health Record
HIMSS:	Healthcare Information and Management Systems Society
HIS:	Health Information System
HIT:	Health Information Technology
HITECH:	Health Information Technology for Economic and Clinical Health Act
HMIS:	Health Management Information Systems
ICT:	Information and Communication Technology
IDC:	International Data Corporation
IS:	Information System
ISO:	The International Organization for Standardization
ITAM:	Information Technology Adoption Model
ITUEM:	Information Technology Usability Evaluation Model (Health-
IxD:	Interaction Design
JHA:	Japan Hospital Association
JOOUST:	Jaramogi Oginga Odinga University of Science and Technology
LMICs:	Low- and middle-income countries
MMR:	Mixed Methods Research
NACOSTI:	National Council for Science, Technology and Innovation
PSQ:	Patient Satisfaction Questionnaire
QSR:	Qualitative Data Analysis software
QUIS:	Questionnaire for user interaction satisfaction
STS:	Socio - Technical Systems

SUS: System Usability Scale

TA: Think Aloud

TAM2: Technology Acceptance Model 2

TEAM: Total Evaluation and Acceptance Methodology

UCD: User-centered Design

UCSD: User-centered Systems Design

UI: User Interface

USE: Ease of use

UX: User Experience

WHO: World Health Organization

CHAPTER ONE: INTRODUCTION

This chapter introduces the thesis topic area, providing an evolution of health information systems, it also introduces the health information systems in Kenya information systems evaluation process, background of health information system usability, problem statement, objectives of the study, research questions, significance of the study, scope of the study, assumptions and definition of terms.

1.1 Background Information

As the health information technology (HIT) and health information system (HIS) have become widely applied in healthcare settings, researchers/clinicians have conducted studies in order to evaluate the outcomes and effectiveness of using technology in patient care. A technology evaluation framework is a set of guidelines for conducting technological appraisals of designs, objectives, subjects, methods, and data analysis skills or processes (Eisenstein, Juzwishin, & Kushniruk, 2011). Strong health systems are central to achieving better health outcomes, and strong health information systems (HIS) are the backbone of strong health systems. A properly functioning HIS gets the right information into the right hands at the right time, enabling policymakers, managers, and individual service providers to make informed choices about everything from patient care to national budgets. Strong health information systems support greater transparency and accountability by increasing access to information. Unfortunately, many low and middle-income countries have a long way to go to achieve these goals.

There are a number of existing usability evaluation frameworks; however, they are suboptimal in providing health information systems (HIS) usability evaluation explicitly at the design and development stage. They each evaluate different aspects of HIS pertinent to human, organizational and technological factors. The frameworks differ in terms of generality and specificity, timing based on the system development phases, thus there exists a gap of an integrated evaluation framework that can merge critical usability constructs together and also be utilized at the design and development of HIS products. From the gaps identified this study sort to investigate and analyze the existing usability evaluation frameworks during the design and development of HIS and develop an integrated usability evaluation framework for health information systems that would help stakeholders perform systems evaluation during the design and development of information systems. The widespread of use of Information and Communication Technologies

(ICT) has permeated almost all aspects of life including health sector (Almunawar & Anshari, 2012). Health information systems (HIS) is critical in health care delivery. Health IS having the potential to improve the health of individuals and the performance of providers (Buntin, 2011), yielding improved quality, cost savings and greater engagement by the patients in their own health care (Buntin, 2011). Despite evidence of these benefits, physicians and hospitals use of health IT and electronic health records still low (Buntin, 2011), even though the use of Health IS is seen as having a lot benefits to health care delivery, Marcial describes this as a "wicked problem," referring to the complex web of stakeholders, systems, and legislative parameters involved (Marcial, 2014). The use health ICT requires a unique attention due to its complexity unpredictability and the erratic nature (Marcial, 2014).

Currently healthcare professionals globally are the main users of electronic health system, however there are strong indications that the involvement of patients will improve healthcare and that a personalized access to the patient's health information systems will support patients empowerment, and aid when requirements of different user groups need as well to be considered in graphical user interface matrixes are concerned(Imaging, 2012). Electronic health system with high usability can make better healthcare services. A survey release in 2013 by the National Opinion Research Center (NORC) at the University of Chicago shows that while nearly all physicians have heard of the HIS Incentive Program, health information exchange, and other electronic data initiatives, frustration among participants remains high (Bresnick, 2013). Sixty-eight physicians in five states were asked about their health IT activities, and most reported that they had been using an HIS system for more than a year, and believed the technology helped improve communication and manage patients proactively (Bresnick, 2013). While 98% were familiar with the HIS Incentive Program and meaningful use, physicians from small practices reported a much more detailed knowledge of the requirements than large practitioners, likely because physicians in a smaller organization need to be more hands-on with such projects than those who can rely on staff at affiliated hospitals. Smaller groups, categorized as practices with fewer than twenty physicians, were more likely to complain about cost being a limiting factor in their IT adoption (Bresnick, 2013).

Adoption of HIS systems by hospitals and clinics has been driven by the belief that these systems can support the provision of efficient and high-quality care. In addition to acting as a store of medical information, HIS systems offer interactive features that can enhance care provision by providing additional support to healthcare workers. One such feature is a Clinical Decision Support

System (CDSS) that can generate an alert, for example, to warn a doctor of potentially dangerous drug interactions when they create an electronic prescription. As use of these systems has gained in popularity, HISs have started to be used as a platform to support hospitals and healthcare systems to continuously learn and develop. In a 'learning health system' such as this, the data collected are analysed to identify areas in need of attention. The hospital can then instigate a programme of quality improvement to target these specific areas and, then follow up in order to determine whether or not the new intervention was effective.

Researchers are also beginning to use the learning health system concept to design cost-effective clinical trials, where the HIS system is used to randomize treatment allocation and collect follow-up data to determine the effect size of the treatment. Used in this way, HIS systems not only act as a digital copy of the record but also allow hospitals to conduct cost-effective research and quality improvement projects. In high-income countries, the adoption of HIS systems has been stimulated by government schemes where healthcare providers have been compensated for the costs of ICT systems if they were able to demonstrate that the systems were used to improve care or increase efficiencies. These incentive schemes have, in some cases, cost many billions of dollars and have had mixed results. Despite this, most hospitals and clinics in high-income countries now have an HIS system in place and are looking at the next level of innovation by leveraging the clinical data collected to improve care. As high-income countries have adopted HIS systems over the last two decades, low- and middle-income countries (LMICs) have also seen increased use of HIS systems, although these have been introduced in different ways. Donor-funded projects linked to programs that have targeted specific diseases such as HIV and tuberculosis (TB) have used open source HIS systems that have enabled better record-keeping, patient management, follow-up and stock control. Health information systems (HIS) systems, are considered as critical factors in transforming the health care industry. Despite the high HIS adoption rates, substantial gaps exist between the current state of HISs and their potential usefulness. Recently, the Health Information Technology (HIT) end-user community and HIS experts have pointed specifically to the cognitive challenges resulting from poor HIS usability as one of the key reasons for this gap. In addition, substantial level of disparity exists around perception of HIT usage and its possible outcomes among its various users, also having wide range of technology skills, further confound the situation. A well designed HIS graphical user interphase (GUI) could help address these challenges by improving system usability leading to improvements in health care delivery.

1.2 Evolution of Health Information systems

Hospital information evolved from the beginning of 1960s, these systems were developed to cover administrative and medical functions. (Velde, 2010). The computers were so expensive and large, typically mainframe. These systems were designed to provide a money-oriented return on investment (get the money) and streamline patient admissions. They managed appointments and provided (stand-alone) ancillary services for hospital laboratories, the pharmacy, and radiology departments. They were developed to support existing manual procedures without adding value, and they functioned as a bonding element among the many disparate systems inside and outside the hospital. They improved accuracy and were supposed to save time for personnel. The 1980s saw the implementation of two nearly worldwide changes with a significant impact on the way computer applications were used in hospitals.

On one hand, reimbursement systems gradually evolved from a fee for service basis to a fixed budget system where figures on resource consumption played a central role. On the other hand, medical systems initially developed to simply automate existing processes became systems supporting physicians, nurses, and other healthcare providers in their daily patient care activities. The aim was to attempt to guarantee standards of care and lead to improved levels of decision-making (Figure 1.1). In early HISs, resource consumption and allocation were only roughly measured by length of stay. The usefulness of data originating from these systems was limited. Because of the significant variance between hospitals, it was impossible to compare one hospital's data with another's. Today, as patients and payers demand evidence of quality of care and cost reduction, it is obvious that these types of indicators are insufficient, and hospitals seek other competitive metrics such as process outcome measurements. The answers to many questions could be found only in reams of mostly hand-written paper-based clinical notes. The need for clinical information systems became obvious. It is more and more necessary for physicians to achieve targeted standards of care, from a quality and cost perspective, and for hospital administrators to gain some level of control over the behavior of clinicians (Clayton, 2006).

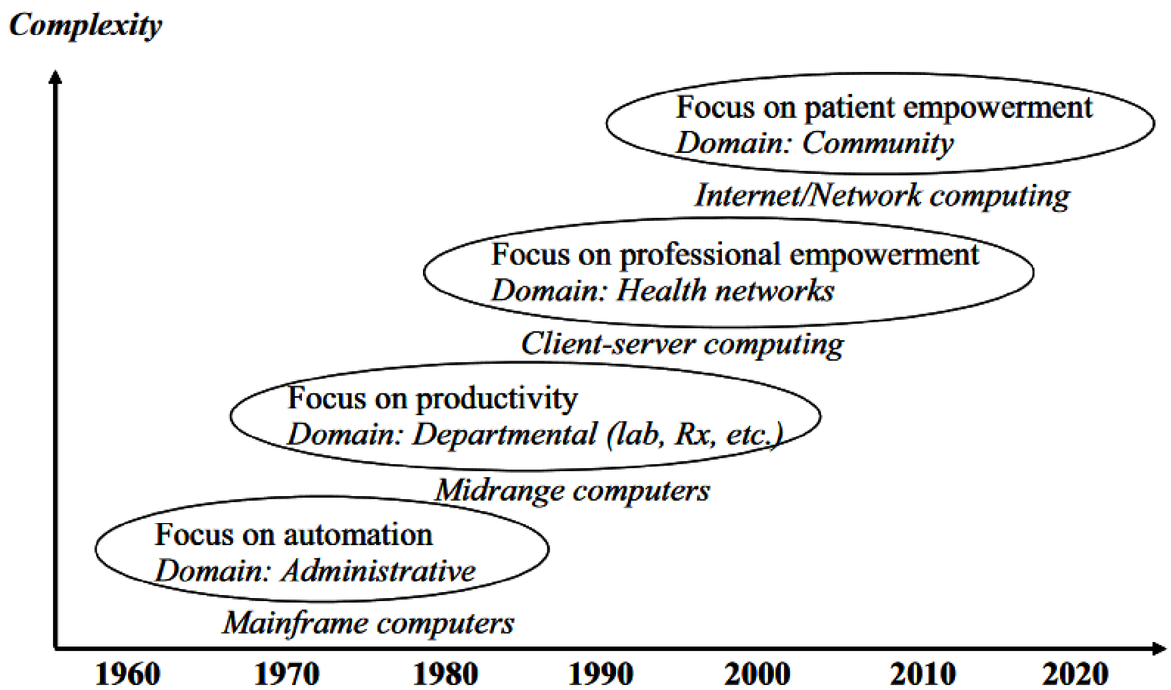

Figure 1. 1 Changing the destiny of information system in health sector

1.5 Problem Statement

Usability is often ignored; many software developers focus on the functionalities and give little thought to the usability. This hinders the users and also damages the reputation of developers and the software. Such systems fail in use, scale up, and at times score very low when evaluated for usability. Users are not satisfied, systems are created ad hoc, and often abandoned, thus resulting in a waste of human and economic resources. Users many times describe the systems as complex, not intuitive and requiring a lot of training for successful use.

There are a number of existing usability evaluation frameworks; however, they are suboptimal in providing health information systems (HIS) usability evaluation explicitly at the design and development stage. They each evaluate different aspects of HIS pertinent to human, organizational and technological factors. The frameworks differ in terms of generality and specificity, timing based on the system development phases. This study sort to develop an integrated usability evaluation framework for the design and development of health information systems.

1.6 Objectives of the study.

The main objective of the study was to develop an integrated framework for usability evaluation for the design and development of health information systems.

Specific objectives include:

1. To investigate the existing usability evaluation frameworks in the design and development of health information systems.
2. To analyse user involvement and satisfaction levels in health information systems during the design and development phase
3. To develop an integrated usability evaluation framework for the design and development of health information systems and the usability aspects.
4. To validate the developed integrated usability evaluation framework for the design of health information systems.

1.7 Research Questions

Specific question will be:

1. What are the characteristics of the existing frameworks for usability evaluation of health information systems?
2. Using an integrated Software Usability Measurement tools, what are the user involvement and satisfaction levels of health information systems during the design and development phase of health information systems?
3. What are the requirements for developing an integrated usability evaluation framework for the design and development of health information systems?
4. How can the developed usability evaluation framework be validated?

1.8 Significance of the study

This study is significant because it informs current health information systems developers, on the considerations for usability evaluation framework in their design and development of HIS products. In terms of Policy and guidance in the design and development of health information systems and in Academia: future researchers of health information systems, the contribution to the literature on health information systems usability, the outcome of the findings of usability evaluation of the current health information systems will contribute to the body of knowledge and also form a basis upon which other studies will be done.

1.9 Scope of the study

The purpose of the study was to develop an integrated usability evaluation framework for the design and development of health information systems. The population and the sample of the study were the health care providers from the level four and five in the 8 western Kenya counties ie Kisumu, Siaya, Migori, Homabay, Vihiga, Kakamega Bungoma and Busia, the national systems developers, and the hospital patients. the study was anchored on the engagement theory and satisfaction theories. This study was conducted in randomly selected levels 4 and 5 health facilities in Kenya that have adopted FANSOFT systems. Facilities were selected based on whether they are using health information systems at point of care model.

1.10 Assumptions

The study assumed that participants provided honest responses to the research questions. Participation to the study was voluntary as the participants were first requested for their consent and voluntary participation, respondents were not required to give their names or any form of identification, and were assured of total confidentiality and that the information they gave were used for research purposes only. The study also assumed that the sample selected was representative and would give plausible outcomes.

1.11 Definition of Terms

This section explains the related terms to the research field which was done through literature and studies.

eHealth: Refers to health services and information that make use of information and communication technology as a way to improve healthcare at all levels. The World Health Organization (WHO) has the following definition of eHealth E-health is the transfer of health resources and health care by electronic means.

Evaluation:

Cambridge dictionary defines evaluation as the process of judging or calculating the quality, importance, amount, or value pf something.

Health Information system:

Health information systems (HIS) is described as the interaction between people, process and technology to support operations, management in delivering essential information in order to improve quality of healthcare services (Almunawar & Anshari, 2012)

Usability:

Nielsen in 2017 described usability as a "*quality attribute that assesses how easy user interfaces are to use*". He further characterized usability by five quality components, 1) Learnability: How easy is it for users to accomplish basic tasks the first time they encounter the design? 2) Efficiency: Once users have learned the design, how quickly can they perform tasks? 3) Memorability: When users return to the design after a period of not using it, how easily can they reestablish proficiency? 4) Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors? 5) Satisfaction: How pleasant is it to use the design?

Bevan and Macleod, 1994, "*the extent to which a product can be used by specified users to* achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". International Organization for Standardization (ISO 9241); defines it *"the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments. effectiveness: the accuracy and completeness with which specified users can achieve specified goals in particular environments*"

User-centered Design: These are all areas aimed at improving the way which people interact with technology. It's also known as Human-centered design, Interaction Design(IxD) and Human Computer Interaction (HCI). Different researches in this area have different approaches, but they share methods for designing effective technologies and systems for human use.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This section is divided into six different parts, part one provides an overview of software development models focusing on Usability components in the phases, part two introduces health information systems, part three talks about health information systems Evaluation and usability evaluation methods, this also includes related studies on usability evaluation methods. Part four describes the standards; especially International Organization for Standardization (ISO) standards. Part five describes Health information systems evaluation models and frameworks, also providing a deep dive analyses of related themes evaluated by each of the existing models. These themes were critical as they were used in the proposed framework as constricts for considerations. Part six provides theoretical underpinnings and the proposed usability evaluation conceptual framework for data analysis.

2.2 Information Systems Evaluation Process

The process of evaluating information system should recognize and control the dire areas of the project (Hallikainen & Chen, 2006). A set of evaluation criteria should be used to ensure that all dimensions are considered (Hallikainen & Chen, 2006). The evaluation process needs to be incorporated into the business development process i.e the software development process (Hallikainen & Chen, 2006). Three steps process is recommended by (Sylla & Wen, 2002) i.e 1) Intangible benefits evaluation, 2) HIS investment risk analysis and 3) Tangible benefits evaluation.

Intangible benefits and risks should be evaluated prior to evaluating the tangible benefits (Hallikainen & Chen, 2006). The success of Information Systems development category is placed prior to the success of Information Systems usefulness since the usefulness can only be observed after the HIS has been used for a while (Hallikainen & Chen, 2006). Preferably, health Information Systems evaluation would include all categories, but the focus of evaluation is different depending on who conducts the evaluation and where the initiative for the evaluation comes from (Hallikainen & Chen, 2006). The focus of evaluation changes according to the organizational interests, which may be on a number of levels, such as costs and benefits, organization's competitive position or industrial relations (Farbey & Land, 1992)

The skill and knowledge of the evaluator determines the organization interests are fully taken into consideration during the evaluation process (Hallikainen & Chen, 2006). Thus, it's very significant that the top management really consider who should be involved in the evaluation. The outcome of the evaluation needs to be shared with all the stakeholders of the project so that a collective decision is made. Such decisions include continuing the investment or changing specifications, range or implementation method of the system, or declining the system. In addition, the changes might include schedule changes; reorganization of the project (project management can be changed); or dealer changes (Hallikainen & Chen, 2006)

Evaluating the success of an Information Systems implementation should consider at least two dimensions such as the process and the product success (Saarinen & Vepsäläinen, 1993). The product achievement includes both the Information Systems functionality and the realisation of the expected benefits from the Information Systems investment (Saarinen & Vepsäläinen, 1993).

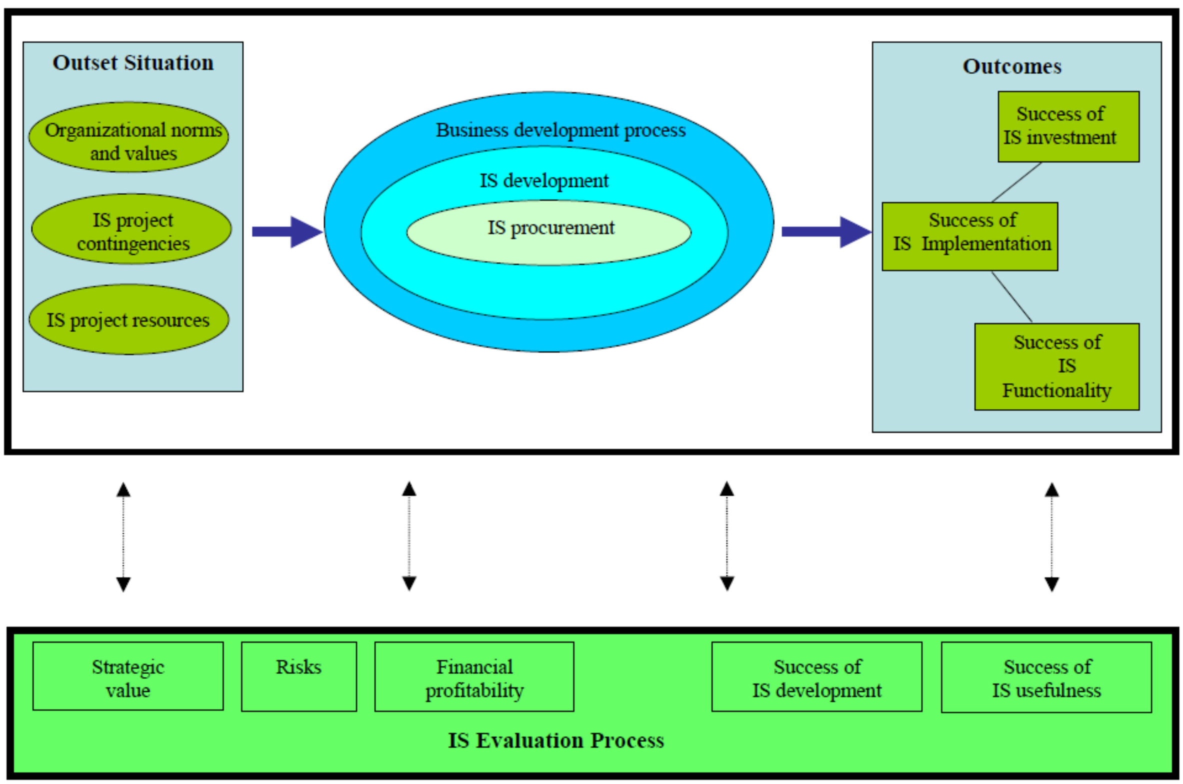

Figure 2.1 Holistic Framework of IS evaluation

2.2.1 Formative and Summative Information Systems Research

Formative evaluation (also known as process or progress evaluation) refers to a particular type of evaluation activity that aims to acquire feedback during the process of development and implementation of the information system, in order to suggest ways of improvement and help in the development of the change, innovation or intervention (Ammenwerth, Gräber, Herrmann, Bürkle, & König, 2003). On the other hand, summative evaluation (also known as outcome or impact evaluation) refers to a different type of evaluation that is carried out after the process of development and implementation is finished, and aims to gather information and feedback to assess the effects, effectiveness, impacts and outcomes of the developed IS (Chen, Osman, Nunes, & Peng, 2011)

Dimensions	Formative	Summative
Target audience	Programme managers, practitioners	Decision-makers, funders or the public
Focus of data collection	Qualitative evidence to clarify aims, content and structure of the programme	Quantitative outcome measures
Role of evaluator	Two way interaction	Independent and one-way communication
Methodology	Heavy use of qualitative design	Experimental and quantitative design
Frequency of data collection	Continuous monitoring	Limited or one round of data collection
Reporting procedures	Informal via group discussion and meetings	Formal reports
Frequency of reporting	During the overall process of evaluation	After completion of evaluation

Figure 2. 2 Evaluation Methods

Nonetheless, each of these types of evaluation can in turn use different strategies, namely goal-free evaluation, goal-based evaluation and criteria-based evaluation depending on the motivation for evaluation (Chen, 2011). Therefore, this results in six basic types of evaluation methodologies: goal-free summative methodology, goal-free formative methodology, goal based summative methodology, goal-based formative methodology, criteria-based summative methodology and criteria-based formative methodology (Chen, 2011).

Goal – Free Formative Evaluation: This is the evaluation undertaken without clear goal during the development of IS (Chen, 2011). When it is used, it is with an exploratory attitude in mind, that is, to detect, identify and explore the possibility of the occurrence of unpredicted events that may have an undesirable impact in the IS under development (Chen, 2011). Usually, external evaluators are asked to become involved in goal-free formative evaluation in order to avoid internal evaluators biases, preconceived ideas and even acquired prejudices about the IS under development (Scriven 1991). This type of evaluation can be performed using joint application design workshops, cognitive walkthroughs, prototyping or even interpretive observation (Chen, 2011).

Goal-Free Summative Evaluation: This evaluation is carried out without clear goals after the IS is developed (Chen, 2011).. This evaluation as well is scarcely applied. Methods used here are similar to those used in Goal-free formative evaluation ie cognitive walkthroughs and observation (Chen, 2011).

Goal-Based Formative Evaluation: The aim of this evaluations is to investigate whether the project has achieved its goals (Chen, 2011). These goals are expressed in terms of organizational goal descriptions, requirement specifications and IT specifications. The methods used are prototyping an simulation (Lycett 2000).

Goal-Based Summative Evaluation: The aim of this evaluation is to assess if the implemented IS fulfils the business goals and the costs and benefits of implementing the IS for decision making (Chen, 2011)

Criteria-Based Formative Evaluation: The main criteria-based approaches are usability, accessibility and standard verification studies (Chen, 2011). The criteria standards for evaluation stem from the theories as well as precise guidelines or standards (Chen, 2011). Usually, this type of evaluation is better performed by expert evaluators, who in are much more efficient than users with less experience (Chen, 2011). Moreover, experts in usability, accessibility and specific standards are bound to improve acceptance and quality assurance of the development process. Therefore, rapid and efficient interventions by experts in a formative stage are ideal (Chen, 2011).

Criteria-Based Summative Evaluation: This approach is carried out after the development of the IS is completed (Chen, 2011). It also focuses on usability, accessibility and standard verification studies (Chen, 2011). This type of evaluation usually aims at certification with accrediting bodies, acceptance testing and quality assurance and always taken by experts. Methods used here at cognitive walkthroughs and heuristic evaluation (Chen, 2011).

Table 2. 1: A comparison of key differences between summative and formative evaluation (adopted from (Chen, 2011)

Strategy / Nature	Goal-based evaluation	Goal-free evaluation	Criteria-based evaluation
Formative	• Joint Application Design Workshops • Cognitive Walkthroughs • Prototyping • Observation • Mixed method approaches	• Joint Application Design Workshops • Cognitive Walkthroughs • Prototyping • Observation	• Feature inspection • Consistency inspection • Standard inspection • Guideline checklist inspection • Cognitive walkthroughs • Heuristic evaluation • Eye tracking.
Summative	• Cognitive Walkthroughs • Formal Specification Testing • Observation • Mixed method approaches • Cost benefit analysis	• Cognitive Walkthroughs • Observation • Semi-structured interviews • Focus Groups	• Cognitive walkthroughs • Heuristic evaluation

2.3 Health Information System evaluation methods

Health information system (HIS) is described as the interaction between people, process and technology to support operations, management in delivering essential information in order to improve quality of healthcare services (Almunawar & Anshari, 2012). Health information systems is described as systems that process data and provides information and knowledge in healthcare environments (Reinhold, 2006). The International Organisation for Standardization (ISO) defines HIS as a repository of patient data in a digital form, stored, exchanged securely, and accessible by multiple authorized users. It contains retrospective, concurrent, and prospective information and its primary purpose is to support continuing, efficient, and quality integrated health care at all levels individual patient level, health care system level and national level.

In the U.S., the 2009 Health Information Technology for Economic and Clinical Health Act (HITECH Act) established the Office of the National Coordinator for Health Information Technology (ONC). It also introduced the terms "meaningful use" of "certified EHR technology" and offered incentive payments to eligible professionals and hospitals (Marcial, 2014). Meaningful use is constructed from the concept that ERH use may improve quality, safety, efficiency and reduce health (Marcial, 2014). Eventually these would lead to better clinical outcomes, improved population health outcomes, increase transparency and efficiency, empowered individuals, more robust research data on health systems, and would help maintain privacy and security of patient health information (Marcial, 2014). Despite widespread use, usability of health information systems is significantly weak (Marcial, 2014). This may result from lack of focus on usability during the process of ramping health information system use; it can also be caused by poor translation of existing and well-known best practices to ensure usability from the field of design in healthcare (Marcial, 2014). Unfortunately, Health information system require complex technical integration, so design and usability are often an afterthought and fail to incorporate a robust user centered design process or full-scale usability testing (Marcial, 2014).

