APPLYING THE ACTIVITY THEORY AND THE USER CENTERED DESIGN FRAMEWORK TO DEVELOP A WEB-BASED HEALTH INDICATOR MANAGEMENT TOOL

CASE STUDY: APPLYING SCIENCE TO STRENGTHEN AND IMPROVE SYSTEMS (ASSIST) PROJECT

A Post Graduate Report Presented to
Faculty of Science, Department of Information Systems
in Partial Fulfillment of the Requirement for the
Award of Degree of Master of Science in Information Systems
Uganda Martyrs University

Musenge Kenneth
2012-M132-20010

August 2016

DEDICATION

I dedicate this work to my late Dad for his incessant emphasis on the importance of education. My dearest wife Harriet for the encouragement and support and to my children Ethan Jayden, Elaine Janice and Baby Jesse

ACKNOWLEDGEMENT

I express my utmost gratitude to Eng. Yiga Stephen and Dr. Ssembatya Richard, my supervisors who have given me invaluable guidance to ensure that this work comes to a successful completion. Special thanks go to Harriet, my wife, notably for her moral support and inspiration that have kept me going all the way.

My thanks also go to the MSc IS class mates, for their constructive peer criticism and guidance throughout the course and during the research/ project.

I very thankful to the staff at URC-LLC Uganda Office who actively participated the research particularly the Focus Members' discussions, the card sorts, low edition prototyping and the testing.

All the faculty and support team of UMU who have intellectually modeled me during the 2 years. I am forever thankful to you all. Finally, and above all to the ALMIGHTY GOD for the kindness, knowledge and good health.

Musenge Kenneth
August 2016

TABLE OF CONTENTS

DECLARATION i

APPROVAL ii

DEDICATION iii

ACKNOWLEDGEMENT iv

TABLE OF CONTENTS v

LIST OF FIGURES x

LIST OF TABLES xi

LIST OF ABBREVIATIONS xii

ABSTRACT xiv

CHAPTER ONE 15

INTRODUCTION 15

a) District Health Information Software 2 (DHIS2) 17

b) HealthWRQS 20

1.1 Background to the Study 21

1.2 Problem Statement 25

1.3 Main Objective 26

1.4 Specific objectives 26

1.5 Scope 26

1.6 Significance of the study 27

CHAPTER TWO 28

LITERATURE REVIEW 28

2.1 Review of web applications 28

2.2 Health Indicators 31

2.2.1 The importance of health indicators 31

2.2.2 Types of indicators 32

2.2.3 Health indicator analysis tools 34

2.2.4 HealthWRQS 34

2.2.4.1 Strength of HealthWRQS 35

2.2.4.2 Weakness of HealthWRQS. 35
2.3 District Health Information Software 2 (DHIS2)...36
2.3.1 Strength of DHIS2 37
2.3.2 Weaknesses of DHIS2 37
2.4 Requirements elicitation..38
2.4.1 Interviews...38
2.4.2 Observation...39
2.4.3 Focus group discussions (FGD) 40
2.4.4 Card sorting...41
2.5 Design methodologies...42
2.5.1 User Centered Design methodology 42
2.5.2 Key principles of UCD 43
2.6 Joint Application Development (JAD) 45
2.7 Prototyping..46
2.7.1 System Implementation...48
2.7.2 Information System Implementation Challenges...48
2.7.3 Key issues of Information Systems implementation Success..................................49
2.8 System testing..50
2.8.1 Testing approaches...50
2.9 Information System Evaluation...52
2.9.1 Formative and Summative Evaluation in IS Research 53
2.9.2 Goal-Based and Goal-Free Evaluation in Information Systems Research...............53
2.9.2.1 Goal-based evaluation 53
2.9.2.2 Goal-free evaluation 54
2.10 Review of theory...54
2.11 Activity Theory...55
2.11.1 The practical value of Activity Theory...56
2.11.2 Application of Activity Theory in Information Systems 56
2.11.3 Conclusion 58