Health information systems is the connection between healthcare's business processes, and the information systems to deliver better health services. It consists of a range of technology in health care delivery, largely used to acquire, deliver, store and analyse medical data. This is one of the most important components to ensure delivery of high quality and safe health care; for instance, computerized provider order entry (CPOE) which are designed to replace a hospital's manual ordering system. They allow users to electronically write the full range of orders, maintain an online medication administration record, and review changes made to an order by successive personnel. They also offer safety alerts that are triggered when an unsafe order (such as for a duplicate drug therapy) is entered, as well as clinical decision support to guide caregivers to less expensive alternatives or to choices that better fit established hospital protocols. Even through CPOE systems can, when correctly configured, markedly increase efficiency and improve patient safety and patient care, however the configuration requires a tremendous amount of time and effort, eventually these does not result an error free and safe medical records. Thus, CPOE systems are not currently a quick or easy remedy for medical errors. Consequently, despite these benefits, hospitals have been slow to adopt these technologies. Due to this fact, the Institute of Medicine and the Department of Health and Human Services has begun serious efforts to improve the adoption of electronic medical information systems in all health care environments.

The idea of computerizing health information records has been around for years, but only in the past decade has it become widely adopted. Prior to the health information systems (HIS), a patient's medical records consisted of handwritten notes, typed reports, and test results stored in a paper file system. In the recent past health information systems has gained population due to the increasing recognition that a stronger Health Information Technology (HIT) is critical to achieving a higher quality care at lower costs (Florence Femi Odekunle, 2017).

In developed countries HIS are becoming an important aspect of health care for instance the U.K and Sweden have national HIS and the US has also committed to a wide use of HIS by 2014 (Tierneya, 2010). Sood eal.,(2008) informed that United States, United Kingdom and Australia have growing and robust healthcare infrastructures that have incorporated HIS. A study by Schoen et al.,(2006) showed that only 23% of Canadian primary care doctors used electronic patient medical records (Chang, 2015). In Asia, a survey conducted by the Japan Hospital Association [JHA] (2001) reports that most hospitals in Japan have adopted HIS with only 30% citing the high cost of computerization as the major barrier to EMR adoption. In India Singh and Muthuswamy (2013) found out despite use of health information systems in increasing the efficiency of healthcare, many factors like cost, time, training, fear, security and privacy, lack of standards that stops healthcare practitioners to adopt electronic records (Singh, 2013). In South Korea, Park and Lee (2014) found that the HIS adoption rate of small hospitals was 40.3%, which is slightly higher than in the neighboring Japan (Park & Lee, 2014).

Though significant failures still exist in these systems, there is strong support and motivation to accomplish goals associated with comprehensive development of successful HIS systems Avison & Young in developed countries (Avison & Young, 2007). These countries are able to make significant investments in research to develop information systems that would meet the need of their particular healthcare system (Avison & Young, 2007).

A study in the United States by Commonwealth Fund's, the first conducted in 2009 and before enactment of the Affordable Care Act (ACA) and during the very early stages of deployment of Health Information Technology for Economic and Clinical Health of 2009 (HITECH) funds, and the second in 2013 to describe trends in Health Information Technology (HIT) adoption among Federally Qualified Health Centers (FQHCs), the percentage of FQHCs establishing electronic health information systems more than doubled, from 40 per cent to 93 percent (Ryan, Doty, abRams, & Riley, 2014). In sub –Saharan Africa there has been an increase in adoption of health information systems in the last decade mostly driven by the international efforts at stemming the HIV/AIDS epidemic. (Akanbi et al., 2014). Based on the current literature, most countries in sub-Saharan Africa, particularly Francophone countries, are however being left behind in the progress towards health information systems (HIS) adoption. Government institutions in sub-Saharan Africa also appear to be slow in implementing HIS and other appropriate ICT which are required to improve healthcare on the continent.(Akanbi et al., 2014).

HIS implementation has been very critical in addressing challenges such as reducing preventable documentation errors, enhancing communication among health providers and facilities and reducing medical costs (K & Frank, 2017). HIS also helps eliminate legibility issues (Raymond et al 2015), billing and providing data repository for future research and quality improvements (Arsoniadis & Melton, 2016). Essentially, an EMR has the ability to facilitate the continuity of care. The functions of health information systems (HIS) include patient billing, electronic ordering of investigations and receiving investigation results, electronic prescribing, recording of clinical information and in some circumstances, decision support software (Gold, Sheppler, Hessler, & Bunce, 2021).

Information systems (IS) research is important, according to a new forecast from International Data Corporation (IDC) predicts worldwide spending on information and communications technology (ICT) will be $4.3 trillion in 2020, an increase of 3.6% over 2019 (Shirer, 2020). Commercial and sector spending on information technology (hardware, software and IT services), telecommunications services, and business services will account for nearly $2.7 trillion of the total in 2020 with consumer spending making up the remainder (Shirer, 2020). However, and despite this apparent success in the IS market, failure rates of IS implementation and exploitation have been continuously high (Chen, Osman, Nunes, & Peng, 2011). For example, and according to a recent Standish Group Chaos Report (Standish Group, 2009), 44% of IS projects were considered as challenged and 24% were identified as a complete failure in 2008. Giving the large investment and high failure rate of IS implementation, evaluation is now recognized as an increasingly important task that can directly contribute to IS success (Ammenwerth, Gräber, Herrmann, Bürkle, & König, 2003).

Information systems evaluation is categorized in terms of the nature of the evaluation (summative vs. formative) and the strategy to be adopted in the evaluation (goal-based, goal-free and criteria-based (Chen, 2011)

2.4 Introduction to Health Information systems in Kenya

In the Kenya health policy 2014- 2030, and in the vision 2030 documents, health is one of the components of delivering the Social Pillar, given the key role it plays in maintaining the healthy and skilled workforce necessary to drive the economy. To realise this ambitious goal, the health sector defined priority reforms as well as flagship projects and programs, including digitization of records and health information system amongst other projects. Kenya developed HIS policy document and the following are the priority actions for the health information systems policy statements:

1. Promote integration of data collection, information dissemination and utilization at various levels through partnership in health information processes amongst all health service providers. Institute guidelines and legal framework for health data and information reporting and Feedback.
2. Promote standardization, harmonization, management and coordination of data collection tools and systems.
3. Address the application and use of Information and Communication Technology for HIS data and information processes.
4. Define data management processes plus dissemination and utilization strategies.
5. Address challenges regarding Storage and Security of Health Data and Information.
6. Formulate Evaluation Criteria for HIS
7. Address HIS sustainability issues
8. Define the organizational structure for HIS
9. Define roles and responsibilities of various stakeholders
10. Guide the establishment of a regulatory and legal framework for health information
11. Guide the establishment of a Professional Regulatory Board for health records and management information personnel
12. Guide the institution of an HIS Coordinating Committee
13. Put in place resource mobilization strategies and control of investment inflows into HIS Budgetary allocation of at least 10% (Ten per cent) of the total sector allocation

The Health Information System in Kenya covers five inter-linked key areas of information generation, validation, analysis, dissemination and utilization.

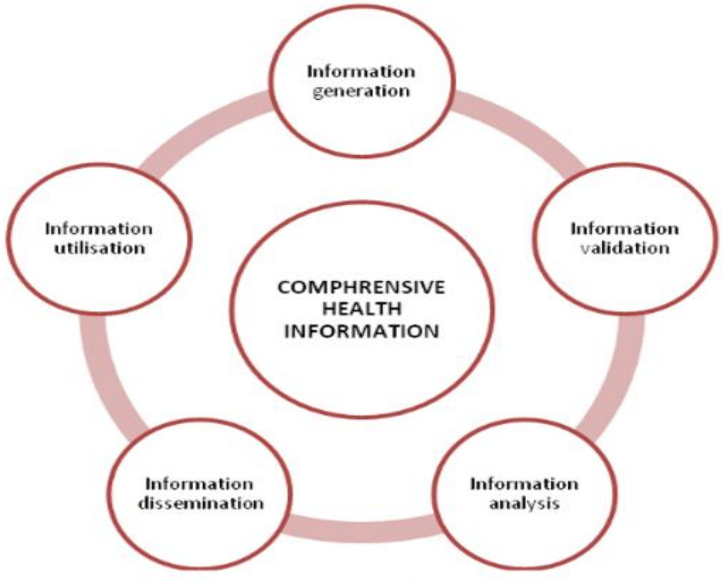

Figure 2. 3 Health Information System(Kenya Ministry of Health)

Information generation: this entails the data collection by health care providers through the various methods of data capture.

Information validation: this consists of ensure that the data collected is accurate

Information analysis: this is the synthesis of the validated information to makes sense and help in decision making.

Information dissemination: distribution of information to the intended recipients

Information utilization: Using the information disseminated to make informed decision that will positively impact patients' care.

The information sources for the Health Sector are: -

1. Routine health information: Information on Health target and management activities occurring in health facilities, and is collected through the routine HMIS-
2. Vital statistics information: Information on vital events occurring in the communities that is collected routinely. These are information on births, deaths and Causes of Death in the community-
3. Disease surveillance information: the information fast track system for critical health events / notifiable conditions occurring in the community-
4. Survey information: Service delivery, or investment information on health and related activities occurring in the communities that is collected on a regular basis. These include

the Demographic and Health Surveys, AIDS and Malaria Indicator Surveys, Service Provision Assessments, Availability and Readiness assessments-

5. Research information: Scientific biomedical, and systems researches coordinated through the Kenya Medical Research Institute, but carried out by many different academic institutions -Given the above-mentioned status and issues in Health Information systems, a number of innovative approaches need to be put in place and implemented, to assure a comprehensive, effective Health Information System that is guiding decision making

A number of health information systems are currently used in Kenya, these are dependent on the department, thus modules are created to support different departments. Seven proprietary health information systems used in Kenya in his study. These covers Registration, billing, outpatient-clinical, pharmacy, laboratory, finance, Human resources, inpatient-administration (Muinga, 2020)

2.5 Systems Development Models with regards to Usability

Usability is a key asset of collaborative systems (Constantine L. , 2002). It's quite a challenging endeavor in practice to develop interactive systems and software products. substantial efforts have been undertaken to recognize the hindrances to integrating usability issues in software development (Gulliksen, et al., 2003). Even though there are a number of software products with poor usability, human computer interaction (HCI) emerged as field of research with the purpose of studying the interaction between user and computer technology (Bengt & Gulliksen, 2003).

Although software development models (SDMs) and usability work have some similarities (they are both applied disciplines, and they play important roles in software development), their differences are much more obvious. While SDMs originated from systems engineering and software economics (Sommerville 2001) in the late 1960s, usability work was developed in the late 1980s and early 1990s from HCI research, cognitive psychology and ergonomics. While software development was – with some notable exceptions - mainly concerned about the inner workings of the system, usability focused on the user (Jensen, 2016). Insufficient or lack of user involvement in software development affect both the product quality and also results in user dissatisfaction (Butt & Ahmad, 2012). Thus, the role of the user is different; in software development the user is primary a means to elicit requirements (Jacobson, 1999), while for usability work the users are the prime means for designing the system (Nielsen, 1999). This difference in perspectives does not imply that users are unimportant in SDMs; rather it indicates that, in the immensely complicated task of constructing high quality software systems, usability of one of many challenges (Jensen, 2016). Traditionally user involvement takes place in two stages, ie when collecting requirement and at a later stage of the development in order to validate and verify their requirements (Butt & Ahmad, 2012).

2.5.1 V- Model

In a classic software model like the V-model coding starts once the requirement gathering from users is completed, implementation of codes takes place in small increments and iteration (Butt & Ahmad, 2012). V-Model also referred to as the Verification and Validation Model. In this, each phase of SDLC must complete before the next phase starts. It follows a sequential design process same as the waterfall model. Testing of the device is planned in parallel with a corresponding stage of development.

Verification: It involves a static analysis method (review) done without executing code. It is the process of evaluation of the product development process to find whether specified requirements meet.

Validation: It involves dynamic analysis method (functional, non-functional), testing is done by executing code. Validation is the process to classify the software after the completion of the development process to determine whether the software meets the customer expectations and requirements.

So V-Model contains Verification phases on one side of the Validation phases on the other side. Verification and Validation process is joined by coding phase in V-shape. Thus, it is known as V-Model.

There are the various phases of Verification Phase of V-model:

1. **Business requirement analysis:** This is the first step where product requirements understood from the customer's side. This phase contains detailed communication to understand customer's expectations and exact requirements.
2. **System Design:** In this stage system engineers analyze and interpret the business of the proposed system by studying the user requirements document.

3. **Architecture Design:** The baseline in selecting the architecture is that it should understand all which typically consists of the list of modules, brief functionality of each module, their interface relationships, dependencies, database tables, architecture diagrams, technology detail, etc. The integration testing model is carried out in a particular phase.
4. **Module Design:** In the module design phase, the system breaks down into small modules. The detailed design of the modules is specified, which is known as Low-Level Design
5. **Coding Phase:** After designing, the coding phase is started. Based on the requirements, a suitable programming language is decided. There are some guidelines and standards for coding. Before checking in the repository, the final build is optimized for better performance, and the code goes through many code reviews to check the performance.

There are the various phases of Validation Phase of V-model:

1. **Unit Testing:** In the V-Model, Unit Test Plans (UTPs) are developed during the module design phase. These UTPs are executed to eliminate errors at code level or unit level. A unit is the smallest entity which can independently exist, e.g., a program module. Unit testing verifies that the smallest entity can function correctly when isolated from the rest of the codes/ units.
2. **Integration Testing:** Integration Test Plans are developed during the Architectural Design Phase. These tests verify that groups created and tested independently can coexist and communicate among themselves.
3. **System Testing:** System Tests Plans are developed during System Design Phase. Unlike Unit and Integration Test Plans, System Tests Plans are composed by the client?s business team. System Test ensures that expectations from an application developer are met.
4. **Acceptance Testing:** Acceptance testing is related to the business requirement analysis part. It includes testing the software product in user atmosphere. Acceptance tests reveal the compatibility problems with the different systems, which is available within the user atmosphere. It conjointly discovers the non-functional problems like load and performance defects within the real user atmosphere.

When to use V-Model?

1. When the requirement is well defined and not ambiguous.
2. The V-shaped model should be used for small to medium-sized projects where requirements are clearly defined and fixed.

3. The V-shaped model should be chosen when sample technical resources are available with essential technical expertise.

Advantage (Pros) of V-Model:

1. Easy to Understand.
2. Testing Methods like planning, test designing happens well before coding.
3. This saves a lot of time. Hence a higher chance of success over the waterfall model.
4. Avoids the downward flow of the defects.
5. Works well for small plans where requirements are easily understood.

Disadvantage (Cons) of V-Model:

1. Very rigid and least flexible.
2. Not a good for a complex project.
3. Software is developed during the implementation stage, so no early prototypes of the software are produced.
4. If any changes happen in the midway, then the test documents along with the required documents, has to be updated

The client is supplied with small release after the development cycle (Butt & Ahmad, 2012). During the requirement analysis phase the development team writes user stories to describe user need and roles (Butt & Ahmad, 2012). The people interviewed also need not to be the real users, thus the product fails due to lack of coordination with real users and fails to collect real user data (Butt & Ahmad, 2012). This models thus fails to incorporate usability testing at its stages.

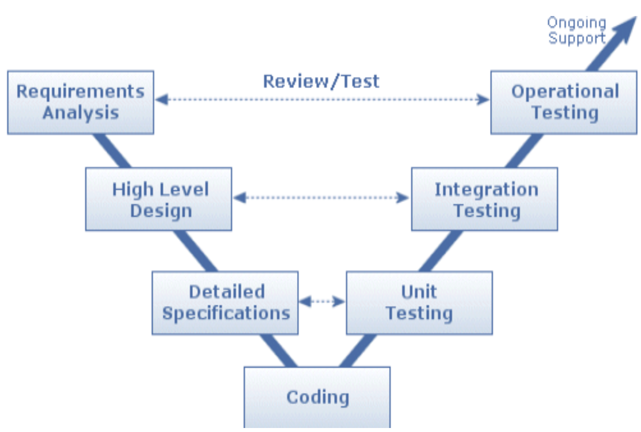

Figure 2. 4 V-Model

2.5.2 Waterfall Model

Winston Royce introduced the Waterfall Model in 1970. This model has five phases: Requirements analysis and specification, design, implementation, and unit testing, integration and system testing, and operation and maintenance. The steps always follow in this order and do not overlap. The developer must complete every phase before the next phase begins. This model is named "**Waterfall Model",** because its diagrammatic representation resembles a cascade of waterfalls.

1. Requirements analysis and specification phase: The aim of this phase is to understand the exact requirements of the customer and to document them properly. Both the customer and the software developer work together so as to document all the functions, performance, and interfacing requirement of the software. It describes the "what" of the system to be produced and not "how."In this phase, a large document called **Software Requirement Specification (SRS)** document is created which contained a detailed description of what the system will do in the common language.

2. Design Phase: This phase aims to transform the requirements gathered in the SRS into a suitable form which permits further coding in a programming language. It defines the overall software architecture together with high level and detailed design. All this work is documented as a Software Design Document (SDD).

3. Implementation and unit testing: During this phase, design is implemented. If the SDD is complete, the implementation or coding phase proceeds smoothly, because all the information needed by software developers is contained in the SDD.

During testing, the code is thoroughly examined and modified. Small modules are tested in isolation initially. After that these modules are tested by writing some overhead code to check the interaction between these modules and the flow of intermediate output.

4. Integration and System Testing: This phase is highly crucial as the quality of the end product is determined by the effectiveness of the testing carried out. The better output will lead to satisfied customers, lower maintenance costs, and accurate results. Unit testing determines the efficiency of individual modules. However, in this phase, the modules are tested for their interactions with each other and with the system.

5. Operation and maintenance phase: Maintenance is the task performed by every user once the software has been delivered to the customer, installed, and operational.

When to use SDLC Waterfall Model?

Some Circumstances where the use of the Waterfall model is most suited are:

1. When the requirements are constant and not changed regularly.
2. A project is short
3. The situation is calm
4. Where the tools and technology used is consistent and is not changing
5. When resources are well prepared and are available to use.

Advantages of Waterfall model

1. This model is simple to implement also the number of resources that are required for it is minimal.
2. The requirements are simple and explicitly declared; they remain unchanged during the entire project development.
3. The start and end points for each phase is fixed, which makes it easy to cover progress.
4. The release date for the complete product, as well as its final cost, can be determined before development.
5. It gives easy to control and clarity for the customer due to a strict reporting system.

Disadvantages of Waterfall model

1. In this model, the risk factor is higher, so this model is not suitable for more significant and complex projects.
2. This model cannot accept the changes in requirements during development.
3. It becomes tough to go back to the phase. For example, if the application has now shifted to the coding phase, and there is a change in requirement, It becomes tough to go back and change it.
4. Since the testing done at a later stage, it does not allow identifying the challenges and risks in the earlier phase, so the risk reduction strategy is difficult to prepare.

In waterfall model user involvement is only at the requirement gathering and design phase. It's not good for rapid change in requirement and large projects (Butt & Ahmad, 2012). This model only fit users or stakeholders who have clear vision about the project (Butt & Ahmad, 2012).

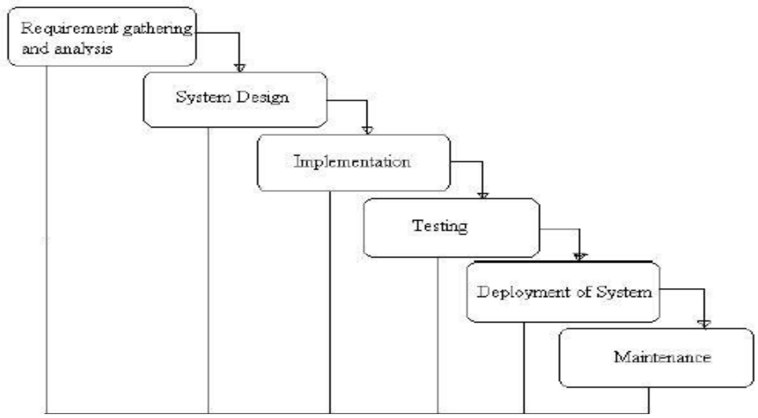

Figure 2. 5 Waterfall-Model

2.5.3 Spiral Model

The spiral model, initially proposed by Boehm, is an evolutionary software process model that couples the iterative feature of prototyping with the controlled and systematic aspects of the linear sequential model. It implements the potential for rapid development of new versions of the software. Using the spiral model, the software is developed in a series of incremental releases. During the early iterations, the additional release may be a paper model or prototype. During later iterations, more and more complete versions of the engineered system are produced.

Each cycle in the spiral is divided into four parts:

Objective setting: Each cycle in the spiral starts with the identification of purpose for that cycle, the various alternatives that are possible for achieving the targets, and the constraints that exists Play Video

Risk Assessment and reduction: The next phase in the cycle is to calculate these various alternatives based on the goals and constraints. The focus of evaluation in this stage is located on the risk perception for the project.

Development and validation: The next phase is to develop strategies that resolve uncertainties and risks. This process may include activities such as benchmarking, simulation, and prototyping.

Planning: Finally, the next step is planned. The project is reviewed, and a choice made whether to continue with a further period of the spiral. If it is determined to keep, plans are drawn up for the next step of the project.

The development phase depends on the remaining risks. For example, if performance or user-interface risks are treated more essential than the program development risks, the next phase may be an evolutionary development that includes developing a more detailed prototype for solving the risks.

The **risk-driven** feature of the spiral model allows it to accommodate any mixture of a specification-oriented, prototype-oriented, simulation-oriented, or another type of approach. An essential element of the model is that each period of the spiral is completed by a review that includes all the products developed during that cycle, including plans for the next cycle. The spiral model works for development as well as enhancement projects.

When to use Spiral Model?

1. When deliverance is required to be frequent.
2. When the project is large
3. When requirements are unclear and complex
4. When changes may require at any time
5. Large and high budget projects

Advantages

1. High amount of risk analysis
2. Useful for large and mission-critical projects.

Disadvantages

1. Can be a costly model to use.
2. Risk analysis needed highly particular expertise
3. Doesn't work well for smaller projects

Spiral model integrates the characteristics of waterfall and prototyping mode (Butt & Ahmad, 2012). It's good for large projects and also very costly, a lot of high expertise is required to handle risks and uncertainties in the project (Butt & Ahmad, 2012).

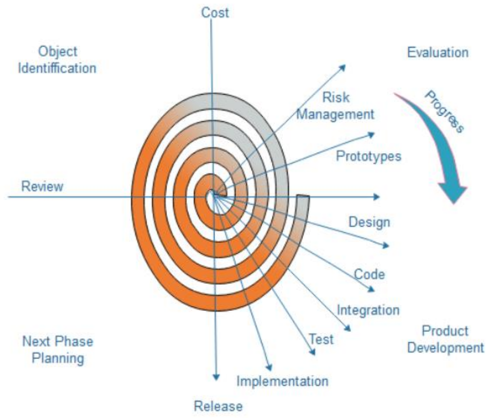

Figure 2. 6 Spiral Model

2.5.4 Agile Model

The meaning of Agile is swift or versatile. "**Agile process model**" refers to a software development approach based on iterative development. Agile methods break tasks into smaller iterations, or parts do not directly involve long term planning. The project scope and requirements are laid down at the beginning of the development process. Plans regarding the number of iterations, the duration and the scope of each iteration are clearly defined in advance.

Each iteration is considered as a short time "frame" in the Agile process model, which typically lasts from one to four weeks. The division of the entire project into smaller parts helps to minimize the project risk and to reduce the overall project delivery time requirements. Each iteration involves a team working through a full software development life cycle including planning, requirements analysis, design, coding, and testing before a working product is demonstrated to the client.

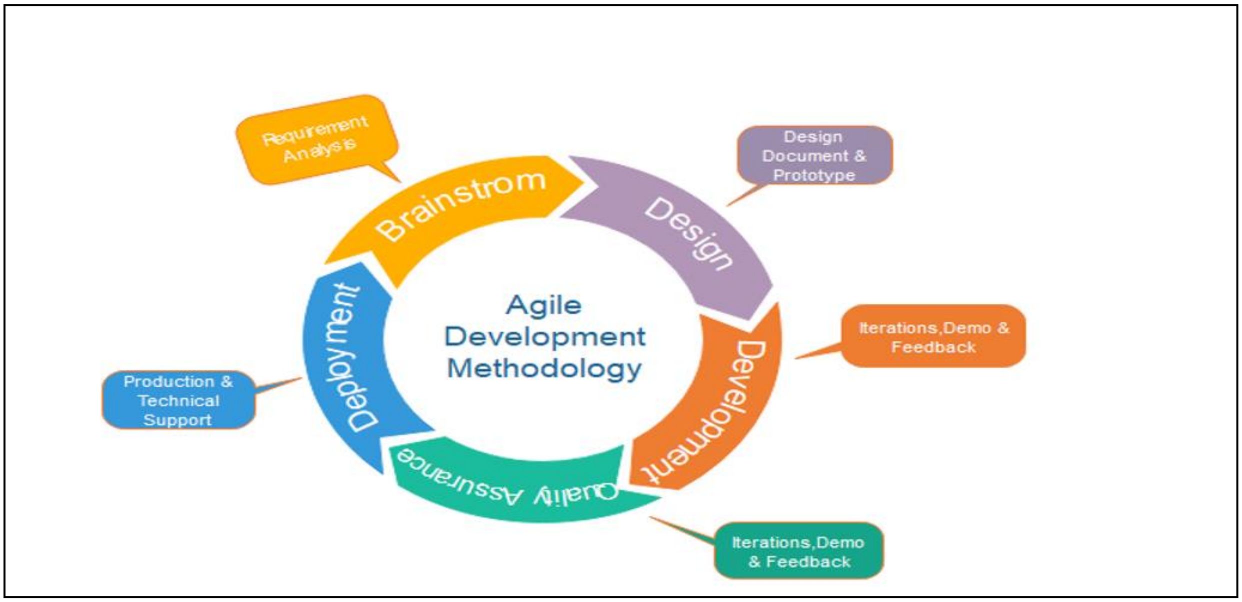

Figure 2. 7 Agile Model

Phases of Agile Model:

Following are the phases in the Agile model are as follows:

1. Requirements gathering
2. Design the requirements
3. Construction/ iteration
4. Testing/ Quality assurance
5. Deployment
6. Feedback

1. Requirements gathering: In this phase, you must define the requirements. You should explain business opportunities and plan the time and effort needed to build the project. Based on this information, you can evaluate technical and economic feasibility.

2. Design the requirements: When you have identified the project, work with stakeholders to define requirements. You can use the user flow diagram or the high-level UML diagram to show the work of new features and show how it will apply to your existing system.

3. Construction/ iteration: When the team defines the requirements, the work begins. Designers and developers start working on their project, which aims to deploy a working product. The product will undergo various stages of improvement, so it includes simple, minimal functionality.

4. Testing: In this phase, the Quality Assurance team examines the product's performance and looks for the bug.

5. Deployment: In this phase, the team issues a product for the user's work environment.

6. Feedback: After releasing the product, the last step is feedback. In this, the team receives feedback about the product and works through the feedback.

Agile Testing Methods:

1. Scrum
2. Crystal
3. Dynamic Software Development Method(DSDM)
4. Feature Driven Development(FDD)
5. Lean Software Development
6. eXtreme Programming(XP)

Scrum

SCRUM is an agile development process focused primarily on ways to manage tasks in team-based development conditions.

There are three roles in it, and their responsibilities are:

1. **Scrum Master:** The scrum can set up the master team, arrange the meeting and remove obstacles for the process
2. **Product owner:** The product owner makes the product backlog, prioritizes the delay and is responsible for the distribution of functionality on each repetition.
3. **Scrum Team:** The team manages its work and organizes the work to complete the sprint or cycle.

eXtreme Programming(XP)

This type of methodology is used when customers are constantly changing demands or requirements, or when they are not sure about the system's performance.

Crystal:

There are three concepts of this method-

1. Chartering: Multi activities are involved in this phase such as making a development team, performing feasibility analysis, developing plans, etc.
2. Cyclic delivery: under this, two more cycles consist, these are:
   A. Team updates the release plan.
   B. Integrated product delivers to the users.
3. Wrap up: According to the user environment, this phase performs deployment, post-deployment.

2.5.5 Dynamic Software Development Method(DSDM):

DSDM is a rapid application development strategy for software development and gives an agile project distribution structure. The essential features of DSDM are that users must be actively connected, and teams have been given the right to make decisions. The techniques used in DSDM are:

1. Time Boxing
2. MoSCoW Rules
3. Prototyping

The DSDM project contains seven stages:

1. Pre-project
2. Feasibility Study
3. Business Study
4. Functional Model Iteration
5. Design and build Iteration
6. Implementation
7. Post-project

2.5.6 Feature Driven Development(FDD):

This method focuses on "Designing and Building" features. In contrast to other smart methods, FDD describes the small steps of the work that should be obtained separately per function.

Lean Software Development:

Lean software development methodology follows the principle "just in time production." The lean method indicates the increasing speed of software development and reducing costs. Lean development can be summarized in seven phases.

1. Eliminating Waste
2. Amplifying learning
3. Defer commitment (deciding as late as possible)
4. Early delivery
5. Empowering the team
6. Building Integrity
7. Optimize the whole

When to use the Agile Model?

1. When frequent changes are required.
2. When a highly qualified and experienced team is available.
3. When a customer is ready to have a meeting with a software team all the time.
4. When project size is small.

Advantage(Pros) of Agile Method:

1. Frequent Delivery
2. Face-to-Face Communication with clients.
3. Efficient design and fulfils the business requirement.
4. Anytime changes are acceptable.
5. It reduces total development time.

Disadvantages(Cons) of Agile Model:

1. Due to the shortage of formal documents, it creates confusion and crucial decisions taken throughout various phases can be misinterpreted at any time by different team members.

2. Due to the lack of proper documentation, once the project completes and the developers allotted to another project, maintenance of the finished project can become a difficulty

From the above discussions of the models above, there are problems that come up, that make the software fail, these include, development process is not flexible, lack of User involvement, lack of focus on User Interface unable to handle rapid change in Requirements, and lack of Software Usability (Butt & Ahmad, 2012).

2.6 Health information systems Usability Evaluation methods

Usability has been defined in various ways and typically encompasses a set of evaluation methods to understand user experiences for the purpose of creating more desirable, usable, and useful products. Healthcare leaders are increasingly expressing dissatisfaction with their clinical information systems, and often cite cost and difficulty of use as contributing factors (Gregg, 2014). The Healthcare Information and Management Systems Society (HIMSS) health information systems Usability Task Force report cited that usability was perhaps the most important factor that hindered the widespread adoption of HISs prior to the signing of the Health Information Technology for Economic and Clinical Health (HITECH) Act in 2009 (Belden, Grayson, & Barnes, 2009). Since then, organizations have worked quickly to get these clinical systems in place to take advantage of the incentive dollars offered through the Centers for Medicare and Medicaid Services (CMS) Meaningful Use incentive program (ONC, 2013). Adoption has been swift since 2009, yet enhancements to usability have been slow. Usability is usually properly addressed in projects where it's a clearly illustrated area of interest, and it as much as it would be necessary to output highly usable software. Usability is not considered and addressed in software development as often as would be necessary to output highly usable software (Xavier, 2014). It is properly addressed only in projects where there is an explicit interest in usability, and the quality of the system-user interaction is perceived as critical by the software development organization (Xavier, 2014). In these kinds of projects, usability experts drive the development, using mostly usability-related techniques in the phases previous to coding (Xavier, 2014).

The challenges that we face regarding usability in healthcare IT are several. First, there is no standard and accepted definition of usability in the healthcare IT industry. Several are offered that are very good, but none seem to be the gold standard from which we all work. Nielson (1995) defined usability as “a quality attribute that assesses how easy the user interfaces are to use.” (Nielsen, 1999) Further, Marcial noted that usability “…refers to how useful, usable, and satisfying a system is for the intended users to accomplish goals by performing certain sequences of tasks” (Marcial, 2014). Second, we have the issue of individual perspectives and paradigms. What may make perfect sense on a display screen to one person may not be as clear to another. Reasons for this are several and may be due to the person’s level of exposure to technology, their age and education, and perhaps gender. The bottom line is that healthcare is complex, HIS are complex, and attempting to visually display the nonlinear work of caring for patients is a huge challenge. However, several core concepts that are evidence-based can help lay a strong foundation for those informaticians working in the area of system design.

Usability is the ease with which a system can be used by the intended actors to achieve specified goals. It also includes a system’s learnability. Usability considers satisfaction, efficiency, effectiveness, and context of use (Zhang, 2011). Usability is deeper than the look and feel of a system or user satisfaction; it also includes how a system works in context to complete work or manage work flows, and how well that fits with the needs of users (Francis Lau, 2016). Usability includes how easy the system is to learn for users and how quickly users can relearn the tool if it is upgraded or if it is not used for a period of time (Francis Lau, 2016). Finally, usability can positively or negatively impact safety (Francis Lau, 2016).

Usability refers to the quality of a user's experience when interacting with products or systems, including websites, software, devices, or applications. Usability is about effectiveness, efficiency and the overall satisfaction of the user. It is important to realize that usability is not a single, one-dimensional property of a product, system, or user interface. ‘Usability’ is a combination of factors including: a nearly effortless understanding of the architecture and navigation of the site, Ease of learning: how fast a user who has never seen the user interface before can accomplish basic tasks, Efficiency of use: How fast an experienced user can accomplish tasks, Memorability: after visiting the UI, if a user can remember enough to use it effectively in future, Error frequency and severity: how often users make errors while using the system, how serious the errors are, and how users recover from the errors and Subjective satisfaction**:** If the user likes using the system.

There are many methods for assessing and improving the usability of systems. Usability methods can be broadly categorized into inspection methods and testing methods (Francis Lau, 2016).

1. Usability inspection methods, as a group, are expert-driven assessments of a design or product's usability (Francis Lau, 2016). They do not involve users. This is also referred to as analytical usability evaluation methods (Bernérus, 2010).
2. Usability testing methods, by contrast, engage real-world users potential or expected users to explore user interfaces, often completing important or common tasks within the system that test both the user interface and user experience. This is also referred to as empirical usability evaluation methods (Bernérus, 2010).

Both types of usability methods can vary in their focus (Francis Lau, 2016). For example, they can be very granular, focusing on an individual's interaction with the eHealth application, or they can focus on the broader interactions between actors in a group. Figure 2.2 provides some examples in each category. A system's usability can be evaluated in different settings, including real (i.e., in-situ) or simulated environments (i.e., clinical simulations in a usability lab). Using clinical simulations for usability evaluations often results in higher evaluation fidelity (E. Borycki, 2013).

	Individual Focus	Group Focus
Inspection	• Cognitive Task Analysis • Heuristic Inspection	• Distributed Task Analysis
Testing	• Think Aloud User Testing	• Observational Studies • Contextual Analysis

Figure 2. 8 Usability methods categorized type and focus

2.6.1 Analytical Usability Evaluation Methods (AUEMs)

Analytical methods do not involve the users and are performed by experts and the category mainly consists of three evaluation methods: "design guidelines", "formal-analytical techniques" and "inspection methods" (Blecken, 2010). These methods can in turn be performed or used in different ways, inspection methods can for example be either heuristic evaluation or cognitive walkthrough (Bernérus, 2010).

Design guidelines: this category contains guidelines that should be followed in order to design a user-friendly interface (Bernérus, 2010). These methods are in turn divided into five categories: design rules, ergonomic algorithms, style guide, standards and collection of guidelines (Vanderdonckt J. , 1999). Each group of design guidelines have its own characterization; Design rules contains concise instructions in such way that no further interpretation is needed; Ergonomic algorithms collect design requirements in a rigid manner that describes how the design process has to be carried out under certain conditions; Style guides contains rules and standards in order to provide a model graphical user interface design, the actual content is then later inserted. Standards, for example International Organization for Standardization (ISO) 9241 are defined by national or international organizations to generalize design of interfaces. Finally, Collections of guidelines offers a number of different guidelines for different types of user interfaces (Bernérus, 2010).

Formal-analytical techniques: These are also done by experts and can be categorized into two sub groups (Bernérus, 2010). The first, task analytical methods focuses on the task within the system. These tasks are broken down into small sub-tasks in order to distinguish potential problems in each one of them (Bernérus, 2010). The outcome of this method is data on execution times or sequences. GOMS (Goals, Operators, Methods, and Selection Rules) are one such technique and it provides time intervals in which a user should need in order to solve a task (Bernérus, 2010). This time includes both cognitive and physical actions. This can be helpful if there are two designs to choose from as it would be easy to compare them and see what design is most efficient (Bernérus, 2010). The second formal-analytical technique is “expert guidelines”, which instead of focusing on the tasks focuses on the ergonomics of the software. It could be said that expert guidelines are a set of questions and statements for the design of software (Blecken, 2010).

Finally, inspection methods: This can also be divided into two sub groups, design principles such as heuristic evaluation or design task analysis such as cognitive walkthrough (Bernérus, 2010). In heuristic evaluation the usability experts put themselves in the position of the user and evaluate the interface independently (Bernérus, 2010) When this is done the evaluations can be merged to an overall assessment of the system. The evaluation is done according to the usability heuristics, among them the ten basic heuristics defined by Nielsen (Nielsen, 1999). These heuristics have been further developed and can be adopted differently depending on what type of system being developed (Blecken, 2010). Cognitive walkthrough are more focused on tasks the users are to perform. It’s a review process, where experts evaluate the design using criteria appropriate to the design issues (Wharton et. al, 1994).

Distributed Task Analysis builds on the theory of Distributed Cognition and is a model that expands the concept of cognition outside of the mind to groups of actors (both human and technical). Understanding how a patient is kept alive in a trauma in an emergency or during surgery are two examples where a distributed task analysis would be helpful as there are many actors working together in parallel (Francis Lau, 2016). Like cognitive task analysis, distributed task analysis is an inspection method; however, the scope is typically larger, considering how a process unfolds and how groups of actors (and in this case eHealth tools) work together to come to decisions and complete actions (Francis Lau, 2016).

Cognitive Task Analysis is a form of expert inspection that focuses on the cognitive needs of an individual user (in a particular role) as they complete tasks. Cognitive Task Analysis is well suited for eHealth systems; much of healthcare is focused on the cognitively intensive tasks of collection and synthesizing patient information for diagnoses and managing treatment (Francis Lau, 2016).

2.6.2 Empirical Usability Evaluation Methods (EUEMs)

Empirical usability evaluation methods are done by the intended end-user and can consist of Usability Tests or Questionnaires (Bernérus, 2010). These methods can be carried out either on a prototype of the system or on a deployed system (Bernérus, 2010). Usability Test can be in several forms including video feedback or screen recording, log files & input protocols, thinking aloud protocol and attention-tracking (mouse tracking) & eye-tracking (Bernérus, 2010). The objective of these methods is to identify real problems users encounter when using the system. By analysing the data i.e. result from these tests, conclusions can be made concerning the problems and what actions that needs to be taken in order to solve these issues (Blecken, 2010). This process can be described as collecting empirical data while users are observed when interacting with the system and performing typical tasks (Jeff Rubin, 2008). (Blecken, 2010) say usability test is a convenient process as it enables the identification and explanation of errors in the interface. Usability tests should, however, not exclude tests made by experts, rather complement them (Jeff Rubin, 2008); (Blecken, 2010). As mentioned above usability tests can be done in several ways, each of them having both advantages and disadvantages.

Video feedback films the users' actions and visible reactions and this can then be analysed by an investigator and the filmed user together. This is useful to thoroughly analyse occurring issues, but it is very intensive (Bernérus, 2010).

Log files record and document the user's actions in a file which can then be analysed and enables the investigator to see the exact time and sequence of these actions. However, this method requires substantial preparation and is thus not used very often (Bernérus, 2010).

The think aloud protocol requires the user to verbally express his or her reactions and say what s/he is doing. According to Nielsen et al this is one of them most powerful methods to identify usability problems (Nielsen, 1999). This is however unnatural to most users creating a stressful environment which can lead to prolonged answers and task performance time from user (Blecken, 2010).

Think Aloud is a common form of usability testing where individual users are asked to use an application and encouraged to speak their mind while completing tasks (Francis Lau, 2016). By thinking aloud in the moment, the designers are able to capture usability challenges that might not otherwise be remembered by the user in follow-up interviews (Francis Lau, 2016). Multiple users are asked to individually complete a set of tasks in the application, typically while being recorded. The analyst then reviews the session (or their notes) to highlight usability challenges in using the system to complete the tasks (Francis Lau, 2016). The findings across the multiple test sessions are then synthesized into design recommendations that can be implemented and retested (Francis Lau, 2016).

Attention tracking: User uses the mouse to pint and click in the area or section he find the most noticeable, making the mouse both tool and pointer of focus and attention. This makes it not so good for interactive tasks and it diverts the mouse from its intended use (Bernérus, 2010).

Eye Tracking: In this method eyes and views are tracked and recorded. This can later be analysed to see what was most distracting, where the attention where most and how long the user remained on certain sections. This comes with the disadvantage as it requires more technical equipment than other methods (Blecken, 2010). Questionnaires can be used to collect quantitative data and can consist of different types of questions, multiple choice questions and a rate scale as well as open ended questions (Bernérus, 2010). There are several standardised questionnaires for usability evaluation, for example "Questionnaire for user interaction satisfaction" (QUIS), "Software usability measurement inventory" (SUMI) and System Usability Scale (SUS). The latter one is very short and should therefore be conducted together with other usability evaluation methods (Blecken, 2010).

Observational Studies place the analyst within an environment to observe the context of work. There are several approaches to observational studies, with varying focus, methods for recording observations (from note taking to digital recording of audio and video), and duration (Francis Lau, 2016).

Observational studies permit better understanding of the interactions between the technology and the interdependent workflow between actors (people, patients' physicians, nurses, etc.) (Francis Lau, 2016). Observations can take place at single or multiple locations and may focus on care flows of single patients through the healthcare system, or can be team focused, observing how a ward or department might work (Francis Lau, 2016).

2.6.3 Health Information Systems Usability characteristics

Preece, Rogers and Sharp in 2002 (Preece, Rodgers, & Sharp, 2002) (Interaction Design) propose 6 usability goals:

1. **Effective:** effective to use
2. **Efficient:** efficient to use
3. **Utility:** have good utility
4. **Learnable:** easy to learn
5. **Memorable:** easy to remember how to use
6. **Safe:** safe to use
7. **Ergonomics:** Some HIS are used for prolonged period without users taking breaks while utilizing them.
8. **Accessibility:** can be used by many different people, even people with disabilities.

The above usability goals are pragmatic or operational goals. Preece, Rogers and Sharp (Preece, Rodgers, & Sharp, 2002) (Interaction Design) propose that designers evaluate how well a design achieves these usability goals by asking questions directed at the design. The questions should not be general, such as "Is the design effective?" Rather, the question should be more specific, such as "Can users of a filing systems understand the categories and use them to find information?"

Effectiveness and utilities refer to usefulness. **Effectiveness** is an overall measure of how well the system performs (Preece, Rodgers, & Sharp, 2002). "Can users use the system to do the work they need to do?" **Efficiency** is more akin to usable and can refer to the time required to use the interface and the likelihood of making errors using the system (Preece, Rodgers, & Sharp, 2002). **Utility** is a measure of the correct functionality and breadth of functionality. Most good software is driven by utility, for example word processors have nearly all the features required to compose and format text documents. "Does the system provide all the functionality that user's needs?" (Preece, Rodgers, & Sharp, 2002)

The computer is a new cognitive tool, **learnability** has been a concern of UI designers (Preece, Rodgers, & Sharp, 2002). Designers have been plagued with trying to design "familiar and natural interfaces" that can be learned without reading a manual. But learnability depends on functionality; not all interfaces should be expected to be immediately usable (Preece, Rodgers, & Sharp, 2002).

Memorable is how easy is it to remember how to use an interface after the user has experience with the system (Preece, Rodgers, & Sharp, 2002). Memorable is related to learnability and has generated GUIs with

menus and icons, but the menu names and icons images need to be appropriate for them to be memorable. "What kind of support does the system have for remembering how to do tasks, especially infrequent tasks?" (Preece, Rodgers, & Sharp, 2002)

Safety is protecting the users from dangerous errors, for example losing all the user's data or protecting the user's confidential information (Preece, Rodgers, & Sharp, 2002) Safety can also refer to how users recover from errors. Safety is a little considered usability goal. An example of designing by safety is not putting the delete button next to the save button. Another example, is providing users various ways to recover from errors, both by reverting to a priority state or progressing the system to the correct state. For example in a word processor, the write can use control-z to correct, back button, or retype to correct mistakes. "What kind of errors can users make and how can they recover from the mistake?"

A little thought of usability is **ergonomics**. "Is the device physically safe and comfortable to use?" I believe that new devices, smart phones and tablets, should drive designers to consider ergonomics. For example, the designers should ask, "Can the user perform the operations in the work environment?" "Can the user press buttons wearing gloves?"

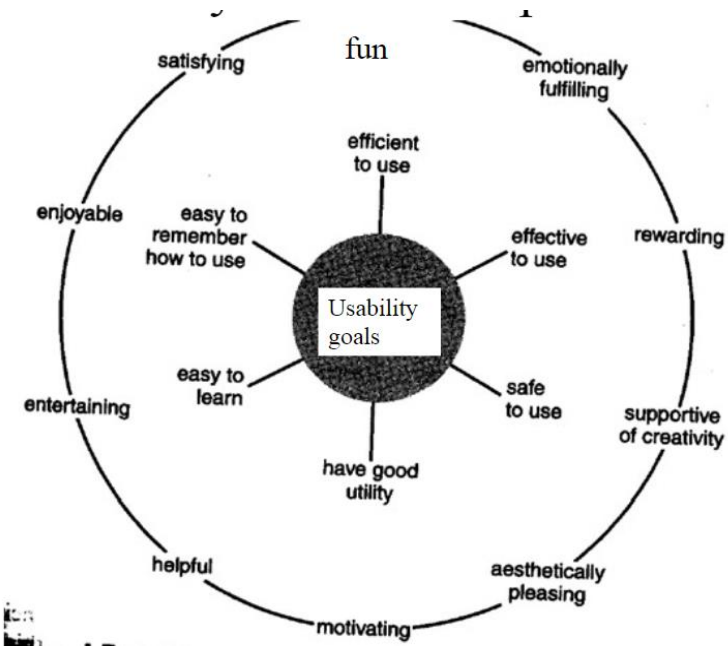

Figure 2. 9 Usability goals: at center of Interaction Design, User-experience goals: outer ring of diagram (secondary to usability goals)

2.6.3.1 User Experience Goals

User experience (UX) focuses on having a deep understanding of users, what they need, what they value, their abilities, and also their limitations. It also considers the business goals and objectives of the group managing the project. UX best practices promote improving the quality of the user's interaction with and perceptions of your product and any related services.

He notes that in order for there to be a meaningful and valuable user experience, information must be:

1. **Useful.** As practitioners, we can't be content to paint within the lines drawn by managers. We must have the courage and creativity to ask whether our products and systems are useful, and to apply our knowledge of craft + medium to define innovative solutions that are more useful.
2. **Usable.** Ease of use remains vital, and yet the interface-centered methods and perspectives of human-computer interaction do not address all dimensions of web design. In short, usability is necessary but not sufficient.
3. **Desirable.** Our quest for efficiency must be tempered by an appreciation for the power and value of image, identity, brand, and other elements of emotional design.

4. **Findable.** We must strive to design navigable web sites and locatable objects, so users can find what they need.
5. **Accessible.** Just as our buildings have elevators and ramps, our web sites should be accessible to people with disabilities (more than 10% of the population). Today, it's good business and the ethical thing to do. Eventually, it will become the law.
6. **Credible.** Thanks to the Web Credibility Project, we're beginning to understand the design elements that influence whether users trust and believe what we tell them.
7. **Valuable.** Our sites must deliver value to our sponsors. For non-profits, the user experience must advance the mission. With for-profits, it must contribute to the bottom line and improve customer satisfaction.

2.6.3.2 Principles of Usable Design

A well-designed user interface is comprehensible and controllable, helping users to complete their work successfully and efficiently, and to feel competent and satisfied. Effective user interfaces are designed based on principles of human interface design. The principles listed below are consolidated from a wide range of published sources (Nielsen, 1999), (Constantine L. , 2002), (Cooper, 2003), (William Lidwell, 2003); and are based on a long history of human-computer interaction research, cognitive psychology, and design best practices.

2.6.3.2.1 Usefulness

1. **Value:** The system should provide necessary utilities and address the real needs of users.
2. **Relevance:** The information and functions provided to the user should be relevant to the user's *task* and context.

2.6.3.2.2 Consistency

1. **Consistency and standards:** Follow appropriate standards/conventions for the platform and the suite of products. Within an application (or a suite of applications), make sure that actions, terminology, and commands are used consistently.
2. **Real-world conventions:** Use commonly understood concepts, terms and metaphors, follow real-world conventions (when appropriate), and present information in a natural and logical order.

2.6.3.2.3 Simplicity

1. **Simplicity:** Reduce clutter and eliminate any unnecessary or irrelevant elements.

2. **Visibility:** Keep the most commonly used options for a task visible (and the other options easily accessible).
3. **Self-evidency:** Design a system to be usable without instruction by the appropriate target user of the system: if appropriate, by a member of the general or by a user who has the appropriate subject-matter knowledge but no prior experience with the system. Display data in a manner that is clear and obvious to the appropriate user.

2.6.3.2.4 Communication

1. **Feedback:** Provide appropriate, clear, and timely feedback to the user so that he sees the results of his actions and knows what is going on with the system.
2. **Structure:** Use organization to reinforce meaning. Put related things together, and keep unrelated things separate.
3. **Sequencing:** Organize groups of actions with a beginning, middle, and end, so that users know where they are, when they are done, and have the satisfaction of accomplishment.
4. **Help and documentation:** Ensure that any instructions are concise and focused on supporting the user's task.

2.6.3.2.5 Error Prevention and Handling

1. **Forgiveness:** Allow reasonable variations in input. Prevent the user from making serious errors whenever possible, and ask for user confirmation before allowing a potentially destructive action.
2. **Error recovery:** Provide clear, plain-language messages to describe the problem and suggest a solution to help users recover from any errors.
3. **Undo and redo:** Provide "emergency exits" to allow users to abandon an unwanted action. The ability to reverse actions relieves anxiety and encourages user exploration of unfamiliar options.

2.6.3.2.6 Efficiency

1. **Efficacy:** (For frequent use) Accommodate a user's continuous advancement in knowledge and skill. Do not impede efficient use by a skilled, experienced user.
2. **Shortcuts:** (For frequent use) Allow experienced users to work more quickly by providing abbreviations, function keys, macros, or other accelerators, and allowing customization or tailoring of frequent actions.

3. **User control:** (For experienced users) Make users the initiators of actions rather than the responders to increase the users' sense that they are in charge of the system.

2.6.3.2.7 Workload Reduction

1. **Supportive automation:** Make the user's work easier, simpler, faster, or more fun. Automate unwanted workload.
2. **Reduce memory load:** Keep displays brief and simple, consolidate and summarize data, and present new information with meaningful aids to interpretation. Do not require the user to remember information. Allow recognition rather than recall.
3. **Free cognitive resources for high-level tasks:** Eliminate mental calculations, estimations, comparisons, and unnecessary thinking. Reduce uncertainty.

2.6.3.2.8 Usability Judgment

1. **It depends:** There will often be tradeoffs involved in design, and the situation, sound judgment, experience should guide how those tradeoffs are weighed.
2. **A foolish consistency...:** There are times when it makes sense to bend or violate some of the principles or guidelines, but make sure that the violation is intentional and appropriate

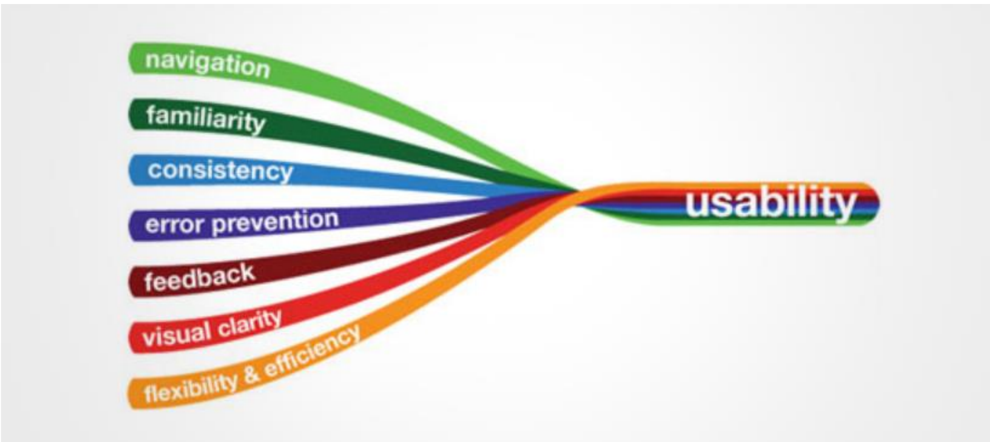

Figure 2. 10 Graphical Representation of the principles of Usability Design

2.7 An analysis of Health Information Systems Usability Evaluation Studies

Information technology (IT)-based applications in healthcare have existed for more than three decades and have gained widespread use (Alotaibi, 2017). Nowadays, it is hard to imagine healthcare without IT-based applications for both the accumulation and interchange of clinical information (Alotaibi, 2017). This is in part because IT has been recognized as an "enabler," that is, as a tool that offers solutions to the problem of the increasing accumulation of patient data (Silumbwe & Nkole, 2018). Because of their central role enabling the diverse use of information, IT systems ensure the timely and accurate collection and exchange of information, and thus a more efficient use of the scarce resources of healthcare organizations. With an increased need for the implementation of IT in all healthcare domains—such as primary healthcare and clinical settings or home healthcare environments—for the purpose of providing an optimal use of resource investment, its use is expected to rise. Evaluating such ICT applications to help decision makers acquire knowledge about the impact of IT-based systems therefore becomes a key issue to all organizations that aim to implement any new application (Omona & Weide, 2010).

However, despite the fact that evaluation studies have increased in importance, they usually only provide answers to questions such as why the system should be studied, why a specific IT application should be chosen among many other systems, or why they only present a general picture about costs and benefits to both users and the organization. Case studies that examine the costs and benefits of specific IT applications are the most common examples of empirical analysis, but the published work is neither extensive nor comprehensive. Studies discussing evaluation methodologies in the area of medical informatics have usually been performed descriptively, and often use approaches from domains such as computer science, cognitive science, economics, and organization, and usually do not use in a multi-actor focus that includes the consequences of the implementation and use of IT-based systems for all participants, including care recipients and stakeholders, involved in the healthcare process. The aim of this review is to outline the methodological approaches and results of studies that measure the impact of IT on healthcare organizations during 3 years (between 2003 and 2005).