CHAPTER THREE.....59
METHODOLOGY.....59
3.1 Review of the Existing System.....59
3.1.1 Document Review.....59
3.1.2 Questionnaire.....60
3.1.3 Focus Group Discussion.....60
3.2 System Requirements.....61
3.2.1 Design for usability.....62
3.2.1.1 Conceptual design.....62
3.2.1.2 Interaction Design.....63
3.3 Evaluating the Design.....64
3.4 Designing the Best Solution.....65
3.5 Implementation.....65
3.6 Testing.....65
3.6.1 System Tests Carried Out.....66
CHAPTER FOUR.....68
SYSTEM ANALYSIS, DESIGN AND IMPLEMENTATION.....68
4.1 System Analysis.....68
4.2 Requirements analysis.....71
a) Functional requirements.....71
b) Non-functional requirements.....71
4.3 Application of User Centered Design and the Activity Theory.....72
4.3.1 Specifying the context of use.....72
4.3.2 Specifying the requirement.....76
4.3.3 Analysis of activity and actions.....83
4.3.4 Required Data.....85
4.3.5 Enhanced Entity Relationship Diagram (EERD).....86
4.3.6 Physical data model.....88
4.3.7 Hardware and Software Requirements.....96

4.3.8 Producing design solutions 96

a) Navigation 98

b) Activity theory application for extracting navigational semantics from activity descriptions 98

c) Drop down lists snapshot 99

d) Indicators data entry form 99

e) Advanced Search Feature 101

f) Indicator analysis view 102

g) Data visualization module 103

h) Group by Option 103

i) Date criteria Option 104

j) Export option 104

k) Summary option 105

l) System testing and validation 105

4.3.9 Evaluation of the system 109

a) Cognitive walkthrough 109

b) Participants based method 109

1. End User satisfaction 110

2. Learning effectiveness 110

3. Perceived Benefits 111

4.3.10 Conclusion 111

CHAPTER FIVE 112

DISCUSSION, CONCLUSION AND RECOMMENDATION 112

5.1 Conclusion 113

5.2 Recommendation and Future Work 114

REFERENCES 115

Appendix i: the SMC DATA COLLECTION TOOL 123

Appendix ii: Questionnaire 126

appendix iii: Focus Group Discussion Guide 129

APPENDIX IV: Test plan 130

Appendix V: Web based analysis tool evaluation form 131

Appendix vii: SDG 3 Targets 132

LIST OF FIGURES

Figure 3-1: User Centred System Design Process (Jan Gulliksen2003) 62
Figure 4-1: ASSIST Data management process 69
Figure 4-2: Sample database currently used 74
Figure 4-3: Monitoring and Evaluation Officer’s Use Case Diagram 79
Figure 4-4: Quality Improvement Officer’s Use Case diagram 79
Figure 4-5: Steps taken to add a new indicator 80
Figure 4-6: Adding a new health facility 81
Figure 4-7: User Centered System Design Process 82
Figure 4-8: Hierarchical decomposition of an activity into actions 84
Figure 4-9: Enhanced Entity Relationship Diagram for the system 87
Figure 4-10: Card sorting during derivation of the user interfaces 97
Figure 4-11: Paper prototyping 97
Figure 4-12: Dropdown-List with Fast Item Selection 99
Figure 4-13: Data Entry form 100
Figure 4-14: Data modification message 100
Figure 4-15: Prompt for deletion 101
Figure 4-16: Advanced Search Options. 101
Figure 4-17: Screenshot of a Detailed View of indicator analysis report. 102
Figure 4-18: Select column options. 103
Figure 4-19: Summary options. 103
Figure 4-20: Date Picker option 104
Figure 4-21: Excel export functionality. 104
Figure 4-22: Summary options. 105
Figure 4-23: System out of test data 106
Figure 4-24: Successful login 106
Figure 4-25: Unsuccessful login 107
Figure 4-26: Validation checks 107
Figure 4-27: Before retrieval 108
Figure 4-28: Retrieval results 109

LIST OF TABLES

Table 2-1: Indicator Types ... 33
Table 2-2: Advantages and disadvantages of UCD ... 45
Table 4-1: Use Cases ... 78
Table 4-2: District table ... 88
Table 4-3: Health Facility table ... 89
Table 4-4: Program Area table ... 89
Table 4-5: Implementer table ... 89
Table 4-6: HIV general indicators table ... 90
Table 4-7: HIV Retention indicators table ... 90
Table 4-8: HIV Pregnancy Indicators table ... 91
Table 4-9: HIV TB Indicators table ... 92
Table 4-10: SMC- CT indicators table ... 93
Table 4-11: SMC- QI indicators table ... 94
Table 4-12: HIV Cascade indicators table ... 95
Table 4-13: System requirements ... 96
Table 4-14: Unit testing data ... 105
Table 4-15: User credentials used for testing ... 106
Table 4-16: End user satisfaction ... 110
Table 4-17: Results of learning effectiveness ... 110
Table 4-18: Results concerning the perceived benefits ... 111