This section reviewed health information systems evaluation studies highlighting the themes that were studied, the objectives of the study, and the timing of the evaluation in relation to the systems development life cycle. Health informatics evaluation is still at its infancy and what constitutes 'good' HIS is still unclear. It seems desirable to have a broadly accepted, detail evaluation framework that could guide researcher to undertake evaluation studies. Similarly, HIS evaluation should start at the conception, thus this study proposes to evaluate usability during the design and development of the Health information systems.

Table 2. 2 Analysis of Health Information Systems Usability Evaluation studies

Author(s)	**Title/Objective of Study**	**Item(s) of study**	**Usability evaluation Method(s) used**	**Time of evaluation**
Berglind Smaradottir, Santiago Martinez 2011,	Usability Evaluation of a Collaborative Health Information System (*Lessons from a User-centered Design Process)*	Effectiveness, efficiency and satisfaction	1)Test in usability laboratory with end-users, 2) Individual questionnaire and, 3) Group interview. A mixed methods research approach was used including observations, interviews and a questionnaire.	Implementation and post-implementation
Prithima Reddy Mosaly, Lukasz Mazur, Lawrence B. Marks, 2016	Usability Evaluation of Electronic Health Record System (EHRs) using Subjective and Objective Measures	Effectiveness of Usability evaluation Methods	1)Subjectively using subject's informal feedback and usability expert's heuristics, (2) workload measures using eye tracking, (3) behavior measures using clicks and navigation windows, and (4) performance measures using actual time on task and predictive time based on CogTool	Post- implementation
Noelia Vicente Oliveros, Teresa Gramage Caro, Covadonga Pérez Menéndez-Conde, 2017	A continuous usability evaluation of an electronic medication administration record application	Usability problems and their severity.	Heuristic evaluation complemented by usability testing	Development

Rajesh Vedanthan, Evan Blank, 2014.	Usability and feasibility of a tablet-basedDecision-Support and Integrated Record-keeping(DESIRE) tool in the nurse management ofhypertension in rural western Kenya	Usability and feasibility testing	Think aloud, and focus group discussion	Post- implementation
Emily Beth Devine, Chia-Ju Lee, 2014	Usability evaluation of pharmacogenomics clinical decision support aids and clinical knowledge resources in a computerized provider order entry system: A mixed methods approach	Heuristic evaluation and satisfaction	Mixed method approach	Post- implementation
William Brown III, Po-Yin Yen, 2013	Assessment of the Health IT Usability Evaluation Model (Health-ITUEM) for evaluating mobile health (mHealth) technology	Error prevention, Completeness, Memorability, Information needs, Flexibility/Customizability, Learnability, Performance speed, Competency	Focus group discussions	Post- implementation
Arielle M. Fisher, Timothy M. Mtonga, 2018	User-centered design and usability testing of RxMAGIC: a prescription management and general inventory control system for free clinic dispensaries	Usefulness, interaction challenges	Interviews	design, develop, and deploy

Samuel J. Wang et al. [2003]	To estimate the net financial benefit or cost of implementing electronic medical record systems in primary care during a period of 5 years.	Primary care	Economic data on costs and benefits came from patient medical records –Expert opinion	After implementation
Hallvard Laerum et al. [2003]	Evaluating the effects of scanning and elimination of paper based records by studying physicians and their attitude toward the system	Hospital	–Questionnaire (open ended questions) completed by 70 physicians –Interview with 8 physicians	After implementation
Cornelia M. Ruland et al. [2003]	To describe the effects of the new system for evaluation on: cost reductions; financial management, and decision making	Hospital	Economic data extracted from nursing records –Semi structured Interview (7 nurse managers) –Focus group with nurses –Questionnaire to 7 nurse managers	After implementation

Adams W.G. et al. [2003]	To evaluate the quality of documentation and delivery of paediatric primary care before and after the implementation of an EMR	Hospital and Primary care	Review of medical records (235 paper based visits and 986 computer based visits documents)	Before and after implementation
Houston T.K et al. [2003]	To survey patients' perceptions of handheld computer use by physicians, and compare those with their providers' perceptions	Hospital	Interview with 93 patients and 82 physicians	After implementation
Elske Ammenwerth et al. [2003]	To evaluate the preconditions and consequences of computer-based nursing process documentation with a special emphasis on acceptance issues among nurses	Hospital	Questionnaire completed by 39 nurses – Interview with 12 nurses	Before and during and after implementation

W. P. Zhang et al. [2004]	To clarify the implementation and maintenance costs of a computerized patient record (CPR) system in hospitals	Hospital	Questionnaire open-ended questions to 81 hospitals	After implementation
Laerum H et al. [2004]	To evaluate use of and attitudes to a hospital information system by medical secretaries, nurses, and physicians	Hospital	–Questionnaire completed by 79 medical secretaries, 172 nurses, 70 physicians – Interview with 8–12 representative medical secretaries, nurses, physicians	After implementation
Joseph K. Rotich et al. [2004]	Evaluation of the impact of introducing CPR on time of healthcare delivery within the rural health centre	Primary care	Time measurement	Before and after implementation

(Stengel, Bauwens, Walter, Köpfer, & Ekkernkamp, 2004)	To determine whether the introduction handheld computer-based documentation could improve both the quantitative and qualitative aspects of medical records	Hospital	Data obtained from patient medical records –Archived economic records assessed by expert observers	After implementation
(Likourezos, 2004)	To measure clinicians' computer background and experience, satisfaction with, perception of, and concerns about an EMR in emergency department (ED	Hospital	–Questionnaire completed by 23 physicians, and 21 nurses	After implementation
(Mijin, Jang, Choi, & Khongorzul, 2017)	Tim Scott et al. [2005]	Primary care and hospital	Semi structure interviews with senior clinicians, managers, project team members	Before and after implementation

2.8 Information Systems Usability Evaluation Standards

Evaluation of information systems (IS) represents an important topic among practitioners and researchers of information systems development (ISD) field. The evaluation of an IS may regard different aspects of the system, for example, performance, cost-benefit analysis, user acceptability, usability, reliability, functionality, efficiency, job satisfaction, etc. the study focused on usability evaluation (UE) of health information systems. UE is concerned with planning and conducting the measuring of the usability attributes of the user interface and identifying specific problems (Ivory & Hearst, 2001). Dix, Finlay, Abowd, and Beale (2004) point out that UE should be done throughout the design life-cycle and planned as providing results that can be used for improving the design (Dix, Finlay, Abowd, & Russell Beale, 2004). There are many models of usability that define the usability attributes that have to be measured. For example, Nielsen (1993) highlights the following usability attributes: learnability, efficiency, memorability, error rate, and satisfaction (Nielsen, 1999).

The study reviewed five standards, developed by the International Organisation for Standardization (ISO), that address usability of information technology (IT) and interactive systems. The standards that were review were: ISO/IEC 9126 – 1, ISO/IEC 14598 – 1, ISO 9241 – 11, ISO 13407, and ISO 18529. We studied these standards because they are intended to provide guidelines and general principles for planning and conducting evaluation during product/system development life-cycle. Other studies concerned with analysing the international standards that address usability are, for example, Jokela, Iivari, Matero (Jokela, Iivari, & Matero, 2003). In an interpretative study between ISO 13407 against ISO 9241-11 with the aim to find whether the two standards are consistent (Jokela, Iivari, & Matero, 2003), their aim was to highlight the need for a unified theory of usability measurement and propose a model for usability measurement. Nielsen (1993) describe and compare the advantages of using interface standards (national, international, industry or in-house built standards) when designing interactive systems (Nielsen, 1999). Our aim was to identify how the ISO standards address the UE process of IS. We studied the guidelines provided by the standards with respect to planning and conducting UE of information systems.

One of the main purposes of international standards is to impose consistency, compatibility, and safety (Bevan, 2009). Usability depends on the context of use, design environment, resources constraints, importance of usability etc (Bevan, 2009). Even though there are a number of usability evaluations standards, the following provide guidelines of information technology and interactive systems (Rajanen, 2014); ISO/IEC 9126 – 1, ISO/IEC 14598 – 1, ISO 9241 – 11, ISO 13407, and

ISO 18529 (Rajanen, 2014). These standards provide guidelines and general principles for planning and executing evaluation during product/system development cycle (Rajanen, 2014). The research studied these standards because they were intended to provide guidelines and general principles for planning and conducting evaluation during product/system development life-cycle.

Table 2. 3 Scopes of ISO/IEC 9126-1, ISO/IEC 14598-1, ISO 9241-11, ISO 13407, ISO 18529

Standard	*Entity*	*Stakeholders*	*Phase in life-cycle*
ISO/IEC 9126-1 ISO/IEC 14598-1	Software product	Designers, developers, evaluators, maintainers, acquirers	Requirements, development, use, evaluation, support, maintenance, quality assurance, audit of software, acquisition
ISO 9241-11	Software, hardware or service product in interactive systems	Designer, developer , evaluator, acquirer	Design, development, evaluation, procurement
ISO 13407	Computer-based interactive system	Project managers, All parties involved in human-centred system development	Throughout the system development life-cycle
ISO 18529	Life-cycle process of computer-based interactive system, software and hardware	Those involved in design, use and assessment of life-cycle processes	Design, development, use and assessment of life-cycle process of system, software and hardware

Usability is defined by ISO 9241-11 as the extent to which a product can be used by specified users to achieve specified goals with *effectiveness*, *efficiency* and *satisfaction* in a specified context of use. Most of the early efforts in standards for usability was focused in providing guidelines for use interface design, both hardware and software, in the ISO 9241 series (Earthy, 2009). The exhaustive ISO 9241 guidelines include the presentation of information (ISO 9241-12), design of user guidance (ISO 9241-13), menus (ISO 9241-14), command languages (ISO 9241-15), direct manipulation (ISO 9241-16), and forms (ISO 9241-17) (Bevan, 2009).

2.9 Information Security Standards

2.9.1 ISO/IEC 27002

ISO/IEC 27002 is an information security standard published by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) as ISO/IEC

17799:2005 and subsequently renumbered ISO/IEC 27002:2005 in July 2007, bringing it into line with the other ISO/IEC 27000-series standards. It is entitled Information technology – Security techniques - Code of practice for information security management (Tofan, 2011). This current standard has been revised from first published by ISO/IEC in 2000, which was a word-for-word copy of the British Standard (BS) 7799-1:1999 (Tofan, 2011). Its purpose is to set out a structured set of literally hundreds of information security controls, the use of which will help to achieve conformity with 27001 (Tofan, 2011). However, it is not an compulsory list: organizations are free to implement controls not specifically listed, so long as they are effective and conform to the requirements outlined in 27001 (Tofan, 2011).

ISO/IEC 27002 provides best practice recommendations on information security management for use by those who are responsible for initiating, implementing or maintaining Information Security Management Systems (ISMS). Information security is defined within the standard in the context of the C-I-A triad: the preservation of **confidentiality** (ensuring that information is accessible only to those authorised to have access), **integrity** (safeguarding the accuracy and completeness of information and processing methods) and **availability** (ensuring that authorised users have access to information and associated assets when required).

ISO/IEC 27002 contains best practices and security controls in the following areas of information security management: security policy, organization of information security, asset management, human resources security, physical and environmental security, communications and operations management, (Access control, Information systems acquisition), development and maintenance, information security incident management, business continuity management, compliance (Tofan, 2011).

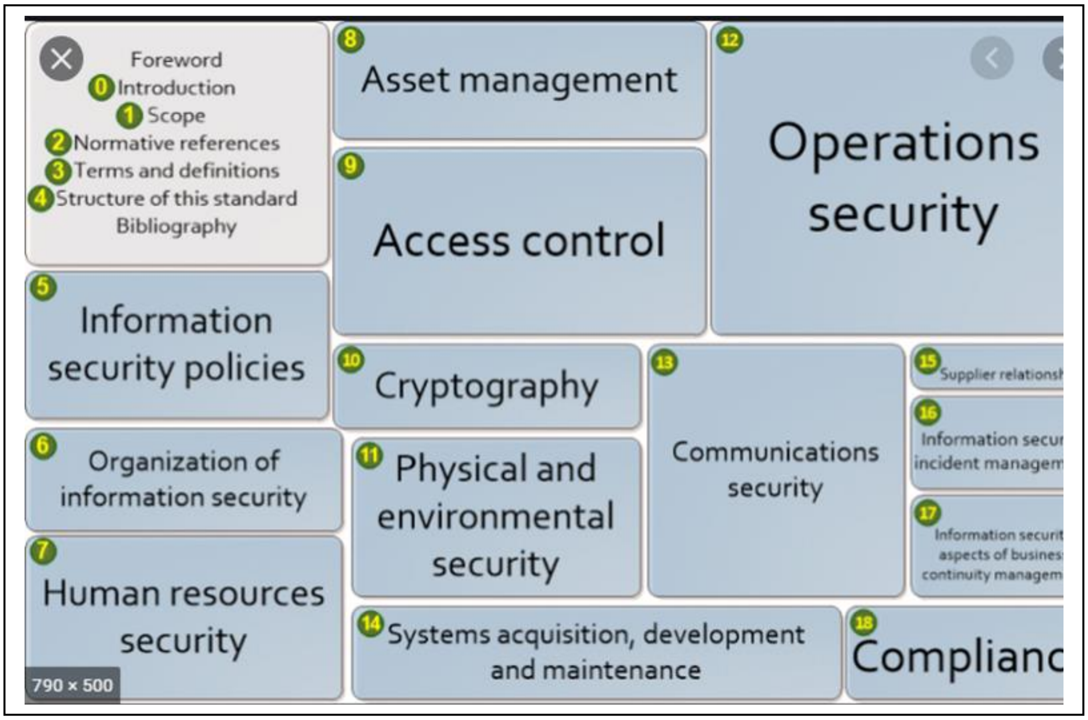

Figure 2. 11 ISO/IEC 20072 control domains

2.10 Health Information System related evaluation framework

The evaluation frameworks complement each other in that they each evaluate different aspects of HIS pertinent to human, organizational and technological factors. As illustrated in table 2.5 below, these frameworks differ in terms of generality and specificity, timing based on the system development phases and the aspects that have been assessed in the model. In addition, these frameworks do not provide explicit evaluation categories to the evaluator, thus specific measures within the dimensions of each aspect can be defined to facilitate HIS evaluation. The proposed PhD research study seeks to combine different evaluation aspects into a proposed framework, through building on the strengths and weakness of the existing frameworks.

Usability Aspects: Usability is measured by evaluating the interaction between user, tool, and task in a specified environment (Yen, 2010). These measures of interaction are called usability aspects. Various researchers have identified several usability aspects for system design and evaluation with the goal of providing a usable tool for users (Table 2.3). Some aspects are broader concepts (e.g., effectiveness, efficiency, etc.); some can be embedded as sub-concepts (e.g., flexibility to efficiency)

Table 2. 4 Usability evaluation models with the aspects examined

	Shackel (1991)	*Nielsen (1993)*	*Dix (1993)*	*Preece (1994)*	*Shneiderman (1998)*	*ISO 9241 (1998)*	*ISO 9126 (2001)*
Effectiveness	√			√		√	√
Efficiency/ Speed of performance		√		√	√	√	
Satisfaction/ Attitude	√	√		√	√	√	√
Productivity							√
Memorability / Retention over time		√			√		
Safety/Errors		√		√	√		√
Learnability / Time to learn	√	√	√	√	√		
Flexibility	√		√				
Robustness			√				

Table 2. 5 An Analysis of health information systems evaluation frameworks and studies

Study/Usability Evaluation Frameworks/Authors	**Domain/Evaluation aspects**	**Strengths**	**Weaknesses**
TURF: Toward a unified framework of EHR usability. (Zhang, 2011)	Systems implementation	TURF defined usability around the representation effect on: useful, usable, and satisfying, and listed a set of representative measures for each of these three dimensions. Also demonstrated how TURF can be used as a method to redesign products to improve their usability.	Did not include discussion on how to develop usability guidelines and standards.
Towards a Framework for Health Information Systems Evaluation (Mohd & Maryati, 2006) *HOT-fit framework (Human, Organization and Technology-fit)*	Systems implementation, System Quality, Information Quality, Service Quality, System Use, User Satisfaction, Organizational Structure, Organizational Environment and Net Benefits.	HOT-fit addresses the essential components of IS, namely human, organization and technology and the fit between them.	
Information Systems (IS) Success model (DeLone and McLean, 2004)	Systems implementation	These measures are included in these six system dimensions: *System Quality* (the measures of the information processing system itself), *Information Quality* (the measures of IS output), *Service Quality* (the measures of technical support or service), *Information Use* (recipient consumption of the output of IS), *User Satisfaction* (recipient response to the use of the output of IS) and *Net Benefits* (the overall IS impact).	It does not include organizational factors that are pertinent to IS evaluation. Van der Meidjen et al discovered that a number of measures such as user involvement during system development and organizational culture do not match any of the dimensions of the framework
4Cs (Kaplan, 1997)	Systems implementation	Developed from the Social Interactionist Theory, which stands for Communication (interaction within department), Care (medical care delivery), Control (control in the organization), and Context (clinical setting)	

CHEATS (Shaw, 2002)	Systems implementation, Clinical, Human and organizational, Educational, Administrative, Technical and Social	CHEATS is a generic framework for evaluating IT in healthcare that has six evaluation aspects: clinical, human and organizational, educational, administrative, technical and social. CHEATS attempts to provide a more comprehensive evaluation and some more specific measures, especially in the clinical aspect.	However, the dimensions within some of the aspects, such as technical, human and organizational could benefit from further development
Total Evaluation and Acceptance Methodology (TEAM) (Grant, et al., 2002)	Management level	It has 2 dimensions: Role, Time (evaluation phase) and Structure (strategic, tactical, operational management level). The 3D structure of this model illustrates	The selection of evaluation measures that match the management level can be challenging as the same measures can be categorized into more than one management level. As a whole, this framework is quite broad for a specific type of IS evaluation.
IT Adoption Model (ITAM) (Dixon, 1999)	Systems implementation,	Was constructed to study the individual user perspective and potential IT adoption. From the individual user perspective, this framework includes comprehensive evaluation criteria and relationships among them	This framework is clearly insufficient for a wider scope of evaluation, which involves the organizational aspect
A Framework for Usability Evaluation in EHR Procurement (TYLLINEN, 2018)	Systems procurement. Looked at usability attributes, evaluation methods and measures.	Emphasizes the detailed planning of usability evaluations. There were five key factors in developing and using the framework: Defining (1) the key user groups and use contexts; (2) the central tasks and goals; and (3) the usability objectives, attributes and their importance for the user groups. (4) Applying suitable methods to evaluate these attributes reliably, efficiently and extensively; and (5) quantifying the results for selection purposes.	The results and data gathering methods are not presented.
A framework for evaluating electronic health record vendor user-centered design	Systems implementation. Looked at UCD process, summative testing	The framework utilizes existing vendor safety-enhanced design SED reports, as required for certification by the Office of the National Coordinator for Health	One of the limitations of the framework is that it is based on the

and usability testing processes (Raj M Ratwani, 2016)	methodology, and summative testing results.	Information Technology (ONC), to systematically examine vendor UCD and summative testing processes. By identifying the SED certification requirements and aligning them with standards that are recognized in the human factors literature, the framework provides a method to quickly understand and compare vendor usability processes based on ly available CHPL reports.	reported UCD process, summative testing methodology, and summative testing results as provided in the SED certification reports that are self-reported by each vendor. The scores reflect the UCD and testing processes based on these reports and do not reflect the usability of the actual vendor EHR product.
Framework for Evaluating the Usability of Mobile Educational Applications for Children (Tahir, 2014)	Usability characteristics, goals (interface design criteria), questions, usability metrics (objective and subjective) and two evaluation instruments (task list and satisfaction questionnaire	Provides a comprehensive structure for evaluating the usability. At the base level it presents the usability characteristics and the UI design criteria for educational apps for children and how these are related	Due to rapid changes in mobile technology and a large number of educational apps being developed may cause the interface design criteria (goals) and metrics presented in this paper to be updated in future in order to match the needs of changing technology. This study didn't also check the effectiveness of this framework with different devices and operating systems.
Development of a Usability Evaluation Framework for the flight deck (Banks, 2018)		Provides a structured approach to flight deck design that may help reduce the risk of system failure from usability-related issues.	
Development Framework for the Evaluation of Usability in E-Government: A Case Study of E-Finance Government of Malang (Lestari, 2017)	Systems implementation. effectiveness, efficiency, and user satisfaction	The framework assessed 3 aspects of usability ie effectiveness, efficiency, and user satisfaction	Did not look at the design and development stages of the system
A user-centered framework for redesigning health care interfaces (Johnson C. M., 2005)	System redesigning phase	Comparison between the original and redesigned interfaces showed improvements in system usefulness, information quality, and interface quality	Only used at the redesign stage

Assessment of the Health IT Usability Evaluation Model (Health-ITUEM) for evaluating mobile health (mHealth) technology (William, 2013)	Systems implementation, Error prevention, Completeness, Memorability, Information needs, Flexibility/Customizability, Learnability, Performance speed, Competency, Other outcomes	This study demonstrated the flexibility, robustness, and limitations of this model. Health-ITUEM framework advances the science of mHealth technology evaluation and supports the effective use of these tools.	Did not look at the design and development stages of the system
Investigating evaluation frameworks for health information systems(*Maryati,2008)*		This study has added the following knowledge: • A classification of HIS based on their particular descriptions and characteristics. • A review of findings of both health informatics and information systems evaluation. • A critical appraisal of existing evaluation frameworks of HIS	

2.11 Theoretical Underpinnings

Theories are formulated to explain, predict, and understand phenomena and, in many cases, to challenge and extend existing knowledge within the limits of critical bounding assumptions. The theoretical framework is the structure that can hold or support a theory of a research study. The theoretical framework introduces and describes the theory that explains why the research problem under study exists. In this research the main theory is the engagement theory. Alongside the engagement theory are other four theories were reviewed and utilized. Throughout the design and development phase of the health information systems engagement theory was utilized, while during the evaluation and testing phases selected user satisfaction theories, learnability theory,

efficiency theory, Socio-Technical Systems (STS) theory and the Technology Acceptance Model 2(TAM2) were used.

2.11.1 User Engagement Theory

The theoretical framework is grounded on the engagement theory and user satisfaction theories. Engagement theory’s basic concept was used in student-learning context to mean that all student activities involve active cognitive processes such as creating, problem-solving, reasoning, decision-making, and evaluation (Kearsley & Shneiderman, 1998). In addition, students are intrinsically motivated to learn due to the meaningful nature of the learning environment and activities. Engagement theory is based upon the idea of creating successful collaborative teams that work on ambitious projects that are meaningful to someone outside the classroom. In this thesis this is used to imply that health information systems developers must meaningful engage the users through interaction, this could occur with or without technology: - thus this theory is utilized to demonstrate the engagement aspects during the design and development of health information system between the design and development team and the users. Engagement theory leads to constructive products which through user satisfaction theories demonstrates clear defined health information systems usability outcomes in the healthcare delivery.

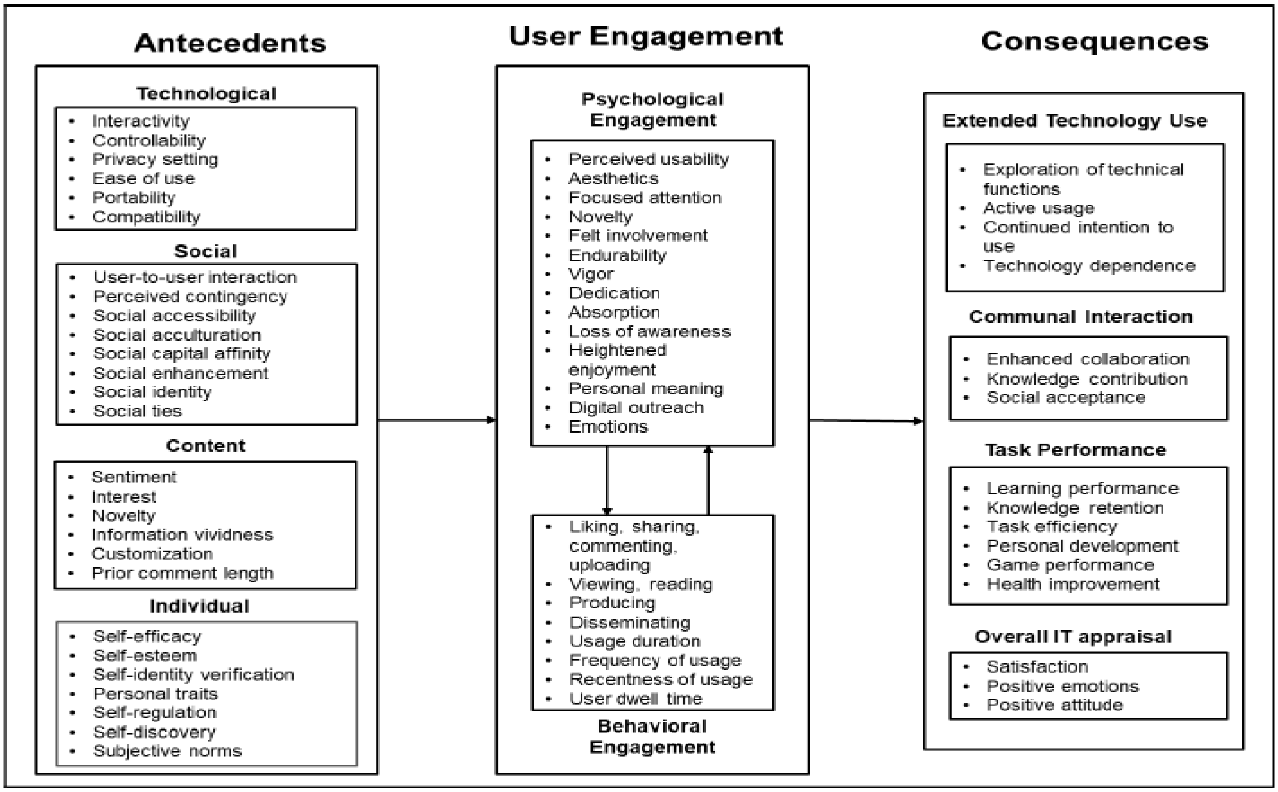

Figure 2. 12 A Framework for User engagement

2.11.2 Socio - Technical Systems Theory

Socio-technical (STS) systems theory was initially coined by Eric Trist and Fred Emery, consultants in Tavistock Institute in London, in 1960. The initial problem was that business were not achieving high level of productivity with the investments in technological systems. (Ada, Sharman, & Gupta, 2009). Thus, it was argued that organizations need be approached as socio-technical systems, to increase productivity. The theory basically discusses that organizational systems are composed of social and technical systems, which are independent and interactive (Ada, Sharman, & Gupta, 2009). The social system component of the theory is concerned with the people, their attributes and the interactions between people in the organization. (Ada, Sharman, & Gupta, 2009). Technical system component of theory deals with the processes, tasks, technology that is required to transform the input into outputs (Bostromand & Ileinen, 1977). In this study this theory is used in the area of information security, to include establishing and maintaining the systems.

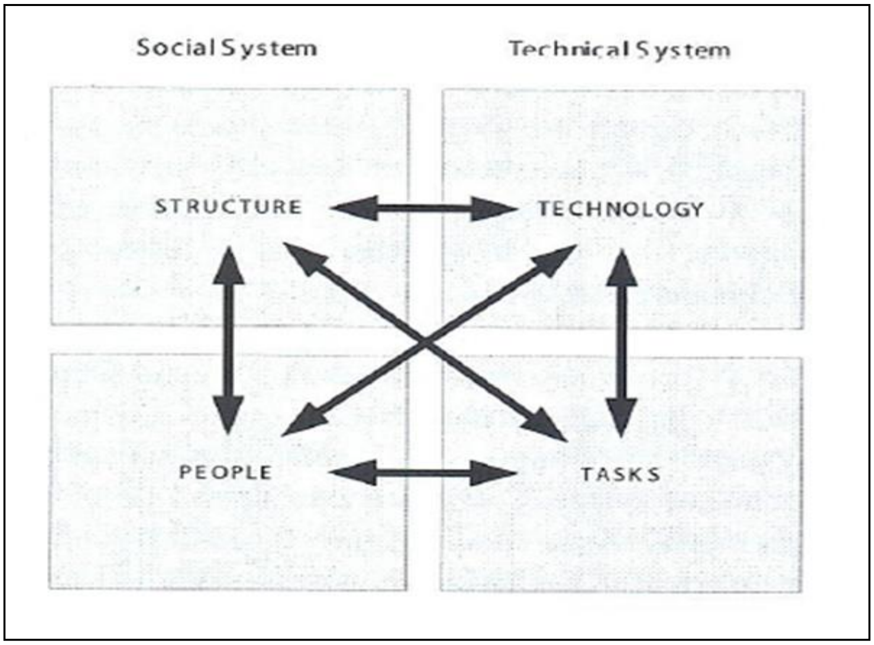

Figure 2. 131 Components of socio-technical systems

2.11.3 User Satisfaction Theories

The place of users or customers' satisfaction in software products development and the influence this holds in the quality of such products cannot be over emphasized (Mkpojiogu & Hashim, 2016). It's important to identify user requirements and satisfaction levels even before the product is designed (Mkpojiogu & Hashim, 2016). This is to avoid unnecessary rework and redesign, later product delivery, extra costs, effort, personnel and finance (Mkpojiogu & Hashim, 2016). Product quality is determined by customer satisfaction (Hartoyo & Simanjuntak, 2017). Thus, issues on user or customer satisfaction are worth considering (Mkpojiogu & Hashim, 2016). Knowing the extent of user or customers satisfaction is not enough, it is useful to also know the importance of the product requirements or features from the point of view of the user-customer stakeholder (Mkpojiogu & Hashim, 2016). This information provides a double boost for the designs that succinctly delight users or customers and that also enhances the perceived quality of such products (Mkpojiogu & Hashim, 2016). Software companies stand to gain when their customers are satisfied and delighted, but loss when their customers are dissatisfied as they will lose their patronage and loyalty (Mkpojiogu & Hashim, 2016).

2.11.3.1 Expectancy-Disconfirmation Theory

Expectation theory (also commonly known as Expectancy-Disconfirmation Theory) is the most widely accepted theory concerning customer satisfaction processes. The theory holds that satisfaction/dissatisfaction results from a customer's comparison of performance (of a product or service) with predetermined standards of performance (Yüksel & Yüksel, 2008). The expectation level then becomes a standard against which the product is gauged (Yüksel & Yüksel, 2008). Once the product/service has been used, outcomes are measured against expectations (Yüksel & Yüksel, 2008). If the outcome matches the expectation *confirmation* occurs. *Disconfirmation* occurs where there is a difference between expectations and outcomes (Yüksel & Yüksel, 2008). A customer is either satisfied or dissatisfied as a result of positive or negative difference between expectations and perceptions (Yüksel & Yüksel, 2008). Thus, when service performance is better than what the customer had initially expected, there is a positive disconfirmation between expectations and performance which results in satisfaction, while when service performance is as expected, there is a confirmation between expectations and perceptions which results in satisfaction (Yüksel & Yüksel, 2008). In contrast, when service performance is not as good as what the customer expected, there is a negative disconfirmation between expectations and perceptions which causes dissatisfaction (Yüksel & Yüksel, 2008).

2.11.4 The Kano Model

Kano model, developed by Professor Noriaki Kano, identifies and categorizes customer requirements or attributes as must-be, one-dimensional, attractive, indifferent and reverse requirements (or features) (Mkpojiogu & Hashim, 2016). Understanding of these attributes is critical to the development of products. Software engineering is a user- centered process that is potentially error prone. These errors can be minimized though engaging the users in requirements elicitation (Mkpojiogu & Hashim, 2016). Kano model brings out the nonlinear relationship between product performance and customer satisfaction (Mkpojiogu & Hashim, 2016). This model stipulates five key categories of requirements or product attributes (Mkpojiogu & Hashim, 2016), which defines the perceived quality of the proposed products

Must-be requirements: These set of requirements are the basic criteria of a product or the basic needs/expectations of the potential customers/users (Mkpojiogu & Hashim, 2016). They are the basic features customers/users expect from a software product (Mkpojiogu & Hashim, 2016). They are threshold requirements (Mkpojiogu & Hashim, 2016). The user or customer will be extremely dissatisfied if these requirements are not met or incorporated into the product design (Mkpojiogu & Hashim, 2016). However, customers take such requirements for granted and their fulfillment will not increase their satisfaction (Mkpojiogu & Hashim, 2016). Meeting must-be requirements only lead to a start of not being dissatisfied (Mkpojiogu & Hashim, 2016).

One-dimensional requirements: These requirements are satisfiers (Mkpojiogu & Hashim, 2016). They are linear requirements, with respect to these requirements, customer satisfaction is proportional to the level of requirements or feature fulfillment (Mkpojiogu & Hashim, 2016). The more the fulfillment, the more the customer is satisfied and vice versa (Mkpojiogu & Hashim, 2016).

Attractive requirements: Attractive requirements are the product criteria that have the greatest impact on how satisfied a user or customer will be with a particular product (Mkpojiogu & Hashim, 2016). They are delighters or excitement requirements (Mkpojiogu & Hashim, 2016). These kinds of requirements are neither explicitly expressed nor expected by users or customers (Mkpojiogu & Hashim, 2016). So, meeting these requirements leads to a more than proportional satisfaction (Mkpojiogu & Hashim, 2016). If these requirements are not met there may be a feeling of dissatisfaction by the user or customers.

Indifference requirement: This is a no preference requirement, which implies that the user/customer is indifferent to the requirement/feature (Mkpojiogu & Hashim, 2016). He or she does not care if the feature is present or not (Mkpojiogu & Hashim, 2016). The users do not actually care about this feature (Mkpojiogu & Hashim, 2016). This feature is neither good nor bad and they do not result in either the satisfaction or dissatisfaction of users/customers. Customers are not concerned with this requirement whether it is present or absent (Mkpojiogu & Hashim, 2016)

Reverse requirement: Is an inverse requirement (that is, can be either way), here, the user/customer expectation about the feature is in a reverse order (Mkpojiogu & Hashim, 2016). The users prefer that the requirement would not be considered (Mkpojiogu & Hashim, 2016). These are the requirements/features that users' do not expect (Mkpojiogu & Hashim, 2016). The more these features are met, the more dissatisfied users and customers will be (Mkpojiogu & Hashim, 2016). The requirements with a high degree of achievement result in dissatisfaction as all users are not the same/alike. With this requirement, customer's/user's satisfaction will be decreased (Mkpojiogu & Hashim, 2016).

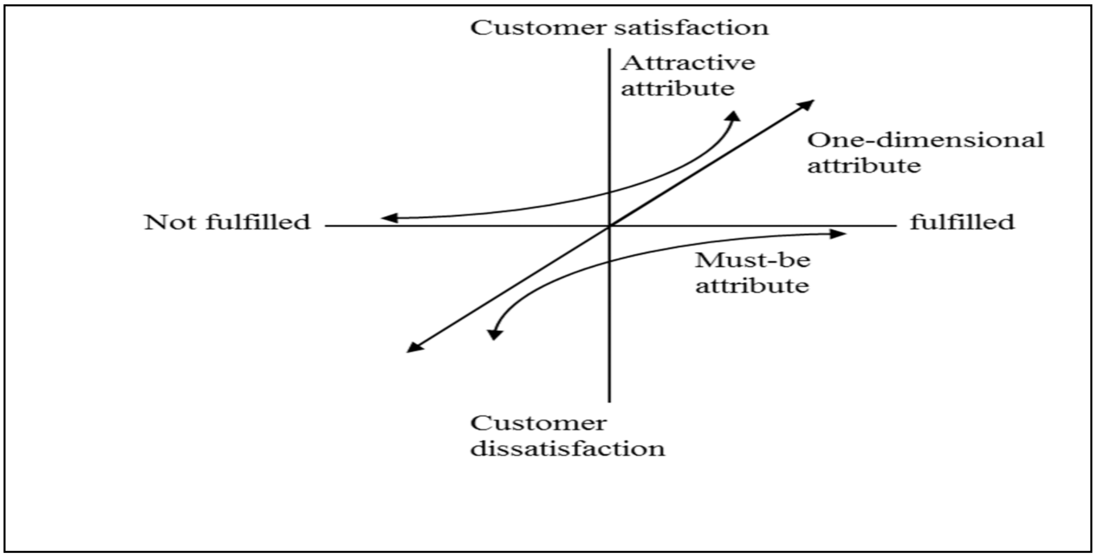

Figure 2. 142 Kano's model of customer satisfaction

2.11.4 Efficiency Theory

Efficiency describes the extent to which resources such as time, space and energy are well used to the intended task. (Yampolskiy, 2011). In complexity theory it's a property of algorithm for solving problems which require solutions (Yampolskiy, 2011). In this thesis context efficiency theory is used to describe the time and energy taken by the users of the health information system. Efficiency is also used to mean shorter representation of redundant data sharing (Yampolskiy, 2011).

2.11.5 Learnability Theory

Learnability theory is a body of mathematical and computational results concerning questions such as: when is learning possible? What prior information is required to support learning? What computational or other resources are required for learning to be possible? It is therefore complementary both to the computational project of building machine learning systems and to the scientific project of understanding learning in people and animals through observation and experiment (Fulop & Chater, 2013). Learnability theory includes work within a variety of theoretical frameworks, including, for example, identification in the limit, and Bayesian learning, which idealize learning in different ways (Fulop & Chater, 2013). Learnability theory addresses one of the foundational questions in cognitive science: to what extent can knowledge be derived from experience (Fulop & Chater, 2013). In this thesis this theory is used to demonstrate the learnability components of the health information system by the users.

2.11.6 The Technology Acceptance Model2 (TAM2)

TAM is an adoption of theory of reasoned action (TRA) (Davis, 1985). TAM theorizes that user's perceptions of usefulness and ease of use are significant determinants of technology acceptance or adoption (Halawi & McCarthy, 2006). TAM has been expanded by adding two additional variables into the model ie perceived quality (QUAL) and anticipated enjoyment of the using the system (FUN) (Davis, 1985). TAM2 has also been employed to measure technology acceptance across several different cultures (Halawi & McCarthy, 2006). TAM2 clearly investigates and tackles the role of the end-user when new technology is initiated. It also facilitates the examination of additional and external forces (Halawi & McCarthy, 2006). In the thesis this theory is used to describe the anticipated enjoyment by the users when using the health information systems under study.

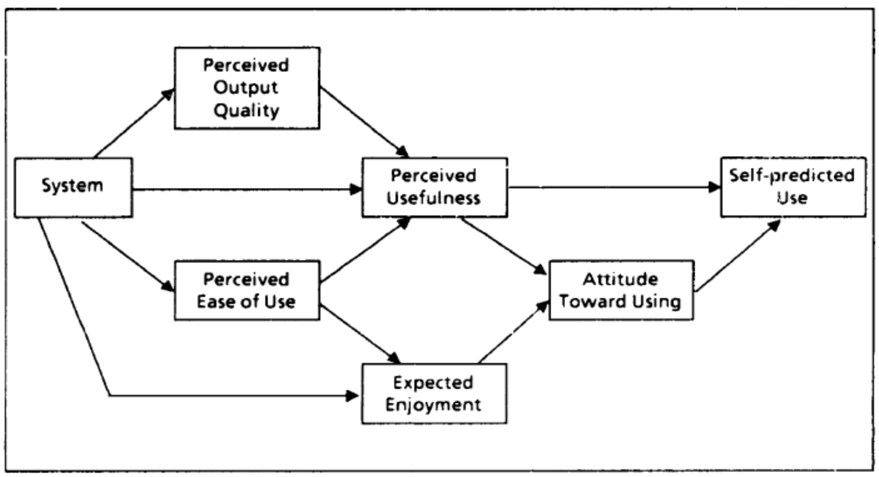

Figure 2. 15 TAM2 Hypothesized Relationships

2.12 Literature Review Summary

Having reviewed and studies the areas in this chapter, the research anchored the developed framework on the gaps of the existing usability frameworks, merging some of the underlying constructs into the structure of the developed framework. The research also included the theoretical underpinning to the framework, the engagement theory and the user satisfaction theories were the at the core of the usability evaluation framework developed. These were considered across the structure and the process of the framework matrix.

CHAPTER THREE: THE PROPOSED INTEGRATED USABILITY EVALUATION FRAMEWORK FOR THE DESIGN AND DEVELOPMENT OF HEALTH INFORMATION SYSTEMS

3.1 INTRODUCTION

This chapter provide the processes and the requirements that were considered for the development of the usability evaluation framework for the design and development of health information systems. It also presents the proposed framework that was developed.

3.2 COMPONENTS OF THE FRAMEWORK

The framework was categorised into a 3X3 matrix that included structure, process and outcome and technical systems functionality, human perspective and healthcare provision.

3.2.1 Structure: This is the manner in which the systems design and development process is constructed, including the requirements ie factoring the systems functionality, the human perspective and health care provision. In this section under the systems technical functionality, the framework has the constructs outlined in the socio technical systems theory ie People, tasks, technology and stricture, the software development models focusing on usability, the International Organization for Standardization (ISO). In terms of human perspective, the framework considered the constructs under the user engagement theory; user involvement and user participation. These constructs have to be evaluated as the design and development of the HIS is ramped up. At the health care provision, the framework identified the satisfaction theory and its constructs. The theory holds that satisfaction/dissatisfaction results from customer comparison of performance of product/service with predetermined standard of performance. If the outcome matches the expectation confirmation occurs, otherwise disconfirmation occurs.

3.2.2 Process: This is the systems development usability evaluation requirements that need to be considered for an efficient systems product. This is also the method by which the system transforms its data, the information processing, correct and valid. In the systems technical functionality, the study considered the five standards, developed by the International Organisation for Standardization (ISO), that address usability of information technology (IT) and interactive systems. The standards that were review were: ISO/IEC 9126 – 1, ISO/IEC 14598 – 1, ISO 9241 – 11, ISO 13407, and ISO 18529. We studied these standards because they are intended to provide guidelines and general principles for planning and conducting evaluation during product/system development life-cycle. Usability is defined by ISO 9241-11 as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. ISO/IEC 27002 was also reviewed as it provided best practice recommendations on information security management for use by those who are responsible for initiating, implementing or maintaining Information Security Management Systems (ISMS). Information security is defined within the standard in the context of the C-I-A triad: the preservation of confidentiality (ensuring that information is accessible only to those authorised to have access), integrity (safeguarding the accuracy and completeness of information and processing methods) and availability (ensuring that authorised users have access to information and associated assets when required).

The summative and formative evaluation methods also provided the framework with opportunity for the HIS development team evaluate the system both during and after development. Usability evaluation methods ie testing and inspection were also considered to evaluate usability as the HIS is developed. Software design, modeling and prototyping were also critical in terms of systems technical functionality. In terms of human perspective, the framework considered the constructs under the user engagement theory; user involvement and user participation. These constructs have to be evaluated as the design and development of the HIS is ramped up. The framework identified the satisfaction theory and its constructs at the health care provision. The theory holds that satisfaction/dissatisfaction results from customer comparison of performance of product/service with predetermined standard of performance. If the outcome matches the expectation confirmation occurs, otherwise disconfirmation occurs.

3.2.3 Outcome: these are the results relevant, applicable and reliable? Does it meet the requirement specifications? A number of existing constructs were borrowed from existing usability evaluation frameworks ie systems technical functionality the TAM2 constructs expected enjoyment, ease of use and attitude towards use were factored. Memorability and Safety/errors were new constructs introduced in the development framework. The human perspective had the expectation disconfirmation theory constructs (expectation and performance), learnability and efficiency theory. The health care provision the study focused on improved health care ie reduction of mortality, and readmission, improvement of patients' experience and reduction of timeliness of care.

3.3 Merging of constructs for the integrated usability evaluation framework for the design and development of health information systems.

Table 3. 1 Theoretical analysis matrix

Constructs	User Satisfaction Theories				Design and Development Phases		
	Expectancy Disconfirmation Theory	Efficiency Theory	Learnability Theory	TAM2	Socio-Technical Systems Theory	Engagement Theory	Integrated constructs for the Proposed conceptual Framework
Learnability			✓				✓
Efficiency		✓					✓
Memorability							✓
Safety/Errors							✓
Satisfaction	✓						✓
Ease of Use				✓			✓
Participation						✓	✓
Involvement						✓	✓
Tasks					✓		✓
People					✓		✓
Technology					✓		✓
Structure					✓		✓

3.4 Proposed Integrated Usability Evaluation Framework for the Desifn and Development of the health Information Systems.

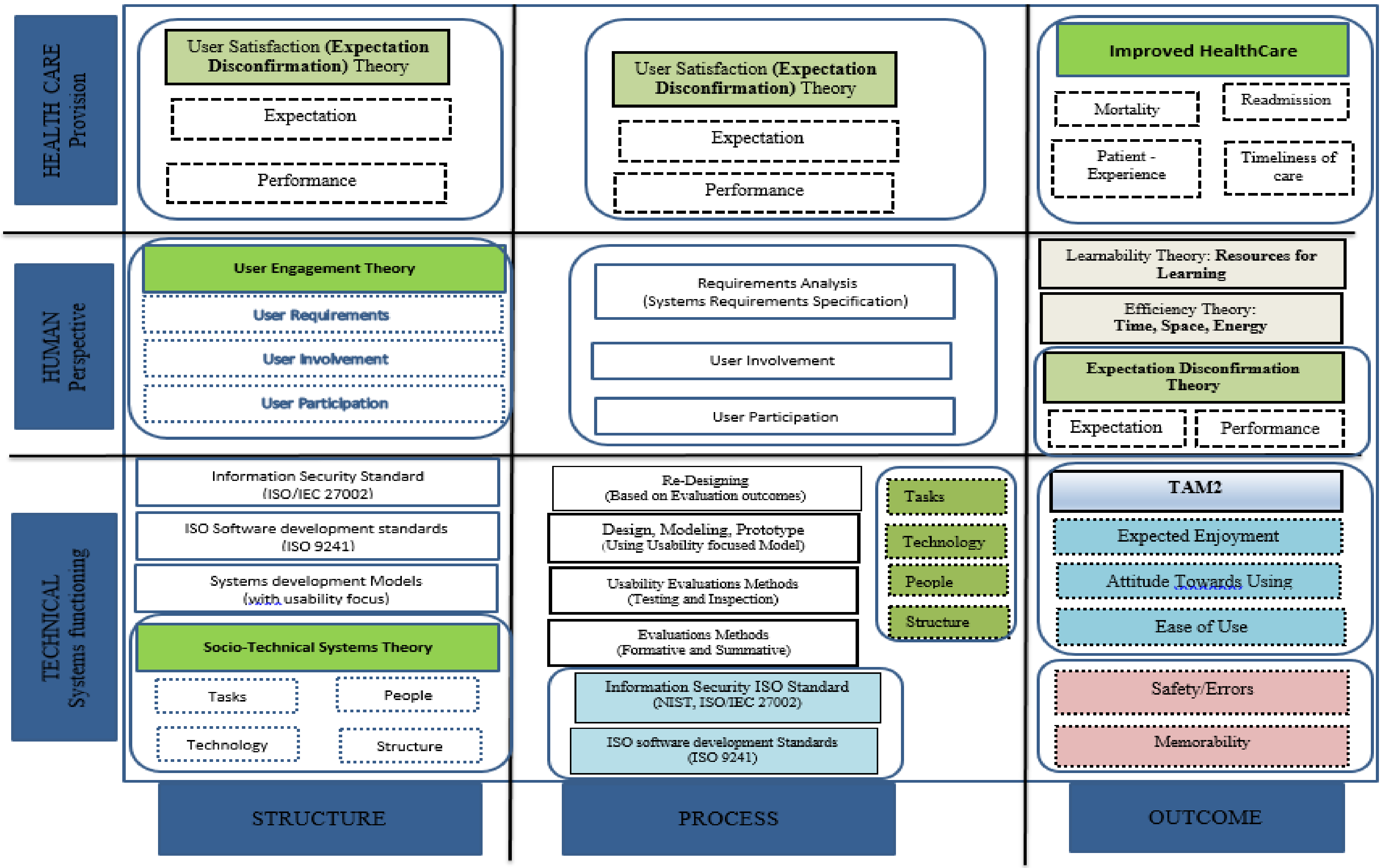

Figure 3. 1 Proposed Integrated Usability Evaluation Framework for the Desifn and Development of the health Information Systems.

3.5Conceptual Framework

The conceptual framework consisted of the independent and dependent variables together with the mediating variables. These were utilised in data collection and analysis of the study questions.

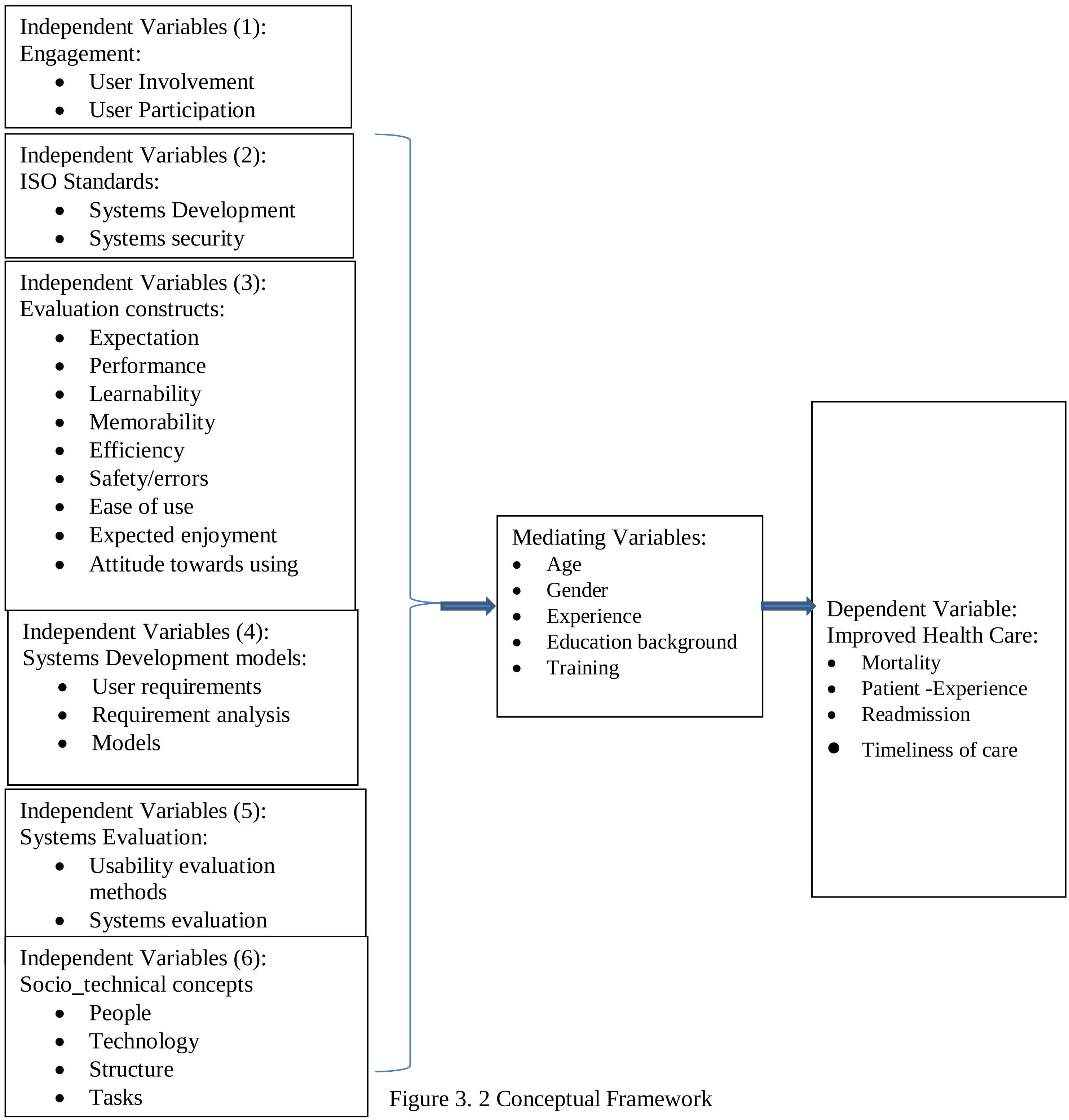

Figure 3. 2 Conceptual Framework

CHAPTER FOUR: METHODOLOGY

4.1 Introduction

This chapter provided the research methodology including the research design, population and sample size and determination, data collection instruments, data analysis and tools, research validity and reliability and ethical considerations. This study was conducted in the western Kenya counties selected health facilities level 4 and 5. The counties are Kisumu, Kakamega, Busia, Vihiga, Bungoma, Homabay, Siaya, and Migori. Assumption was made that the facilities are implementing the health information system under study at point of care.

4.2 Research Design

The aim of this research was to develop an integrated usability evaluation framework for the design and development of health information systems. Mixed Method Research (MMR) research design was used, this is a combination of qualitative and quantitative research methods to gather insightful understanding throughout the steps of User Centered Design of health information systems. The use of MMR can strengthen and enrich research results, as well as achieve a result with strong validity (Johnson R. B., 2007) provided the following definition of MMR:

Qualitative research methods sort to understand social phenomena in a natural context and stems from the field of social sciences. Qualitative research methods led to an in-depth account from individuals and groups using different techniques such as participant observation, interviews, focus groups and case studies. The research materials usually systematically collected and interpreted and includes textual materials. One of the concerns of the scientific community is related to the validation of subjective qualitative material and representativeness of sample size. Triangulation and reflexivity have been suggested to improve the validity of qualitative data.

Quantitative data is usually in numerical form and its analysis made through statistics and mathematical modelling. One of the strengths is the collection of large sample data with validation, verification and hypothesis testing. The outcomes are precise and numerical results. Criticism regarding the method is lack of personal expressions to interpret the meaning of phenomena or behaviour in a qualitative way. Qualitative and quantitative methods are often compared to each other in the validation of research results and they are frequently presented as adversaries in the methodological battle. Kuper et al., (2008) provided a brief explanation of the difference between the methods (Kuper, 2008).