LIST OF ABBREVIATIONS

API	Application Programming Interface
ART	Anti-Retroviral Therapy
ASSIST	Applying Science to Strengthen and Improve Systems
CCIS	Chronic Care Impact Studies
DHO	Districts Health Offices
DSS	Decision-Support Systems
ERD	Entity Relationship Model
ESS/EIS	Executive Support/Information Systems
FP	Family Planning
GIS	Geographic Information Systems
HI	Health indicators
HIV	Continuum of Response
HIV	Human Immunodeficiency Virus
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transfer Protocol
IS	Information Systems
IT	Information Technology
LHD	Local Health Department
MDG	Millennium Development Goals
MDG	Millennium Development Goals
MEO	Monitoring and Evaluation Officer
MIS	Management Information Systems
MOH	Ministry of Health
NACCHO	National Association of County and City Health Officials
OAS	Office Automation Systems
OVC	Orphans and Vulnerable Children
PHFS	Partnerships for HIV Free Survival
QIO	Quality Improvement Officers
RAD	Rapid application development
SMC	Safe Male Circumcision
SMEs	Small and Medium Enterprises
SMGL	Saving Mothers Giving Life

TPS	Transaction-Processing Systems
UCD	User Centered Design
UI	User Interface
UML	Unified Modeling Language
URLs	Uniform Resource Locators
USAID	United States Agency for International Development
WHO	World Health Organization

ABSTRACT

In most developing countries, particularly in sub-Saharan Africa, health indicators data collection, processing, reporting and storage has been dominated by paper-based approach at times generating incomplete and inaccurate reports. Evidence from literature shows that the continued use of paper-based systems contributes to poor data quality in terms of reliability, availability, timeliness, completeness and this compromises health service delivery. In Malawi, for instance it was found that the use of paper-based health facility reports to generate national summaries resulted in a twelve percent underreporting of persons on first-line antiretroviral treatment because many sites did not submit accurate data to the national level. In South Africa, It was found that 2.5% of the total data values that should have been collected at 10 primary health care clinics using a paper-based system were missing while 25% of the data were outside the minimum and maximum values specified for the facilities. A conception inquiry at a USAID funded project in Uganda also revealed similar problem.

This project addressed the above problems by developing a Web based Health Indicators Management tool that employed the Activity Theory and the User Centered Design (UCD) approach. Employing the Activity theory and the UCD approach ensured that users and the way they interacted with the system was of prime focus. The synergic result was a solution that provides usability measures for the Ugandan local context in terms of effectiveness, efficiency and satisfaction of managing and monitoring health indicators. The solution is anticipated to cause minimal disruptions to workflow since participants were heavily involved and learnt a lot during the process. This is expected to minimize interruptions in productivity that may be a result of learning a new system. It is anticipated that the solution will benefit USAID ASSIST by drastically improving the processing, management and control of health indicators.

.

CHAPTER ONE

INTRODUCTION

Chapter one gives an introduction which includes the projects background, a statement of the problem, objectives of the study, the scope of the study and the significance of the study.
This research was framed within Information and Communication Technology for Development (ICT4D). According to Heeks (2009), ICT4D is applying information and communication technologies, including the internet and mobile phones, video and audio for the purpose of enhancing and positively effecting development. ICT4D is the use of new technologies, new approaches to innovation and new intellectual integration (Jean 2014).
The research was also grounded in applied research, aimed at finding a solution for an immediate problem facing a society, or an industrial/business organization (Kothari 2008). Further, this type of research involves seeking new applications of scientific knowledge to the solution of a problem, such as a development of a new system or procedure, new device, or new method in order to solve the problem (Pattarin, 2010). The end of research required to design an efficient and affective information system previously standalone to a web based one, the main purpose being to improve work activities related to the data management of health indicators.

The purpose of information systems is to facilitate work activities. Activity is a collective phenomenon with a shared object and motive (Ánja et al. 2007).The activity is divided into actions through the division of work. Action is conducted by an individual or group using some kind of tool. This research considered how the Activity Theory can be applied in information systems development.

Activity theory is a conceptual framework originating from the socio-cultural tradition in Russian psychology (Krogstie, 2011). The foundational concept of the framework is “activity”, which is understood as purposeful, transformative, and developing interaction between actors (“subjects”) and the world (“objects”), (Ánja et al. 2007).