> *"In general, quantitative research focuses on answering the questions "what?","how much?", and "why?", whereas qualitative research focuses on answering the questions "why?" and "how?"* (Kuper, 2008)

Mixed Methods Research (MMR) is often called *the third methodological movement* and applies the qualitative and quantitative approaches in conjunction with one another.

> *"Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purpose of breadth and depth of understanding and corroboration."* (Johnson R. B., 2007)

4.3 Population Size

The target population for this study comprised of selected systems users ie health practitioners, systems development team and selected patients. The systems users are the people who on a daily basis routinely use the system to offer patient care while the systems development team are the people contracted by health facilities and the ministry of health to design and develop health information systems. The total number of facilities targeted was 99 (both level 4 &5) with a total health care population of 8000. Each facility had different catchment of patient volumes; this also formed part of the sample. The two large national software organizations systems developers were selected. Assumption was that they are a representation of all the health facilities in the study counties.

4.4 Sample size

The study involved systems users, ie the health care workers (medical officers, laboratory staffs, clinicians, nurses, record staffs, etc) working in the selected hospitals, hospital patients and software developers. Health care workers respondents were selected from the level 4 and 5 health facilities in western Kenya eight counties ie Kisumu, Kakamega, Busia, Vihiga, Bungoma, Homabay, Siaya, and Migori. Two systems developers from each of the two large national software organization were selected. Five hospital patients were randomly selected from each hospital. The sample size shall comprise of 152 respondents. Each county had 15 participants split into 8 from level 5 facility and 7 coming from level 4 facilities. The sample was selected according to Gay (1992) who recommends 10% of the accessible population in a descriptive study.

4.5 Sampling Technique

This study employed simple random sampling, systematic and purposive sampling. Simple random sampling is a method of sampling which involves giving a number in a container and then picking any number at random, (Mugenda, 2003) it was used because it ensures each member of the target population have gotten an equal and independent chance of being included in the sample (Oso & Onen, 2005). Purposive sampling was used to select the health care workers i.e medical officers, clinicians, nurses, records staffs who interact with the system on a day today basis, and the patients who get service using the system. Purposive will also be used to select the focus group for qualitative data collection.

Purposive sampling was used for the qualitative component of the research. It is a biased type of sampling that allows a researcher to use cases that have the required information with respect to the objectives of his/her study. This method was used because it allows for selection of typical and useful cases only and thus saves time and money. It entails sampling with a purpose in mind, usually one or more specific predefined group one is seeking a sampling method in which elements are chosen based on purpose of the study. Purposive sampling does not produce a sample that is representative of a larger population. It's a sample which is selected by the researcher subjectively. It is also called judgment sampling. Purposive sampling is the most popular in qualitative research and subjects are selected because of some characteristic. Areas/Instances of application of the technique. This sampling technique can be applied in several situations. The main examples are:

- Validation of a test or instrument with a known population
- Collection of exploratory data from an unusual population (When the population for study is highly unique e.g. Parents of children with Tay Sack's disease).
- Use in qualitative studies to study the lived experience of a specific population.
- Intended to counteract the potential biases in convenience sampling

- When the desired population for the study is rare or very difficult to locate and recruit for a study, purposive sampling may be the only option.
- Where it is particularly important to explore the range of different potential impacts e.g. ensuring that the quota for women includes a selection of single women, very old women, and a literate woman and so on.

Advantages

1. Easy to undertake
2. It is sometimes possible to carry it through where randomization is not feasible.
3. Very useful for situations where you need to reach a targeted sample quickly and where sampling for proportionality is not the primary concern.
4. Cheaper.
5. Used when sampling frame is not available.
6. Useful when population is so widely dispersed that cluster sampling would not be efficient.
7. Often used in exploratory studies, e.g. for hypothesis generation.

Disadvantages

1. Results can be useless.
2. Difficulty in determining how much of the effect (dependent variable) results from the cause (independent variable).
3. Potential for bias/inaccuracy in the researcher's criteria and resulting sample selections
4. Unable to generalize.

Slovin's formula was used to calculate the sample size per county. The formula is used to calculate the sample size (n) given the population size (N) and a margin of error (e).

It is computed as

$n = N / (1+Ne^2)$. (*Slovin's formula*)

whereas:

n = no. of samples

N = total population

e = error margin / margin of error

The error margin was 0.40.

4.6 Data collection Instruments

This study utilized a questionnaire and focus group discussion as a tool for data collection. The questionnaire contained four sections containing structured and unstructured questions which involved use of closed and open-ended questions. Section A captured questions on demographic characteristics of respondents; Section B had questions on rating of the current HIS product the respondents are using in the health facilities. These rated ease of use, ease of learning, user satisfaction measurement, user participation during the systems definition phase of the development life cycle, user participation during the physical design phase, user participation during the systems implementation phase and user involvement during the systems development processes. Section D captured questions on improvement of healthcare, as a validation of the developed integrated usability framework outcomes, mortality and re-admission measurements also as a validation of the developed integrated usability framework outcome, and feedback on the use of the developed usability evaluation framework. For closed-ended questions, a seven-point Likert scale were used with meanings as shown: (1) Strongly Agree (SA), (2) Agree (A), (3) Somewhat Agree (SA) (4) Neither Agree nor Disagree (NA/D) and (5) Strongly Disagree (SD) (6) Disagree (D) (7) Strongly Disagree. The strongly disagreed responses were scored at 7 for direct positive responses while those of strongly agreed responses were scored at 1.

To measure user satisfaction levels on the information systems during the development stages a Usefulness, Satisfaction, and Ease of use (USE) Questionnaire developed by Lund et al 1986 was used with modifications. Purdue Usability Testing Questionnaire by Lin, 1997 was used with modifications. Regarding user participation using the information systems development stages, tools derived from (Barki & Hartwick, 1994)were used to measure these constructs. For user involvement the study used the categorization provided by (Manuel, Pastor, & Casanovas, 2003) ie user process involvement and user systems involvement to derive the questions to be administered.

User involvement refers to a belief to the extent to which a user believes that a new system is both important and personally relevant (Barki & Hartwick, 1994). Similarly defined by Manuel, Pastor and Casonovas, 2003 as refers to the psychological identification of users with the process of IS development (i.e. their subjective attitude toward the IS development task). While user system involvement refers to the psychological identification of users with respect to the IS itself (i.e. their subjective attitude toward the product of development (Manuel, Pastor, & Casanovas, 2003). All of these tools were developed in google forms and administered online. During validation specific to improved healthcare measurement, the Patient Satisfaction Questionnaire (PSQ-18) which is a short form version of the original PSQ developed by Ware, Snyder, and Wright, 1976 was modified and used. The PSQ sub-scales show acceptable internal consistency reliability.

For the qualitative data collection instrument, a focus group discussion was conducted with the support group comprising of 5 health care workers from each facility selected. The support group comprised of only one person per cadre ie Medical officers, Clinicians, Nurses, Laboratory officers and Record and Information officers.

4.7 Data Collection Method

A questionnaire was used to collect data for this study. The questionnaire wasbe divided into three sections. Section A focusing on respondents' demographics and basic characteristics. Section B; measured user satisfaction constructs and section C; measured user engagement constructs. User satisfaction constructs measured items such as ease of use, learnability, satisfaction, memorability, safety/errors, and efficiency while user engagement constructs measured items such as user participation and involvement in the information systems development process. Qualitative data was collected through focus group discussions. Focus group discussion was used to assess user need for engagement during design and development of HIS.

4.8 Data Analysis

Ordinal logistics regression model was used in analyzing quantitative data. Ordinal logistic regression is a statistical analysis method that can be used to model the relationship between an ordinal response variable and one or more explanatory variables. An ordinal variable is a categorical variable for which there is a clear ordering of the category levels.

For qualitative data thematic analysis was done using spreadsheet. Responses were categorised into themes and analysed through Microsoft excel. Thematic analysis is a method for analyzing qualitative data that entails searching across a data set to identify, analyze, and report repeated patterns (Braun & Clarke, 2006). It is a method for describing data, but it also involves interpretation in the processes of selecting codes and constructing themes. A distinguishing feature of thematic analysis is its flexibility to be used within a wide range of theoretical and epistemological frameworks, and to be applied to a wide range of study questions, designs, and sample sizes (Kiger & Varpio, 2020). Results were presented in tables, figures and narrations

4.9 Pilot Testing

The questionnaire was pre-tested first to make appropriate modifications before embarking on the main study. This was carried out two weeks prior to the main study. Pilot testing entailed picking 10 respondents and administering the questionnaire to them to help determine its mechanics and point out any problems with test instructions, instances where items are not clear, help format the questionnaire and remove any noted typographical errors or inconsistencies (OM Mugenda & Mugenda, 2003). During piloting, the study familiarized itself with the respondents. Due diligence was taken to ensure that the questions asked in the questionnaires were not too lengthy or so worded that would make respondents unable to follow them. Information from the pilot study was cross checked to establish deficiencies. Corrections and modifications were therefore undertaken to correct any anomalies noted on the instrument before it was administered.

4.10 Validity of Research Instrument

Validity examines whether the mean of measure is accurate and whether they are actually measuring what they intended to measure (Golafshani, 2003). Also, Validity is the accuracy and meaning of inferences which are based on the research results (Price, 2013). Validity of the research instruments was determined through content and construct validity. Content related validity is ideal for this study since it is consistent with the objectives of the study. 30 Kothari (2002) argued that constructs are abstractions that are deliberately created by researchers in order to conceptualize the latent variable, which is the cause of scores on a given measure. Research supervisor from School of Informatics and Innovative Systems scrutinized and checked whether research questionnaire measured what they are supposed to measure. Amendments done by research supervisor on the research instrument were made prior to field study.

4.11 Reliability of Research Instrument

To measure the reliability coefficient of the research instrument, Cronbach"s Alpha reliability coefficient was obtained for all the variables in the study. Cronbach"s alpha coefficient is like probability and therefore ranges between zero and one. A coefficient of zero implies that the instrument had no internal consistency while that of one implied a complete internal consistency. Donald and Delno (2006), Creswell (1994) indicated that a reliable research instrument should have a composite Cronbach Alpha Reliability coefficient of at least 0.7 for all items under study.

If the composite reliability coefficient is less than 0.7, then the instrument will have to be revised before administration. Larry (2013) observed that Cronbach coefficient is used to test internal consistencies of samples of a given population with research instruments having Likert scales with multiple responses. Cronbach Alpha coefficient has been viewed by scholars as an improvement of Kuder-Richardson Formula 20 (KR-20) which is an equivalent measure of dichotomous test items. The study obtained a reliability index of 0.723 for the research questionnaire making it to be reliable. For qualitative component, the study examined the process and the product for consistency. This was achieved by verifying the steps of the research through items as raw data, data reduction products, and process notes.

4.12 Ethical considerations

To ensure high ethical values and response rates, the respondents were first requested for their consent and voluntary participation, respondents were not required to give their names or any form of identification. All the respondents were assured of total confidentiality and that the information they give was used for research purposes only. There were no personality-based questions which could cause discomfort or anxiety to respondents. There were no direct benefits or inducements to the participants. Respondents who participated were thanked for their time and participation.

The study strictly adhered to the National Council for Science, Technology and Innovation (NACOSTI) conventions and guidelines. Permit was procured from the relevant authorities in order to conduct the research in the identified area. Authorization was sought from Jaramogi Oginga Odinga University of Science and Technology (JOOUST) in line with the University's post graduate guidelines

4.13 Summary

Mixed method research design was used for the study, data collection was done using questionnaires and focus group discussions, ordinal logistic regression and thematic analysis were utilised to arrive at the results. Assumption was made that the facilities are implementing the health information system under study at point of care.

CHAPTER FIVE: DATA ANALYSIS

5.1 Introduction

This chapter presents results from the data analysis, both from the quantitative and qualitative tools including reliability and validity of data collection instruments measurements. The results were presented in table, charts and also narrative especially from the focus group discussions. At the end the chapter provide a summary to establish whether the objectives of the study were achieved or not.

5.2 Demographics

5.2.1 Distribution of respondents by age groups

One hundred and fifty-two (152) respondents were interviewed, spread across the targets 8 western Kenya counties of Kisumu Siaya, Kakamega, Vihiga, Bungoma, Busia, Homabay and Migori. 69.7% of them were aged 26 and 35 years old, 27.6% were between 36 and 45 years old while only 2.6% were 25years and below. The age categorization was based on youths, young adults and adults.

Table 5. 1 Distribution of respondents by age groups

County	**Less than 26 years Old**	**Between 26 and 35 years Old**	**Between 36 and 45 years Old**	**Total**
Kisumu	0	15	4	19
Kakamega	0	16	3	19
Vihiga	0	6	13	19
Busia	3	16	0	19
Bungoma	0	13	6	19
Homabay	0	15	4	19
Migori	1	13	5	19
Siaya	0	12	7	19
Total	**4(2.6%)**	**106(69.7%)**	**42(27.6%)**	**152(100%)**

5.2.2 Distribution of respondents by department

More than a third of the participants worked at the outpatient department, 22% of them were working at the casualty, 20% if them at the clinic finance while only 7% of them worked at the child welfare clinic.

Table 5. 2 Distribution of respondents' departments

Department	**Frequency**	**Percent**
OPD	57	38
Casualty	33	22
IPD	21	14
Child welfare	10	7
Clinic finance	31	20
total	152	100

5.2.3 Distribution of respondents by Length of Service

About 41% of the respondents have between 5 to 9.9 years of services, 29% of them had between 2-4.9 years of service, 23% have less than 2 years of service while only 7.2 of the respondents has over 10 years of service.

Table 5. 3 Distribution of respondents by Length of Service

Length of Service	**Frequency**	**Percent**
Over 10yrs	11	7.2
Between 5-9.9yrs	62	40.8
Between 2-4.9yrs	44	28.9
Less than 2yrs	35	23.0
Total	152	100.0

5.2.4 Distribution of respondents by Education Level

More than half of the respondents had college diploma education level, 24% of them had university degree while 9.9% had certificate education level.

Table 5. 4 Distribution of respondents by Education level

Education Level	**Frequency**	**Percent**
College Certificate	15	9.9
College Diploma	101	66.4
University degree	36	23.7
Total	152	100.0

5.2.5 Distribution of respondents by Designation

Majority (58.6%) of the respondents were health records and information officers, 18.4% of them were clinical officers, 21.1% were nurses and 2% of them were financial officers.

Table 5. 5 Distribution of respondents by Designation

Designation	**Frequency**	**Percent**
Nurse	32	21.1
Clinical Officer	28	18.4
Financial Officer	3	2.0
Health Records Information Officer	89	58.6
Total	152	100.0

5.2.6 Respondents Training on the current health information (FANSOFT) in use in the facility

Most of the respondents (87.5%) had been trained in the current health information system in use in their respective facilities. Only 12.5% had not been trained on the current health information system in use in their respective facilities.

Table 5. 6 Training on Health Information System in use

Have you been trained on FANSOFT (the current health information in use in this facility)	**Frequency**	**Percent**

Yes	133	87.5
No	19	12.5
Total	152	100.0

5.2.7 Respondents Training on the current health information in use in the facility and length of service.

Results show that respondents who had served in the facilities for between 5-9.9 years old had many of them trained that the others, followed by those who had served for 2 years and below in the facilities and those between 2-4.9 years of service.

Table 5. 7 Training on Health Information System in use and duration of service in the facility

	Trained in HIS		
Length of Service	**Yes**	**No**	
10yrs and above	4(36.4%)	7(63.6%)	11(100%)
Between 5-9.9yrs	62(100%)	0(0%)	62(100%)
Between 2-4.9yrs	32(72.7%)	12(27.3%)	44(100%)
2 years and below	35(100%)	0(0%)	35(100%)
	133(87.5%	19(12.5%)	152(100%)

5.2.8 Respondents distribution by sex

Slightly more than half of the respondents were males while 48% of them were females.

Table 5. 8 Distribution of Gender

Sex	**Frequency**	**Percent**
Male	79	52.0
Female	73	48.0
Total	152	100.0

5.3 To investigate user involvement and satisfaction levels in health information systems during the design and development phase

5.3.1 User Participation - Physical Design Phase

Only about a quarter of the respondents (health providers) had main responsibility for the development project during physical design, while 85.5% of them did not have a main responsibility for the development project during physical design. Equal respondents agreed and disagreed that the Information systems/data processing staff drew up a formalized agreement of the work to be done during system physical design. Twenty five percent of the respondents were able to make changes to the formalized agreement of work to be done during system physical design while 75% of them were not able to make changes to the formalized agreement of work to be done during system physical design. Close to half of the respondents said that the information systems/data processing staff kept me informed concerning progress and/or problems during system physical design, while 52% of them were not kept me informed concerning progress and/or problems during system physical design by the information systems/data processing staff. About thirty eight percent of the respondents did formally review the work done by information system/data processing staff during system physical design, while 61.8% did not review the work done by information system/data processing staff during system physical design.

Only 25.7% of the respondents formally approved work done by information system/data processing staff during system physical design, while 74.3 did not respondents formally approved work done by information system/data processing staff during system physical design. 25% of the respondents signed off a formalized agreement of the work by the information systems/data processing staff during system physical design while 75% of them did not sign off a formalized agreement of the work by the information systems/data processing staff during system physical design. Below 35% of the respondents helped define input/output forms, screen layouts, report formats, development systems controls, and security procedures for the health information systems. Thirty five percent of the respondents evaluated systems controls and /or security procedures developed by information systems/data processing, while 64.5% of them did not evaluate systems controls and /or security procedures developed by information systems/data processing. Only 25.7% of the respondents approved systems controls and /or security procedures developed by information systems/data processing, while 71.7% of them approved systems controls and /or security procedures developed by information systems/data processing. Forty-one per cent of the respondents agreed that the information systems/data processing staff developed a prototype of the new system for me, while about 60% of them did not agree that the information systems/data processing staff developed a prototype of the new system for them. Only 27.6% of the respondents agreed that the information systems/data processing staff presented a detailed walk-through of the system procedures and processes for them, 72.4% of them did not agree that the information systems/data processing staff presented a detailed walk-through of the system procedures and processes for them.

Table 5. 9 User Participation – Physical Design Phase

Question	**Yes**	**No**
I had main responsibility for the development project during physical design	22(14.5%)	130(85.5%)
Information systems/data processing staff drew up a formalised agreement of the work to be done during system physical design	74(48.7%)	74(48.7%)
I was able to make changes to the formalized agreement of work to be done during system physical design	38(25%)	114(75%)
The information systems/data processing staff kept me informed concerning progress and/or problems during system physical design	73(48%)	79(52%)
I formally reviewed work done by information system/data processing staff during system physical design	58(38.2%)	94(61.8%)
I formally approved work done by information system/data processing staff during system physical design	39)25.7%)	113(74.3%)
I signed off a formalised agreement of the work by the information systems/data processing staff during system physical design	38(25%)	114(75%)
For this system, I defined/helped define input/output forms	42(27.6%)	110(72.4%)
For this system, I defined/helped define screen layouts	34(22.4%)	118(77.6%)
For this system, I defined/helped define report formats	54(35.5%)	98(64.5%)
I developed system controls and/or security procedures for this system	34(22.4%)	118(77.6)

I evaluated systems controls and /or security procedures developed by information systems/data processing	54(35.5%)	98(64.5%)
I approved systems controls and /or security procedures developed by information systems/data processing	39(25.7%)	109(71.7%)
The information systems/data processing staff developed a prototype of the new system for me	62(40.8%)	90(59.2%)
The information systems/data processing staff presented a detailed walk-through of the system procedures and processes for me	42(27.6%)	110(72.4%)

5.3.2 User Participation - Implementation Phase

Slightly more than a quarter of the respondents had a main responsibility for the development project during implementation, while 72.4% of them did not have a main responsibility for the development project during implementation. 61.2% agreed that the Information systems/data processing staff drew up a formalised agreement of the work to be done during system implementation, while 38.8% of them did not agree. Slightly over a quarter of the respondents were able to make changes to the formalised agreement of work to be done during system implementation, while 80.3% of them were not able to make changes to the formalised agreement of work to be done during system implementation. Close of 50% of the respondents agreed that the information systems/data processing staff kept them informed concerning progress and/or problems during implementation, while 51.3% of them did not agree that the information systems/data processing staff kept them informed concerning progress and/or problems during implementation. Also close to 50% of the respondents formally reviewed work done by information system/data processing staff during implementation, while 51.3 of them did not formally review the work done by information system/data processing staff during implementation.

About a third of the respondents formally approved work done by information system/data processing staff during implementation, while 69.7% of them did not formally approve work done by information system/data processing staff during implementation. Again, about a third of the respondents signed off a formalized agreement of the work by the information systems/data processing staff during implementation while 64.5% of them did not sign off a formalized agreement of the work by the information systems/data processing staff during implementation. 36.2% of the respondents was involved in the development of test data specifications for this system, while 63.8% of them were not involved in the development of test data specifications for this system. 41.4% of the respondents reviewed the results of system tests done by the information systems/data processing staff, while 58.6% did not review the results of system tests done by the information systems/data processing staff. Slightly over a third of the respondents approved the results of system tests done by the information systems/data processing staff, while 63.8% of them did not approve the results of system tests done by the information systems/data processing staff. Sixty-five per cent of the respondents agreed that the information systems/data processing staff held a 'special event' to introduce the system to them while 34.9% of them did not agree that the information systems/data processing staff held a 'special event' to introduce the system to them. More than a third of the respondents were trained in the use of the systems and were able to train other users on the use of the systems. Only 15.1% of the respondents designed the user-training program for this system, while 84.9% of them did not design the user-training program for this system, 20.4% of the respondents created the user procedures manual for this system, while 79.6% of them did not create the user procedures manual for this system

Table 5. 10 User Participation-Implementation Phase

Question	**Yes**	**No**
I had main responsibility for the development project during implementation	42(27.6%)	110(72.4%)
Information systems/data processing staff drew up a formalised agreement of the work to be done during system implementation	93(61.2%)	59(38.8%)
I was able to make changes to the formalised agreement of work to be done during system implementation	30(19.7%)	122(80.3%)
The information systems/data processing staff kept me informed concerning progress and/or problems during implementation	74(48.7%)	78(51.3%)
I formally reviewed work done by information system/data processing staff during implementation	74(48.7%)	78(51.3%)
I formally approved work done by information system/data processing staff during implementation	46(30.3%)	106(69.7%)

I signed off a formalized agreement of the work by the information systems/data processing staff during implementation	46(30.3%)	98(64.5%)
I developed test data specifications for this system	55(36.2%)	97(63.8%)
I reviewed the results of system tests done by the information systems/data processing staff	63(41.4%)	89(58.6%)
I approved the results of system tests done by the information systems/data processing staff	55(36.2%)	97(63.8%)
The information systems/data processing staff held a 'special event' to introduce the system to me	99(65.1%)	53(34.9%)
I was trained in the use of this system	126(82.9%)	26(17.1%)
I designed the user training program for this system	23(15.1%)	129(84.9%)
I trained other users to use this system	106(69.7%)	46(30.3%)
I created the user procedures manual for this system	31(20.4%)	121(79.6%)

5.3.3 User Involvement and Satisfaction Measurement

This was measured by running ordinal regression model. The dependent variable was the transformed 7-point Likert scale response from user involvement and satisfaction measurement while the independent variables were all the user participation during the design and development phase and user participation in the implementation phase. The null hypothesis was that the user participation in both the design, development and implementation phases of health information systems does not influence the user involvement and satisfaction levels. The model fitting information results shows that there is a significant improvement in fit of the final model over the null model [$\chi 2$ (30)=280.571, p<.001]. Further showing that the model fits the data very well.

Table 5. 11 Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	673.146			
Final	392.575	280.571	30	.000

5.3.3.1 Parameter Estimates Testing

Ordinal regression was run with the user involvement and satisfaction measure as the dependent variable and the user participation during the design and development of the health information systems as the independent variables. In interpreting the parameter estimates, the following independent variables had positive estimates. These include the following questions; Information systems/data processing staff drew up a formalised agreement of the work to be done during system physical design (Coeff=74.799),

The information systems/data processing staff kept me informed concerning progress and/or problems during system physical design (Coeff=86.022), I formally reviewed work done by information system/data processing staff during system physical design (Coeff=124.956), For this system, I defined/helped define input/output forms (Coeff=398.075), I evaluated systems controls and /or security procedures developed by information systems/data processing (Coeff=193.119), I approved systems controls and /or security procedures developed by information systems/data processing (Coeff=107.314), The information systems/data processing staff presented a detailed walk-through of the system procedures and processes for me (Coeff=18.917), I had main responsibility for the development project during implementation (195.711), The information systems/data processing staff kept me informed concerning progress and/or problems during implementation (Coeff=89.399), I formally approved work done by information system/data processing staff during implementation (Coeff=45.217), I approved the results of system tests done by the information systems/data processing staff, and I trained other users to use this system (Coeff=62.535), I designed the user training program for this system (Coeff=161.238), and I trained other users to use this system (Coeff=76.597).

This indicates that for every one unit increase in independent variable there is a predicted increase (of a certain amount) in the log odds falling at a higher level of the dependent variable. Generally showing that as scores increase on the independent variables, there is an increase probability falling at a higher level on the dependent variable.

The following variable questions had negative estimates; I had main responsibility for the development project during physical design (Coeff=-10.072), I was able to make changes to the formlised agreement of work to be done during system physical design (Coeff=-143.392), I formally approved work done by information system/data processing staff during system physical design (Coeff=-135.923), I signed off a formalised agreement of the work by the information systems/data processing staff during system physical design

(Coeff=-101.647), For this system, I defined/helped define screen layouts (Coeff=-105.379), For this system, I defined/helped define report formats(Coeff=-97.335), I developed system controls and/or security procedures for this system(Coeff=-247.148), The information systems/data processing staff developed a prototype of the new system for me(Coeff=-10.710), Information systems/data processing staff drew up a formalised agreement of the work to be done during system implementation (Coeff=-88.224), I was able to make changes to the formalised agreement of work to be done during system implementation (Coeff=-85.384), I formally reviewed work done by information system/data processing staff during implementation(Coeff=-7.716), I signed off a formalized agreement of the work by the information systems/data processing staff during implementation (Coeff=-96.873), I developed test data specifications for this system (Coeff=-232.323), I reviewed the results of system tests done by the information systems/data processing staff (Coeff=-4.759), The information systems/data processing staff held a 'special event' to introduce the system to me(Coeff=-8.239), and I was trained in the use of this system(Coeff=-75.959).

This indicates that for every one unit increase on an independent variable there is a predicted decrease (of a certain amount) in the log odds of falling at a higher level of the dependent variable. In general, as the scores increase on the independent variables, there is a decreased probability of falling at a higher level on the dependent variable.