The application of Activity Theory in information systems research and practice often focuses on individual activity (or action) rather than collective activity (Bardman et al. 2006). This is quite understandable since the interest is usually in human computer interaction, user interfaces, or computer supported cooperative work. Adopting an activity-theoretical perspective has an immediate implication for design: it suggests that the primary concern of designers of interactive systems should be supporting meaningful human activities in everyday contexts, rather than striving for logical consistency and technological sophistication (Bardman et al. 2006). Currently many systems fail to comply with this, seemingly obvious, requirement (Kaptelinin and Czerwinski, 2007). Focusing on systems that supports meaningful human activity in everyday context can greatly be achieved by greater involvement of the users themselves. This is strengths of the user centered design (Desiree, 2007)

User-Centered Design (UCD), also called Human-Centered Design, is a methodology that centers design efforts on the user (Lauren, 2008). The process starts by defining who the users are including their characteristics, demographics, preferences, etc. with documents such as personas. Next, the users' needs are analyzed through methods such as surveys, interviews, card sorting, etc. Finally a design is created and iterated based on those wants and needs. The most important aspect to this type of design is to know your users. The goal is to create a way for users to complete tasks or activities in a way that is almost completely customized to their preferences, wants and needs.

Human-computer interaction has existed for some time as a research domain and gained a reputation as one of the central elements in designing computer applications even in health (Kuuti, 2003) Health is central to the achievement of the United Nations (UN) Sustainable Development Goals (SDG) (Beisheim, 2015). The UN's SDG Three (3) aspires to ensure health and well-being for all human, including a bold commitment to end the epidemics of AIDS, tuberculosis, malaria and other communicable diseases by 2030. SDG 3 has specific targets attached to it as indicated appendix IV. The targets are what must be achieved for the goal to be considered as having been accomplished. Each target has a numeric value called an indicator which is eventually transformed into a percentage. The percentage obtained indicates whether the target has been achieved or not. Therefore to measure progress towards attainment of each component of a health SDG, data is collected and computed to generate indicator values.

A Health indicator is a characteristic of an individual, population, or environment which is subject to measurement (directly or indirectly) and can be used to describe one or more aspects of the health of an individual or population in terms of quality, quantity and time. (WHO, 2012). Usually, indicators are tracked over time, in order to see whether their outcomes are in the desired direction or not. According to WHO (2012), some derivations and monitoring have to be performed on indicators in order inform the decision making processes.

The analysis, presentation and dissemination of health indicators has many challenges (Haight 2013) including but not limited to meeting the need for speed, real time integration, understanding the data, addressing the data quality, retrieval and displaying of meaningful results and dealing with outliers . However, this project focused on the challenges that are related to efficient and effective retrieval, consolidation and analysis of data. A number of tools like DHIS2 and the NH HealthWRQS, are available on the market that can be used for analysis and presentation of results derived from indicator processing.

Existing Indicator Management Systems

Some indicator management systems are available on the market. These include District Health Information Software 2 (DHIS2) and The New Hampshire Health Web Reporting and Query System (HealthWRQS) This research reviewed the mentioned systems and concluded that they could not be applied in the case study of the research. The various reasons used to draw up that conclusion are mentioned in each of the sub-sections below that explains the various tools that were reviewed. With that conclusion the solution was to develop a system that bridged the gaps existing in those systems.

a) District Health Information Software 2 (DHIS2)

District Health Information Software 2 (DHIS2) is an open-source software initially developed by the Health Information Systems Programme (HISP) at the University of Oslo. Since then it has evolved into a globally distributed development strategy (Braa 2007). Today developers from many countries including Norway, India, Vietnam, Tanzania, and Ireland take part in the ongoing developments of the DHIS 2 platform (DHIS 2013).

DHIS 2 can be described as a tool for collection, validation, analysis, and presentation of aggregate statistical data, tailored (but not limited) to integrated health information management activities (Braa et al. 2010). The users of DHIS 2 platform can customize the web based software package according to their health information needs without having to know or learn a complex programming language. This was made possible because DHIS 2 is a generic tool based on an open meta-data model and a flexible user interface (DHIS2 2013).

According to the official DHIS 2 website (dhis2.org), the software has been adapted for national Health Information Systems (HIS) deployment in seven countries - Kenya, Tanzania, Uganda, Rwanda, Ghana, Liberia, and Bangladesh (Braa et al. 2010). In addition, more than 20 countries, including Uganda, have made use of DHIS 2 at sub-national, program specific or at pilot levels.