Table 5. 12 Parameter estimates: User involvement and satisfaction measurement parameter testing

Parameters User involvement		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[UImeas = 1.17]	-24.816	2.976	69.512	1	.000	-30.650	-18.982
	[UImeas = 1.64]	-23.269	2.923	63.370	1	.000	-28.998	-17.540
	[UImeas = 1.71]	-19.322	2.751	49.338	1	.000	-24.713	-13.930
	[UImeas = 1.79]	-17.559	2.580	46.313	1	.000	-22.616	-12.502

Location	[UImeas = 2.00]	-15.312	2.387	41.165	1	.000	-19.989	-10.634
	[UImeas = 2.07]	-12.755	2.193	33.837	1	.000	-17.053	-8.458
	[UImeas = 2.14]	-11.427	2.127	28.866	1	.000	-15.596	-7.259
	[UImeas = 2.21]	-11.019	2.116	27.108	1	.000	-15.167	-6.871
	[UImeas = 2.29]	-10.611	2.109	25.301	1	.000	-14.745	-6.476
	[UImeas = 2.36]	-9.533	2.106	20.489	1	.000	-13.661	-5.405
	[UImeas = 2.43]	-9.125	2.110	18.702	1	.000	-13.261	-4.989
	[UImeas = 2.50]	-8.318	2.127	15.299	1	.000	-12.486	-4.150
	[UImeas = 2.64]	-7.603	2.151	12.494	1	.000	-11.819	-3.387
	[UImeas = 3.00]	-6.640	2.197	9.137	1	.003	-10.946	-2.335
	[UImeas = 3.71]	-5.678	2.259	6.319	1	.012	-10.105	-1.251
	[UImeas = 5.00]	8.248	484.238	.000	1	.986	-940.842	957.338
	[UPD40=0]	-10.072	1.913	27.724	1	.000	-13.821	-6.323
	[UPD40=1]	0[a]	.	.	0	.	.	.
	[UPD41=0]	74.799	2.478	911.411	1	.000	69.943	79.655
	[UPD41=1]	0[a]	.	.	0	.	.	.
	[UPD42=0]	-143.292	5.257	742.988	1	.000	-153.596	-132.989
	[UPD42=1]	0[a]	.	.	0	.	.	.
	[UPD43=0]	86.022	2.060	1743.568	1	.000	81.984	90.060
	[UPD43=1]	0[a]	.	.	0	.	.	.
	[UPD44=0]	124.956	3.624	1188.662	1	.000	117.853	132.060
	[UPD44=1]	0[a]	.	.	0	.	.	.
	[UPD45=0]	-135.923	6.924	385.357	1	.000	-149.494	-122.352
	[UPD45=1]	0[a]	.	.	0	.	.	.
	[UPD46=0]	-101.647	5.113	395.219	1	.000	-111.668	-91.626

[UPD46=1]	0[a]	.	.	0	.	.	.
[UPD47=0]	398.075	21.115	355.424	1	.000	356.690	439.460
[UPD47=1]	0[a]	.	.	0	.	.	.
[UPD48=0]	-105.379	9.741	117.041	1	.000	-124.471	-86.288
[UPD48=1]	0[a]	.	.	0	.	.	.
[UPD49=0]	-97.335	4.496	468.644	1	.000	-106.148	-88.523
[UPD49=1]	0[a]	.	.	0	.	.	.
[UPD50=0]	-247.148	7.645	1045.002	1	.000	-262.132	-232.163
[UPD50=1]	0[a]	.	.	0	.	.	.
[UPD51=0]	193.119	6.560	866.739	1	.000	180.262	205.975
[UPD51=1]	0[a]	.	.	0	.	.	.
[UPD52=0]	107.314	5.010	458.810	1	.000	97.494	117.133
[UPD52=1]	-10.710	2.160	24.582	1	.000	-14.944	-6.476
[UPD52=11]	0[a]	.	.	0	.	.	.
[UPD53=0]	-88.224	5.033	307.248	1	.000	-98.089	-78.359
[UPD53=1]	0[a]	.	.	0	.	.	.
[UPD54=0]	18.917	4.590	16.989	1	.000	9.922	27.913
[UPD54=1]	0[a]	.	.	0	.	.	.
[UPI55=0]	195.711	7.228	733.193	1	.000	181.545	209.877
[UPI55=1]	0[a]	.	.	0	.	.	.
[UPI56=0]	-85.384	2.333	1339.307	1	.000	-89.957	-80.811
[UPI56=1]	0[a]	.	.	0	.	.	.
[UPI57=0]	-7.716	4.683	2.715	1	.099	-16.894	1.462
[UPI57=1]	0[a]	.	.	0	.	.	.
[UPI58=0]	89.399	2.888	958.333	1	.000	83.739	95.059
[UPI58=1]	0[a]	.	.	0	.	.	.
[UPI59=0]	-95.873	2.997	1023.219	1	.000	-101.747	-89.999
[UPI59=1]	0[a]	.	.	0	.	.	.
[UPI60=0]	45.217	5.581	65.635	1	.000	34.278	56.156
[UPI60=1]	0[a]	.	.	0	.	.	.
[UPI61=0]	-232.719	12.445	349.686	1	.000	-257.111	-208.328
[UPI61=1]	0[a]	.	.	0	.	.	.
[UPI62=0]	-233.323	5.997	1513.941	1	.000	-245.076	-221.570
[UPI62=1]	0[a]	.	.	0	.	.	.
[UPI63=0]	-8.239	1.992	17.103	1	.000	-12.144	-4.334

[UPI63=1]	0[a]	.	.	0	.	.	.
[UPI64=0]	62.535	6.960	80.725	1	.000	48.894	76.177
[UPI64=1]	0[a]	.	.	0	.	.	.
[UPI65=0]	-4.749	1.248	14.476	1	.000	-7.195	-2.303
[UPI65=1]	0[a]	.	.	0	.	.	.
[UPI66=0]	-75.959	.991	5871.074	1	.000	-77.902	-74.016
[UPI66=1]	0[a]	.	.	0	.	.	.
[UPI67=0]	161.238	2.917	3056.270	1	.000	155.522	166.955
[UPI67=1]	0[a]	.	.	0	.	.	.
[UPI68=0]	76.597	.000	.	1	.	76.597	76.597
[UPI68=1]	0[a]	.	.	0	.	.	.
[UPI69=0]	0[a]	.	.	0	.	.	.
[UPI69=1]	0[a]	.	.	0	.	.	.

5.3.3.2 Test of Parallel Lines

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories. The results of the test of Parallel lines (ie assumption of proportional odds) indicate non-significant 0.976, showing the assumption is satisfied. This means that all the independent variables are associated with the dependent variable.

Table 5. 13 Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	392.575			
General	.000[b]	392.575	450	.976

5.4 Inclusion of International Organisation For Standards (ISO) in the development of the current health information system (FANSOFT)

Slightly over ninety percent of the respondents agreed that the information systems design and development considers using the appropriate ISO standards. Close to three quarters of the respondents denied that they had a main responsibility for the development project during the systems definition while 30.9% agreed that they had a main responsibility for the development project during the systems. Over fifty percent of the respondents agreed that the Information systems/data processing staff drew up a formalised agreement of the work to be done during system definition, while 43.4% of them did not agree that the Information systems/data processing staff drew up a formalised agreement of the work to be done during system definition. 75% of the respondents were able to make changes to the formalised agreement of work to be done during system definition, while 25% of them were not were able to make changes to the formalised agreement of work to be done during system definition.

Slightly more half of the respondents said that the information systems/data processing staff kept me informed concerning progress and/or problems during system definition, while 46.1% of the were not kept informed concerning progress and/or problems during system definition. 56.6% of the respondents agreed to formally reviewed work done by information system/data processing staff during system definition while 43.4 did not agree to having formally reviewed work done by information system/data processing staff during system definition. Close to three quarters percent of the responded did not sign off a formalised agreement of the work by the information systems/data processing staff during system definition while only 36.2% of them agreed to have signed off a formalised agreement of the work by the information systems/data processing staff during system definition. Three quarters of the respondents were never interviewed by the information systems/data processing staff during the system definition phase with only a quarter of them interviewed by the information systems/data processing staff during the system definition phase. Of the respondents interviewed more than half responded to questionnaires administered by the information system/data processing staff during the system definition phase while 45.4% did not respond to the questionnaires administered by the information system/data processing staff during the system definition phase.

Only 17.1% of the respondents were involved in the development of the information requirement analysis (ie the analysis of user needs) for this system, while 80.3% of them were not involved in the development of the information requirement analysis(ie the analysis of user needs) for this system. Less than half of the respondents did evaluated an information requirement analysis developed by information systems/data processing, while 53.9% of them did not evaluated an information requirement analysis developed by information systems/data processing. About a third of the respondents approved an information requirement analysis developed by the information systems/data processing staff while three quarters did not approve an information requirement analysis developed by the information systems/data processing staff. Only 19.7% of the respondents were involved in the development of a cost/benefit analysis for this system, 80.3% were not involved in the development of a cost/benefit analysis for this system. Twenty-three per cent of the respondents evaluated a cost benefit analysis developed by the information system/data processing staff while 77% of them did not evaluate a cost benefit analysis developed by the information system/data processing staff.

Table 5. 14 Inclusion of International Organisation for Standards (ISO) in the development of the current health information system (FANSOFT)

Question	**Yes**	**No**
Does this information systems design and development considers using the appropriate ISO standards	137(90.1%)	15(9.9%)
I had main responsibility for the development project during system definition	47(30.9%)	105(69.1%)
Information systems/data processing staff drew up a formalised agreement of the work to be done during system definition	86(56.6%)	66(43.4%)
I was able to make changes to the formalized agreement of work to be done during system definition	38(25%)	114(75%)
The information systems/data processing staff kept me informed concerning progress and/or problems during system definition	82(53.9%)	70(46.1%)
I formally reviewed work done by information system/data processing staff during system definition	86(56.6%)	66(43.4%)
I signed off a formalised agreement of the work by the information systems/data processing staff during system definition	55(36.2%)	97(63.8%)
I was interviewed by the information systems/data processing staff during the system definition phase	39(25.7%)	113(74.3%)

I responded to questionnaires administered by the information system/data processing staff during the system definition phase	83(54.6%)	69(45.4%)
I developed the information requirement analysis (ie the analysis of user needs) for this system	26(17.1%)	122(80.3%)
I evaluated an information requirement analysis developed by information systems/data processing	66(43.4%)	82(53.9%)
I approved an information requirement analysis developed by the information systems/data processing staff	46(30.3%)	106(69.7%)
I developed a cost/benefit analysis for this system	30(19.7%)	122(80.3%)
I evaluated a cost benefit analysis developed by the information system/data processing staff	35(23%)	117(77%)

5.5 To validate the developed integrated usability evaluation framework for the design of health information systems.

The developed integrated usability evaluation framework was evaluated by exposing it to the live systems development cycle, it was used to build a software product whether both the developers and the users were provided with an environment to validate the framework. Qualitative data was collected from the teams and analysed using thematic analysis. The results showed that the developed usability evaluation framework was very useful and provided both the developers and end users with perfect opportunity to engage and also participate in the design and development of health information systems. Some of the extracts and direct feedback from the narratives were:

a. …" the developed integrated usability framework is very easy to use and implement"
b. …" the developed integrated usability evaluation framework provided us with the opportunity to consider critical constructs of usability during the design and development of health information systems"

c. ..." we found the developed integrated usability evaluation framework engaging as it provided robust considerations to the approaches for the user and the development team engagement".

d.…” we think the developers should engage the facility staffs more when developing the system”

e. …...” the HIS was components were easy to remember and were safe from errors.

f. Poor capacity building to the field staffs (facility staffs)”

Below are some of the points that the respondents discussed as strengths of the developed usability evaluation framework

a. …”reduces clinical errors ,thus providing support to healthcare professionals “
b. …….”improves patients access to healthcare and patient management“
c. …..”reduces time needed to gather information “
d. …..”Increase use of the system”

5.6 Relationship between the constructs Ease of use, Efficiency, and safety/Errors of the health Information systems and mortality and re-admission to the health facilities

The developed health information system was then implemented in the selected facilities. The health care provision outcome measurement were studies. Mortality and readmission correlation with the ease of use, efficiency and safety/errors of the newly developed health information system. This was tested by running ordinal regression model. The dependent variable the Ease of use, Efficiency, and safety/Errors was the transformed 7-point Likert scale while the independent variables (mortality and re-admission) were all continuous measurement variables. The null hypothesis was that the Ease of use, Efficiency, and safety/Errors of the health information systems does not influence the mortality and re-admission at the same facilities. The model fitting information results shows that there is a significant improvement in fit of the final model over the null model [$\chi2$ (3)=55.881, p<.001]. Further showing that the model fits the data very well. This is also triangulated the goodness-of-fit output p>0.05.

Table 5. 15 Model Fitting information

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	55.881			
Final	.000	55.881	2	.000

Link function: Logit.

Table 5. 16 Goodness of Fit

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	.016	9	1.000
Deviance	.033	9	1.000

Link function: Logit.

5.6.1 Parameter Estimates Testing

The results in the figure below shows that both the independent variables which were morality and re-admission have negative coefficients relative to the dependent variable Ease of use, efficiency, safety/errors of health information systems. This indicates that for every one unit increase on an independent variable(mortality) there is a predicted decrease (of a certain amount) in the log odds of falling at a higher level of the dependent variable (Ease of Use, efficiency, and safety/errors). In general, as the scores increase on the mortality, there is a decreased probability of falling at a higher level on the Ease of Use, efficiency, and safety/errors (Coeff = -3.876). This implies ease of use, efficiency, safety/errors of health information systems reduces the number of mortalities in the health facilities. This indicates that for every one unit increase on an independent variable(re-admission) there is a predicted decrease (of a certain amount) in the log odds of falling at a higher level of the dependent variable(Ease of Use, efficiency, and safety/errors). In general, as the scores increase on the re-admission, there is a decreased probability of falling at a higher level on the Ease of Use, efficiency, and safety/errors (Coeff = -.017). This implies ease of use, efficiency, safety/errors of health information systems reduce the number of re-admission in the health facilities.

Table 5. 17 Parameter Estimates

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[EUse = 1.73]	1.777	1.408	1.592	1	.207	-.983	4.537
	[EUse = 4.23]	14.006	81.845	.029	1	.864	-146.407	174.419
	[EUse = 4.32]	100.679	41.115	5.996	1	.014	20.096	181.262
	[EUse = 4.57]	104.515	41.780	6.258	1	.012	22.627	186.403
Location	Mortality after Systems Implementation	-3.876	1.590	5.939	1	.015	.759	6.993
	Re-admission after systems Implementation	-.017	.093	.032	1	.859	-.199	.166

Link function: Logit.

5.6.2. Test for Parallel Lines

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories. The results of the test of Parallel lines (ie assumption of proportional odds) indicate non-significant P>0.05, showing the assumption is satisfied.

Both mortality and re-admission have negative coefficients relative to the *Ease of use, efficiency, safety/errors of health information systems*. This indicates that for every one unit increase on an independent variables Ease of Use, efficiency and safety/errors there is a predicted decrease (of a certain amount) in the log odds of falling at a higher level of the dependent *variable mortality and re-admission to the health facilities.*

This implies ease of use, efficiency, safety/errors of health information systems have the potential to reduce the number of mortalities and readmissions in the health facilities

Table 5. 18 Test of Parallel Lines

Model	**-2 Log Likelihood**	**Chi-Square**	**df**	**Sig.**
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	.000			
General	.000[b]	.000	6	1.000

5.7 Summary

The findings established that a number of the existing frameworks are suboptimal in providing HIS usability evaluation explicitly at the design and development stage of HIS. Each of them evaluates different aspects of HIS pertinent to human, organizational and technological factors. The frameworks differ in timing based on the systems development life cycle. Majority of users who participated in the study were not to have been involved and were never satisfied with the processes during the design and development of phase of the FANSOFT which the current health information systems that they facilities are using. User involvement and participation during the design and development positively influence user satisfaction levels.

Using thematic analysis, results showed that the developed usability evaluation framework was very useful and provided both the developers and end users with perfect opportunity to engage and also participate in the design and development of health information systems. Both mortality and re-admission have negative coefficients relative to the *Ease of use, efficiency, safety/errors of health information systems*. This indicates that for every one unit increase on an independent variables Ease of Use, efficiency and safety/errors there is a predicted decrease (of a certain amount) in the log odds of falling at a higher level of the dependent *variable mortality and re-admission to the health facilities.* This implies ease of use, efficiency, safety/errors of health information systems have the potential to reduce the number of mortalities and readmissions in the health facilities

CHAPTER SIX: DISCUSSIONS

6.1 INTRODUCTIONS

In this chapter, the research focused on stating and discussing the interpretations of the results identified in chapter five, declaring his opinions, and explaining the implications of his findings and making suggestions and predictions for future research.

6.2 Objective One: To investigate the existing usability evaluation frameworks in health information systems

6.2.1 Systems Development Models and Usability inclusions

The researcher reviewed four systems development models namely V-model, Waterfall, Spiral and Agile model. V-model does not incorporate usability testing at its stages, similarly the waterfall model only fits users or stakeholders who have clear vision about the project (Butt & Ahmad, 2012). Agile does not consider user interface, but if it does it will fail to quality user centered design (Butt & Ahmad, 2012). From the above discussions of the models above, there are problems that come up, that make the software fail, these include, development process is not flexible, lack of User involvement, lack of focus on User Interface unable to handle rapid change in Requirements, and lack of Software Usability (Butt & Ahmad, 2012). Insufficient or lack of user involvement in software development affect both the product quality and also results in user dissatisfaction (Butt & Ahmad, 2012). Traditionally user involvement takes place in two stages, ie when collecting requirement and at a later stage of the development in order to validate and verify their requirements (Butt & Ahmad, 2012).

6.3 Investigating the existing usability evaluation frameworks in the design and development of health information systems

The researcher analyzed existing usability evaluation frameworks in the design and development of health information systems. The finding shows that specifically each of the evaluation frameworks differ in the domain that they focus on. For instance Towards a Unified Framework of EHR usability (TURF). (Zhang, 2011) only discussed evaluation on the implementation phase. TURF has these weaknesses, it defines usability around the representation effect on: useful, usable, and satisfying, and listed a set of representative measures for each of these three dimensions. Also demonstrated how TURF can be used as a method to redesign products to improve their usability. HOT-fit framework (Human, Organization and Technology-fit) talks about Systems implementation and only focuses on HOT-fit addresses the essential components of IS, namely human, organization and technology and the fit between them. Information Systems (IS) Success model (DeLeon and McLean, 2004) discusses Systems implementation. The six measures included are: System Quality (the measures of the information processing system itself), Information Quality (the measures of IS output), Service Quality (the measures of technical support or service), Information Use (recipient consumption of the output of IS), User Satisfaction (recipient response to the use of the output of IS) and Net Benefits (the overall IS impact). Communication (interaction within department), Care (medical care delivery), Control (control in the organization), and Context (clinical setting (4Cs) (Kaplan, 1997) only looked at systems implementation phase. CHEATS (Shaw, 2002) implements usability evaluation at the systems implementation and also clinical, human and organizational, educational administrative, technical and social domain areas.

Total Evaluation and Acceptance Methodology (TEAM) (Grant, et al., 2002) looks at evaluation at the Management level. IT Adoption Model (ITAM) (Dixon, 1999) looks at the systems implementation perspective and potential IT adoption. From the individual user perspective, this framework includes comprehensive evaluation criteria and relationships among them. A Framework for Usability Evaluation in EHR Procurement (TYLLINEN, 2018), this focused on Systems procurement. Looked at usability attributes, evaluation methods and measures. A framework for evaluating electronic health record vendor user-centered design and usability testing processes (Raj M Ratwani, 2016). This model looks at usability evaluation at the systems implementation ie Looked at UCD process, summative testing methodology, and summative testing results. Both Development Framework for the Evaluation of Usability in E-Government: A Case Study of E-Finance Government of Malang (Lestari, 2017) Assessment of the Health IT Usability Evaluation Model (Health-ITUEM) for evaluating mobile health (mHealth) technology (William, 2013) looks at evaluation at the systems implementation phases.

The study established that the existing usability evaluation frameworks, lacked to provide attention to usability evaluation at the design and development. They largely focused on different phases of the system development life cycle especially on the implementation phase of the systems. This resulted into HIS products that are not user centered with poor usability.

6.4 Objective Two: To investigate user involvement and satisfaction levels in health information systems during the design and development phase of system; using integrated Software Usability Measurement tools (User Participation during the physical design stage)

User involvement is widely accepted principle in the design development of usable systems. Many people think that design phase is only for technical skills of developer as opposed to end users (Sun, 2013). User can help developers build documents files as reference for the new systems, also make a balance between the technical aspect and the simplification aspects as well. Currently user requirements may keep changing thus resulting to the new developed systems drop behind the requirements (Sun, 2013). Developers must keep in close contact with the users and get the latest requirements from them so that they can amend their design reasonably to align to the requirements.

According to Damodaran (1996) a number of studies have demonstrated that effective user involvement in systems design yields the following benefits to the user and also to the organization at large i) User involvement leads to improvement of the quality of the system due to more accurate user requirements provided to the team, ii) user involvement help eliminate some very costly systems features that the user might not want or might not use or will not use at all, iii) user involvement raises the acceptance and satisfaction levels of the system, iv) Leads to greater understanding of the systems by the user resulting in more effective use and v) user involvement leads to increased participation in decision making within the organization. Better effort at the early stages of the design process as this leads to much less effort later on and a good system at the end (Kujala, 2003). During the design and development of health information systems there is a general understanding that users need to be fully involved in all stages of processes. This in return build their confidence, participation and satisfaction level of the health information systems being developed. The study measured using questions whether users were involved and their satisfaction levels in the developed health information systems during the design and development stages, both at the physical design and implementation stages.

6.4.1 User Participation during the physical design stage

Firstly, more respondents did not have main responsibilities during the physical design of the health information systems. Develop. This demonstrates that the developers did not particularly assign users key responsibilities during the physical design stage. Secondly, the study revealed that equal number of participants agreed and disagreed that the Information systems/data processing staff drew up a formalised agreement of the work to be done during system physical design, illustrating un-clear position to the extent of developers' engagement with the users. Similarly, very few respondents were able to make changes to the formalised agreement of work to be done during system physical design, this implies that HIS developers do not allow users any chances to make any changes to the physical design of the systems. Thus, the systems are designed without users view incorporated.

Fourthly, the study revealed that information systems/data processing staff only kept less than half of respondents informed concerning progress and/or problems during system physical design to some extent close to half of the time. This is very critical in terms progress of physical design processes. Very few respondents were formally engaged in reviewing the work done by information system/data processing staff during system physical design, again this puts the entire system product in jeopardy, as the users' input is not included. During reviewing the work, the development team give the users an opportunity to raise any questions and concerns and expectation of the systems. Generally, this is very health for the development teams as their mindset differs greatly with that of the users and they would benefit from the users' reviews since they are actual and final users of the system. Again, the study finds out that few respondents formally approved the work done by information system/data processing staff during system physical design; this implies that the information system/data processing staff did not seek approval from the users to proceed the physical design of the system. This deprives the information system/data processing staff opportunity to get critical input from the users.
From the sampled respondents few of them signed off a formalised agreement of the work by the information systems/data processing staff during system physical design, this implies that they were not fully involvement in the design work thus not able to approve and sign off. This make the information systems/data processing staff loss the benefits of the user involvement to the system design process. In terms of ability to help in defining output forms, screen layouts, report formats, development of systems controls and

security procedures for the health information systems, less respondents were involved and able to perform these processes. Users are core to the input of the outputs and format of both the system input forms and the outputs forms since they are the final consumers. The study revealed that fewer respondents evaluated systems controls and /or security procedures developed by information systems/data processing contrary to the requirement and guidelines, only about 26% of the respondents approved systems controls and /or security procedures developed by information systems/data processing, this implies the insufficient user involvement of the current health information system design and development processes.

Depending on the systems development model prototype is essential as it enable to the users to evaluate the progress of the development process. This finding of this study established that less than half of the respondents had the opportunity to evaluate the prototypes of the systems. This eventually leads to system products with errors that could have been identified during development using prototypes. Thus, increases the costs of providing usable systems as the information systems/data processing will need to go back and forth to ensure concurrence to the user requirements. Similarly, less than a third of the respondents agreed that the information systems/data processing staff presented a detailed walk-through of the system procedures and processes for them, impounding the lack of walkthrough in terms of soliciting for user input early in the physical design stage.

6.4.2 User Participation during the Implementation stage

Even through developers always test the system any times, user have the final right to evaluate whether the new system is satisfactory (Sun, 2013). Developer has to continually communicate with the user to get to know what they think about the system. They also need to provide education and training for users; through these, they get good communication opportunity for feedback from the users. At the end of implementation phase acceptance testing, this is when users feel assured that the new system is developed according to their expectations and fully meet their requirements. The study established that slightly more than a quarter of the respondents had a main responsibility for the development project during implementation, this imply that the development team do not fully assign responsibility to the users of the systems during the implementation stage. System developer are required to collectively with the users draw up formalised agreement of the work to be done during the systems implementation. The study revealed that more than half of the respondents had the opportunity to participate in the drawing up of the agreement. Slightly over a quarter of the respondents were able to make changes to the formalised agreement of work to be done during system implementation, this little comparative proportion suggest that the developer did not allow the respondents to make changes to the formalised agreement of work during the systems implementation stage. Since the users are very important in the implementation phase, an opportunity needs to be granted to them to discuss, suggest and make changes to the agreement of work to be done during system implementation. In terms of keeping the users informed concerning progress and/or problems during implementation, the developer performed averagely well at 50 per cent. This however need to be improved in future systems development. Users need to be a hundred percent informed concerning progress and/or problems during implementation.

More respondents did not formally review the work done by information system/data processing staff during implementation than those who had formally reviewed work done by information system/data processing staff during implementation. This too highlight a gap in terms to engage the users in reviewing the work done by the developer during the implementation phase. About three quarters of the respondents formally did not approved work done by information system/data processing staff during implementation. This shows that the developers were working on their own with little engagement with the users contrary to the requirements. Since users were not fully involvement on the work during the systems implementation phase, more users did not sign off a formalized agreement of the work by the information systems/data processing staff during implementation. Similarly, less users were involved in the development of test data specifications for the system and reviewed the results of system tests done by the information systems/data processing staff.

Since the respondents were not involvement in the test data, they did not approve the results of system tests done by the information systems/data processing staff. Sixty-five per cent of the respondents agreed that the information systems/data processing staff held a 'special event' to introduce the system to them. This shows that apart from not involving the users in a number of processes the development team had the opportunity to organize a special even to introduce the system. Similarly, less and less users were involved in the training of the other users of the systems, designed the user training programs and also were involved in the creation of the user procedures manual for the system.

The research pointed out at the importance of user involvement and participation during the design and development if health information system and its effects on user satisfaction levels positively.

Developers thus need to have end users be involved in the design and development phases of the HIS to ensure satisfaction. The more involved the users are the higher chances of satisfaction they become with the process and the end product.

- *For example as the scores of whether the development team drew up a formalised agreement of the work during the physical design increases, there is an increased probability falling a higher level on the user satisfaction level.*

6.4.3 User Involvement and Satisfaction Measurement

Users are the first members of a team in an organized system developed team. User may participate in data gathering, data flow diagrams development and reviews and use prototyping (Sun, 2013). User involvement can further result in to the following benefits.

1. Through user involvement the systems developer is able to identify the current problems that might be neglected because of lack of the environment understanding (Sun, 2013). Since users are constantly interacting with the perceived environment where the new systems will be deployed, this gives them a very good opportunity to describe it better to the development team for incorporation into the system.
2. Through user involvement conflicts between users and development team. When they are involved throughout the process the development team can communicate with tem at any time for meeting latest needs and improve the systems (Sun, 2013).
3. According to Dodd and Carr, 1994 jointly involving the users and the development team helps to create an understanding of why trade-offs are made. If this is not done users may at the end decline to approve the product citing that the system is not aligned to their requirements. Immediate feedback is required from the users on real time during the development of the system. For instance, if they find any mismatch between the design and the expected requirements thus making trade-off very reliable and reasonable (Sun, 2013).
4. User involvements enable user to lean the systems better besides the development benefits. They gain an opportunity to lean and study the new system, because it is a part of its creation,

thus contribute to further systems implementation phase (Sun, 2013). It improves their computer literacy levels as well.

5. Through user involvement, the development get many insights into how individual work affects the organization department. Both of them become attuned to the systems perspectives of the whole organization, leading a very efficient integration within the organization and work become more efficient (Sun, 2013).

6.4.3.1 Relationship Between User Involvement, Satisfaction Measurement and User Participation during the physical design and implementation phases of systems development.

Through an ordinal regression model where the dependent variable ie user involvement and satisfaction measurement was the transformed 7-point Likert scale response and the independent variables ie user participation during the design and development phase and user participation in the implementation phase. With the null hypothesis was that the user participation in both the design, development and implementation phases of health information systems does not influence the user involvement and satisfaction levels. The model fits information showed the model fitted the data very well [$\chi 2$ (30)=280.571, p<.001]. This demonstrate that the ordinal regression analysis was best choice of statistical systems to help answer the question. In general, user participation has position impact on the satisfaction level of users during the design and development of the system.

From the results a number of questions had positive coefficients indicating that for every one unit increase in independent variable there is a predicted increase (of a certain amount) in the log odds falling at a higher level of the dependent variable. Generally showing that as scores increase on the independent variables, there is an increase probability falling at a higher level on the dependent variable. For example as the scores of whether the development team drew up a formalised agreement of the work during the physical design increases, there an increased probability falling a higher level on the user satisfaction level (Coeff=74.799). As a component of participation, drawing up the agreement of the work together positively contributes to the user satisfaction level during the development process and with the final product. As to whether the development team kept the user informed concerning the progress and problems during the physical design stage, this too has a positive parameter estimate (Coeff=86.022) implying a position relationship with user satisfaction levels. Formally reviewing work done by the development team during the physical design stage, helping define input/output forms, evaluating control and security procedures developed by the developed team.

Additionally, results from the following questions yielded positive parameter estimates. Approving the systems control and/or security procedures developed by the development team, ability of the development team to present a detailed walk-through of the system procedures and processes, the user being informed concerning the progress and/or problems during implementation phase, approving the work done and results during the implementation stage, training of users and designing training programs, all these influences positively the user satisfaction levels. These demonstrate the important aspects of engaging the users in all processes of the development of an information system.

A number of questions also yielded negative parameter estimates. These largely relate to aspects of implementation. These imply that the aspects are not necessarily critical at implementation stage and underscores the need to have some of these practiced during the physical design stages. The results from the regression analysis model established that for every one-unit increase on these independent variables listed below, there is a predicted decrease (of a certain amount) in the log odds of falling at a higher level of the dependent variable. In general, as the scores increase on the independent variables, there is a decreased probability of falling at a higher level on the dependent variable. The results of the test of Parallel lines (ie assumption of proportional odds) indicate non-significant 0.976, showing the assumption is satisfied. This means that all the independent variables are associated with the dependent variable. Thus, the researcher rejected the null hypothesis that stated that there is no relationship between user participation during the physical design and implementation and the user involvement and satisfaction.

6.5 Objective Three: Health information systems evaluation framework models constructs

6.5.1 Health information systems evaluation framework models constructs

The evaluation frameworks complement each other in that they each evaluate different aspects of HIS pertinent to human, organizational and technological factors. These frameworks differ in terms of generality and specificity, timing based on the system development phases and the aspects that have been assessed in the model. These frameworks do not provide explicit evaluation categories to the evaluator, thus specific measures within the dimensions of each aspect can be defined to facilitate HIS evaluation. The researcher worked to develop an integrated framework that combine different evaluation aspects into one single framework, through building on the strengths and weakness of the existing frameworks. The constructs include Learnability, Efficiency, Memorability, Safety/Errors, Satisfaction, Ease of Use, Participation, and involvement, Tasks, People, Technology and Structure. Having analysed a number of components that were considered in the development of the usability evaluation frameworks for the design and development.

1. Usability Practices in Software Development Models
2. HIS Evaluation Methods and Usability Evaluation Methods
3. Analysis of usability Evaluation models and the themes assessed
4. Analysis of existing HIS evaluation frameworks
5. Information Systems Usability Evaluation ISO Standards
6. Theories and analysis

The usability evaluation framework for the design and development of health information systems was developed and data analysis done. These findings addressed the thesis objectives that were set out. Some of the constructs included safety/errors, memorability; these were the new additions of the research to the framework. Others that were integrated included ease of use, satisfaction, effectiveness, efficiency, attitude, speed of performance, flexibility, robustness, and productivity.

6.6 Objective Four: To validate the developed integrated usability evaluation framework for the design of health information systems

The usability evaluation framework for the design and development of health information systems was validated by the systems developers and the users. The framework provided a perfect opportunity for the users and the development team to engage very closely during the process. The validation played a key role in indicating the aspect of promotion of usability of the systems, further this showed that the objectives were met. Mortality and re-admission have negative coefficients relative to constructs Ease of use, efficiency, safety/errors of health information systems. Ease of use, efficiency, safety/errors of health information systems reduces the number of potential mortalities and readmissions in the health facilities. Using thematic analysis, results showed that the developed usability evaluation framework was very useful and provided both the developers and end users with perfect opportunity to engage and also participate in the design and development of health information systems.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The existing usability evaluation frameworks largely provided guidance on evaluation of health information systems at the implementation phase of the systems, thus demonstrating the gap of evaluation at the design and development of health information systems. The research developed an integrated usability framework for the design and development of health information systems. The different existing usability evaluation framework lack usability focus at the design and development phase of HIS life cycle. Many of the framework attempt to assess usability during the implementation, maintenance and other domains of the HIS. Users involvement is very critical in instigating ownership as well to ensure the design and development of HIS is user centered. Further the study established that the during the design and development of the current system in use Fansoft users were not involved, this affected their satisfaction levels during the entire process. The framework allows the impact of an information systems on the health care to be evaluation at three levels. The structure, the process and the outcome. The developed usability evaluation framework ensured an end product which was easy to use, efficient and safety from errors thus the participating health facilities recorded reductions in mortalities and readmissions in the health facilities.

7.2 RECOMMENDATIONS AND FUTURE WORK

Health Information Systems developers need to consider utilizing the components, dimensions in the developed usability evaluation framework as they provide a perfect opportunity to promote engagement and consider key constructs throughout the design and development phase and through the development life cycle. Health care providers need to provide real time feedback to the development team of any mis-alignment and emerging usability issues during the design and development process. The research encourages prospective adoption of the developed integrated framework into routine development of HIS to improve use for the prospective health information systems. There is need to capture the dynamics, processes, and interrelationships involved in technological change during the user engagement during the design and development of the health information systems.

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APPENDICES

APPENDIX A: Parameter Estimates: User Involvement and Satisfaction Measurement Parameter Testing

Parameters User involvement		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[UImeas = 1.17]	-24.816	2.976	69.512	1	.000	-30.650	-18.982
	[UImeas = 1.64]	-23.269	2.923	63.370	1	.000	-28.998	-17.540
	[UImeas = 1.71]	-19.322	2.751	49.338	1	.000	-24.713	-13.930
	[UImeas = 1.79]	-17.559	2.580	46.313	1	.000	-22.616	-12.502
	[UImeas = 2.00]	-15.312	2.387	41.165	1	.000	-19.989	-10.634
	[UImeas = 2.07]	-12.755	2.193	33.837	1	.000	-17.053	-8.458
	[UImeas = 2.14]	-11.427	2.127	28.866	1	.000	-15.596	-7.259
	[UImeas = 2.21]	-11.019	2.116	27.108	1	.000	-15.167	-6.871
	[UImeas = 2.29]	-10.611	2.109	25.301	1	.000	-14.745	-6.476
	[UImeas = 2.36]	-9.533	2.106	20.489	1	.000	-13.661	-5.405
	[UImeas = 2.43]	-9.125	2.110	18.702	1	.000	-13.261	-4.989
	[UImeas = 2.50]	-8.318	2.127	15.299	1	.000	-12.486	-4.150
	[UImeas = 2.64]	-7.603	2.151	12.494	1	.000	-11.819	-3.387
	[UImeas = 3.00]	-6.640	2.197	9.137	1	.003	-10.946	-2.335
	[UImeas = 3.71]	-5.678	2.259	6.319	1	.012	-10.105	-1.251
	[UImeas = 5.00]	8.248	484.238	.000	1	.986	-940.842	957.338

	[UPD40=0]	-10.072	1.913	27.724	1	.000	-13.821	-6.323
	[UPD40=1]	0[a]	.	.	0	.	.	.
	[UPD41=0]	74.799	2.478	911.411	1	.000	69.943	79.655
	[UPD41=1]	0[a]	.	.	0	.	.	.
	[UPD42=0]	-143.292	5.257	742.988	1	.000	-153.596	-132.989
	[UPD42=1]	0[a]	.	.	0	.	.	.
	[UPD43=0]	86.022	2.060	1743.568	1	.000	81.984	90.060
	[UPD43=1]	0[a]	.	.	0	.	.	.
	[UPD44=0]	124.956	3.624	1188.662	1	.000	117.853	132.060
	[UPD44=1]	0[a]	.	.	0	.	.	.
	[UPD45=0]	-135.923	6.924	385.357	1	.000	-149.494	-122.352
	[UPD45=1]	0[a]	.	.	0	.	.	.
	[UPD46=0]	-101.647	5.113	395.219	1	.000	-111.668	-91.626
	[UPD46=1]	0[a]	.	.	0	.	.	.
	[UPD47=0]	398.075	21.115	355.424	1	.000	356.690	439.460
	[UPD47=1]	0[a]	.	.	0	.	.	.
Location	[UPD48=0]	-105.379	9.741	117.041	1	.000	-124.471	-86.288
	[UPD48=1]	0[a]	.	.	0	.	.	.
	[UPD49=0]	-97.335	4.496	468.644	1	.000	-106.148	-88.523
	[UPD49=1]	0[a]	.	.	0	.	.	.
	[UPD50=0]	-247.148	7.645	1045.002	1	.000	-262.132	-232.163
	[UPD50=1]	0[a]	.	.	0	.	.	.
	[UPD51=0]	193.119	6.560	866.739	1	.000	180.262	205.975
	[UPD51=1]	0[a]	.	.	0	.	.	.
	[UPD52=0]	107.314	5.010	458.810	1	.000	97.494	117.133
	[UPD52=1]	-10.710	2.160	24.582	1	.000	-14.944	-6.476
	[UPD52=11]	0[a]	.	.	0	.	.	.
	[UPD53=0]	-88.224	5.033	307.248	1	.000	-98.089	-78.359
	[UPD53=1]	0[a]	.	.	0	.	.	.
	[UPD54=0]	18.917	4.590	16.989	1	.000	9.922	27.913
	[UPD54=1]	0[a]	.	.	0	.	.	.
	[UPI55=0]	195.711	7.228	733.193	1	.000	181.545	209.877
	[UPI55=1]	0[a]	.	.	0	.	.	.
	[UPI56=0]	-85.384	2.333	1339.307	1	.000	-89.957	-80.811

[UPI56=1]	0[a]	.	.	0	.	.	.
[UPI57=0]	-7.716	4.683	2.715	1	.099	-16.894	1.462
[UPI57=1]	0[a]	.	.	0	.	.	.
[UPI58=0]	89.399	2.888	958.333	1	.000	83.739	95.059
[UPI58=1]	0[a]	.	.	0	.	.	.
[UPI59=0]	-95.873	2.997	1023.219	1	.000	-101.747	-89.999
[UPI59=1]	0[a]	.	.	0	.	.	.
[UPI60=0]	45.217	5.581	65.635	1	.000	34.278	56.156
[UPI60=1]	0[a]	.	.	0	.	.	.
[UPI61=0]	-232.719	12.445	349.686	1	.000	-257.111	-208.328
[UPI61=1]	0[a]	.	.	0	.	.	.
[UPI62=0]	-233.323	5.997	1513.941	1	.000	-245.076	-221.570
[UPI62=1]	0[a]	.	.	0	.	.	.
[UPI63=0]	-8.239	1.992	17.103	1	.000	-12.144	-4.334
[UPI63=1]	0[a]	.	.	0	.	.	.
[UPI64=0]	62.535	6.960	80.725	1	.000	48.894	76.177
[UPI64=1]	0[a]	.	.	0	.	.	.
[UPI65=0]	-4.749	1.248	14.476	1	.000	-7.195	-2.303
[UPI65=1]	0[a]	.	.	0	.	.	.
[UPI66=0]	-75.959	.991	5871.074	1	.000	-77.902	-74.016
[UPI66=1]	0[a]	.	.	0	.	.	.
[UPI67=0]	161.238	2.917	3056.270	1	.000	155.522	166.955
[UPI67=1]	0[a]	.	.	0	.	.	.
[UPI68=0]	76.597	.000	.	1	.	76.597	76.597
[UPI68=1]	0[a]	.	.	0	.	.	.
[UPI69=0]	0[a]	.	.	0	.	.	.
[UPI69=1]	0[a]	.	.	0	.	.	.

Figure 17: Parameter Estimates Testing

APPENDIX B: Informed Consent Form

JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF INFORMATION AND INNOVATION SYSTEMS

Title of Thesis: Integrating Engagement Theory in Usability Evaluation Framework for the Design and Development of Health Information Systems

Dear participant,

You are invited to participate in a research study titled **Integrating Engagement Theory in Usability Evaluation Framework for the Design and Development of Health Information Systems**

This study is being done by **Gonza Otieno Omoro** from Jaramogi Oginga Odinga University of Science and Technology pursuing **PhD in Business Information Systems**

The purpose of this research study is **assess and analyse the existing usability framework in the design and development of information systems, and develop an integrated usability framework to be used during the design and development of public information systems.** The data from this study shall be used to understand the levels of engagement of all the stakeholders during the development of public health information systems and help develop the proposed usability evaluation framework. Therefore, I would like you to fill the attached questionnaire that will take you approximately 15 minutes to complete. Your participation in this study is voluntary and if you choose to participate please provide honest and valid answers by filling in the blank spaces to completion. Otherwise, you may withdraw your consent and stop participating at any time. Keep in mind, also, that in all correspondence for this research study, you may choose whether to respond to each question individually and you may opt to skip any question that asks you to reveal any information that you may not wish to reveal. Please note that there is no compensation for participating in this study and there are no known risks associated with this research study. To the best of my ability, I will ensure that your participation in this study will remain confidential, and only anonymized data will be published hence, do not write your name anywhere on the questionnaire. Thank you for your participation

APPENDIX C: Survey Questionnaire

DEMOGRAPHIC DETAILS

1. County

- [ ] Kisum
- [ ] Kakamega
- [ ] Vihiga
- [ ] Busia
- [ ] Bungoma
- [ ] Homabay
- [ ] Migori

2. Department

- [ ] OPD
- [ ] Casualt
- [ ] y IPD
- [ ] Child Welfare
- [ ] Clinic Finance

3. What's your age? ________________Years old

4. Whats your designation?

- [ ] Nurse
- [ ] Clinical Officer
- [ ] Medical Officer
- [ ] Financial Officer
- [ ] Health Records Information Officer

5. What's your Length of Service? *

- [ ] Over 10years
- [ ] Between 5-10 years
- [ ] Between 2-4.9years
- [ ] Less than 2 years

6. Education level

- Secondary Level
- College certificate
- level College Diploma
- level University
- Degree

University Postgraduate level

7. Gender

- Male
- Female

8. Have you been trained on the current health information in use in this facility

- Yes
- No

EASE OF USE, EFFICIENCY, AND SAFETY/ERRORS

#	Items	Strong Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	agree	Strongly Agree
1	The system is easy to use	1	2	3	4	5	6	7
2	The system simple to use and safe	1	2	3	4	5	6	7
3	The system is user friendly	1	2	3	4	5	6	7
4	The system requires the fewest steps possible to accomplish what I want to do with it	1	2	3	4	5	6	7
5	The system is flexible.	1	2	3	4	5	6	7
6	Using the system is effortless	1	2	3	4	5	6	7
7	I can use the system without written instructions	1	2	3	4	5	6	7
8	I don't notice any inconsistencies as I use the system	1	2	3	4	5	6	7
9	Both occasional and regular users would like using the system	1	2	3	4	5	6	7
10	I can recover from mistakes and errors	1	2	3	4	5	6	7

	quickly and easily when using the system							
11	I can use the system successfully every time.	1	2	3	4	5	6	7
12	When using the system, the response time is very short	1	2	3	4	5	6	7
13	When using the system, there is shorter representation of redundant data sharing	1	2	3	4	5	6	7

#	Items	Strong Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	agree	Strongly Agree
14	I learned to use the system quickly	1	2	3	4	5	6	7
15	I easily remember how to use the system	1	2	3	4	5	6	7
16	The system is easy to learn to use	1	2	3	4	5	6	7
17	It's so easy became skillful with the	1	2	3	4	5	6	7

	system							
18	I am satisfied with the system	1	2	3	4	5	6	7
19	I would recommend the system to a friend	1	2	3	4	5	6	7
20	The system is fun to use	1	2	3	4	5	6	7
21	The system works the way I want it to work	1	2	3	4	5	6	7
22	the system is wonderful	1	2	3	4	5	6	7
23	the system is pleasant to use	1	2	3	4	5	6	7

INTERNATIONAL ORGANISATION FOR STANDARDIZATION (ISO)

Number	Questions	Yes	No
24	Does this information systems design and development considers using the appropriate ISO standards	Yes	No
25	I had main responsibility for the development project during system definition	Yes	No
26	Information systems/data processing staff drew up a formalised agreement of the work to be done during system definition	Yes	No
27	I was able o make changes to the formlised agreement of work to be done during system definition	Yes	No
28	The information systems/data processing staff kept me informed concerning progress and/or problems during system definition	Yes	No

29	I formally reviewed work done by information system/data processing staff during system definition	Yes	No
30	I formally approved work done by the information systems/data processing staff during system definition	Yes	No
31	I signed off a formalised agreement of the work by the information systems/data processing staff during system definition	Yes	No
32	I was interviewed by the information systems/data processing staff during the system definition phase	Yes	No
33	I responded to questionnaires administered by the information system/data processing staff during the system definition phase	Yes	No
34	I developed the information requirement analysis(ie the analysis of user needs) for this system	Yes	No
35	I evaluated an information requirement analysis developed by information systems/data processing	Yes	No
36	I approved an information requirement analysis developed by the information systems/data processing staff	Yes	No
37	I developed a cost/benefit analysis for this system	Yes	No
38	I evaluated a cost benefit analysis developed by the information system/data processing staff	Yes	No
39	I approved a cost benefit analysis developed by the information systems/data processing staff	Yes	No

USER PARTICIPATION - PHYSICAL DESIGN PHASE

Number	Questions	Yes	No

40	I had main responsibility for the development project during physical design	Yes	No
41	Information systems/data processing staff drew up a formalised agreement of the work to be done during system physical design	Yes	No
42	I was able to make changes to the formlised agreement of work to be done during system physical design	Yes	No
43	The information systems/data processing staff kept me informed concerning progress and/or problems during system physical design	Yes	No
44	I formally reviewed work done by information system/data processing staff during system physical design	Yes	No
45	I formally approved work done by information system/data processing staff during system physical design	Yes	No
46	I signed off a formalised agreement of the work by the information systems/data processing staff during system physical design	Yes	No
47	For this system, I defined/helped define input/output forms	Yes	No
48	For this system, I defined/helped define screen layouts	Yes	No
49	For this system, I defined/helped define report formats	Yes	No
50	I developed system controls and/or security procedures for this system	Yes	No
51	I evaluated systems controls and /or security procedures developed by information systems/data processing	Yes	No
52	I approved systems controls and /or security procedures developed by information systems/data processing	Yes	No
53	The information systems/data processing staff developed a prototype of the new system for me	Yes	No
54	The information systems/data processing staff	Yes	No

	presented a detailed walk-through of the system procedures and processes for me		

USER PARTICIPATION -IMPLEMENTATION PHASE

Number	Questions	Yes	No
55	I had main responsibility for the development project during implementation	Yes	No
56	Information systems/data processing staff drew up a formalised agreement of the work to be done during system implementation	Yes	No
57	I was able to make changes to the formalised agreement of work to be done during system implementation	Yes	No
58	The information systems/data processing staff kept me informed concerning progress and/or problems during implementation	Yes	No
59	I formally reviewed work done by information system/data processing staff during implementation	Yes	No
60	I formally approved work done by information system/data processing staff during implementation	Yes	No
61	I signed off a formalized agreement of the work by the information systems/data processing staff during implementation	Yes	No
62	I developed test data specifications for this system	Yes	No
63	I reviewed the results of system tests done by the information systems/data processing staff	Yes	No
64	I approved the results of system tests done by the information systems/data processing staff	Yes	No
65	The information systems/data processing staff held a 'special event' to introduce the system to me	Yes	No
66	I was trained in the use of this system	Yes	No
67	I designed the user training program for this system	Yes	No

68	I trained other users to use this system	Yes	No
69	I created the user procedures manual for this system	Yes	No

USER INVOLVEMENT MEASUREMENT

70. The new health information system

	1	2	3	4	5	6	7	
Means A lot	○	○	○	○	○	○	○	Means nothing

- The new health information system is!

	1	2	3	4	5	6	7	
Useless	○	○	○	○	○	○	○	Useful

- The new health information system is!

	1	2	3	4	5	6	7	
Beneficial	○	○	○	○	○	○	○	not beneficial

- The new health information system is!

	1	2	3	4	5	6	7	
Unexciting	○	○	○	○	○	○	○	exciting

- The new health information system is!

	1	2	3	4	5	6	7	
Appealing	○	○	○	○	○	○	○	unappealing

- The new health information system is!

	1	2	3	4	5	6	7	
Significant	◯	◯	◯	◯	◯	◯	◯	insignificant

- The new health information system is!

	1	2	3	4	5	6	7	
Vital	◯	◯	◯	◯	◯	◯	◯	superfluous

- The new health information system is!

	1	2	3	4	5	6	7	
Matters to me	◯	◯	◯	◯	◯	◯	◯	doesn't matter

- The new health information system is!

	1	2	3	4	5	6	7	
Boring	◯	◯	◯	◯	◯	◯	◯	interesting

- The new health information system is!

	1	2	3	4	5	6	7	
Wanted	◯	◯	◯	◯	◯	◯	◯	unwanted

- The new health information system is!

	1	2	3	4	5	6	7	
Important	◯	◯	◯	◯	◯	◯	◯	unimportant

- The new health information system is!

	1	2	3	4	5	6	7	
Valuable	◯	◯	◯	◯	◯	◯	◯	worthless

- The new health information system is!

	1	2	3	4	5	6	7	
Irrelevant								relevant

- The new health information system is!

	1	2	3	4	5	6	7	
Essential								nonessential

HOSPITAL PATIENTS

IMPROVEMENT ON HEALTHCARE

Number	Questions	Strong Disagree	**Disagree**	**Somewhat disagree**	**Neither agree nor disagree**	**Somewhat agree**	**agree**	Strongly Agree
84	The medical care I have been receiving is just about perfect	1	2	3	4	5	6	7
85	I am satisfied with some things about the medical care I receive	1	2	3	4	5	6	7
86	I think my doctor's office has everything needed to provide complete care	1	2	3	4	5	6	7
87	Sometimes doctors make me wonder if their diagnosis	1	2	3	4	5	6	7

	is correct							
88	When I go for medical care, they are careful to check everything when treating and examining me	1	2	3	4	5	6	7
89	Those who provide my medical care sometimes hurry too much when they treat me	1	2	3	4	5	6	7
90	Doctors usually spend plenty of time with me	1	2	3	4	5	6	7
91	I have easy access to the medical specialists I need	1	2	3	4	5	6	7
92	Where I get medical care, people have to wait too long for emergency treatment	1	2	3	4	5	6	7
93	I find it hard to get an appointment for medical care right away	1	2	3	4	5	6	7
94	I am able to get medical care	1	2	3	4	5	6	7

	whenever I need it							

MORTALITY AND RE-ADMISSION(To be completed by facility leadership)

- What is the number of recorded deaths in this facility in the last 3 months?__________
- What is the total catchment population for this facility?____________
- How many Re-admissions have we had in this facility in the last 3 months?__________

APPENDIX D: Focus Group Discussion/Interview

JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF INFORMATION AND INNOVATION SYSTEMS

Title of Thesis Integrating Engagement Theory in Usability Evaluation Framework for the Design and Development of Health Information Systems

Welcome and thank you for volunteering to take part in this focus group discussion. You have been asked to participate, as your point of view is important. I realize you are busy and I appreciate your time.

Introduction: You are being invited to participate in a research study titled **Integrating Engagement Theory in Usability Evaluation Framework for the Design and Development of Health Information Systems**. This study is being done by **Gonza Otieno Omoro** from Jaramogi Oginga Odinga University of Science and Technology pursuing **PhD in Business Information Systems**. The purpose of this research study is to **assess and analyse the existing usability framework in the design and development of information systems, and develop an integrated usability framework to be used during the design and development of public information systems**. The data from this study shall be used to understand the levels of engagement of all the stakeholders during the development of public health information systems and also help develop the proposed usability evaluation framework. The focus group discussion will take no more than one hour. The discussion to assist with data collection.

Anonymity: Despite being taped, I would like to assure you that the discussion would be anonymous. The tapes will be kept safely in a locked facility until they are transcribed word for word, then they will be destroyed. The transcribed notes of the focus group will contain no information that would allow individual subjects to be linked to specific statements. You should try to answer and comment as accurately and truthfully as possible. We request that you refrain from discussing the comments of other group members outside the focus group. You are not under any obligation to participate in all questions.

Consent Form

Respondent's Initials……………………………………………………………………………

I understand that:

a. *This focus group may be audio recorded and/or video-recorded for the purpose of maintaining an accurate record of the discussion that will be a reference for any reports derived from the discussion;*
b. *The information gathered in this focus group will be summarized by the researcher*
c. *Information derived from this focus group discussion may be used in publications and presentations to but it will not be linked to any specific individual.*

I have read and understand this consent form and agree to voluntarily participate in this project.

Participant's signature Date

4. County

- Describe how you conceive the developed usability evaluation framework for the design and development of health information systems

- What are some of the strengths of the developed usability evaluation framework for the design and development of health information systems

- What are some of the weaknesses of the developed usability evaluation framework for the design and development of health information systems

APPENDIX E: JOOUST Data Collection Request Form

JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE & TECHNOLOGY

BOARD OF POSTGRADUATE STUDIES

Office of the Director

Tel. 057-2501804
Email: bps@jooust.ac.ke

P.O. BOX 210 - 40601
BONDO

Our Ref: I162/4062/2015

Date: 21st April 2021

TO WHOM IT MAY CONCERN

RE: GONZA OTIENO OMORO– I162/4062/2015

The above person is a bonafide postgraduate student of Jaramogi Oginga Odinga University of Science and Technology in the School of Informatics & Innovative Systems pursuing a PhD in Business Information Systems. He has been authorized by the University to undertake research on the topic: "***Integrating Engagement Theory in Usability Evaluation Framework for the Design Development of Health Information Systems.***"

Any assistance accorded him shall be appreciated.

Thank you.

for.

Prof. Dennis Ochuodho
DIRECTOR, BOARD OF POSTGRADUATE STUDIES