Apart from being open source, the adaptability of DHIS 2 to the requirements of various countries has been supported by many different features integrated within the DHIS 2 platform. These features include, customized data entry, indicator defining, data visualizing through various types of graphs, web based pivot tabling, integrated GIS module, meta-data importing and exporting, custom data quality checks, user access control, integrating messaging system and DHIS 2 mobile solutions.

i) Strength of DHIS2

Manya et al. (2004) explains gives the following as some of the strengths of DHIS2

1. The inbuilt validation rules and data quality checks improve data quality.
2. Use of the cloud-based Central Server ensures that changes made in the system are available immediately to all users, and this setting also ensures that DHIS2 is available on a 24/7 basis.
3. Previously some of the HIS data was contained in parallel, mostly donor- sponsored systems which were not easily accessible to potential users. The DHIS2 data is however web-based and all interested users can use web- browsers to access HIS reports from any location.
4. The implementation HTML5 standard allowing for offline data entry has made use of DHIS2 a reality even in rural parts of a country with poor internet connectivity.

ii) Weaknesses of DHIS2

This research identified several weaknesses with the DHIS2 implementation. The weaknesses include;

1. Political Leadership - It is essential to obtain highest level endorsement from Health Information Systems Programme (HISP) at the University of Oslo for DHIS2 implementation at National (MOH) and Provincial Level and to communicate such endorsement to all stakeholders and have the agreement of all parties involved in writing prior to using it.

2. Project planning and financing - It is necessary to identify needs for DHIS2 implementation, plan the projects (including identifying the project team and indicating their roles clearly), identify financial requirements and projects to the annual plan of the MoH so that the projects are institutionalized and supported financially and otherwise.

3. Development of a DHIS2 support team - It is necessary to have a team of software developers who can customize DHIS2 to local needs as and when required. When an institution develops a project under the guidance of their own technical officers in Health Informatics and decide that it is implemented on a DHIS2 platform, there should be a team who can move in and do that work. This team can be a MOH Team.

4. Change Management - It is necessary to ensure engagement of all stake holders and appropriate training of users of new systems to ensure that they are comfortable with what is being done.

5. Capacity - User capacity to use DHIS2 effectively has also been a challenge because of the limited availability of skilled ICT work force in the health sector.

6. Too many data collecting and reporting tools (forms and registers) and lack of integration at the various levels. In addition, too many indicators defined to monitor the sector with inadequate data collection and reporting tools at the data collection

b) HealthWRQS

The New Hampshire Health Web Reporting and Query System, or NH HealthWRQS, is a web-based data analysis system that allows public health practitioners the ability to query data and view reports instantly about the health of New Hampshire communities. The system is organized in a series of modules based on common community health indicators. Each module contains a user's guide which provides detailed, module-specific information and includes an introduction to the module, instructions on running and interpreting standard indicator reports, methodology and terminology used within the module, and detailed indicator lists with descriptions. The NH HealthWRQS website also contains information about the history and future of the system, training opportunities, and other sources of documentation.

To be able to access and use this tool, one applies to the directorate of health services of the state of New Hampshire. HealthWRQS reports are run by software that runs best with Internet Explorer 6 or higher. Reports can be run using Mozilla Firefox; however, it has been observed for slower run-times. Unfortunately, the software is not currently compatible with Google's Chrome or Apple Safari browser; other browser and hardware combinations have not been tested, viewing of reports also requires one to install software like Adobe Reader. If one absolutely needs to use an incompatible browser, then they have got to contact the owners for help. Example of indicators handled include; Births, Death, Inpatient, outpatient, cancer incidences, environmental health, health care claims and behavior risk factors indicator reports

i) Strength of HealthWRQS

i. NH HealthWRQS data analysis system allows public health practitioners the ability to query data and view reports instantly about the health of New Hampshire communities.

ii. The system is organized in a series of modules based on common community health indicators. Each module contains a user's guide which provides detailed, module-specific information and includes an introduction to the module, instructions on running and interpreting standard indicator reports, methodology and terminology used within the module, and detailed indicator lists with descriptions.

ii) Weakness of HealthWRQS.

HealthWRQS is a community health web reporting and querying system that available to only to New Hampshire Department of Health and Human Services and the Institute for Health Policy and Practice at the University of New Hampshire.

Solutions to the above weaknesses was the focus of this research. To develop a tool which wouldn't require political clearance, no requirement for direct financing by the organization under study, minimize challenges brought about by change and capacity related issues as the research will employ a methodology that puts users at the center of the design all through the development process.

A web based application refers to a software package that can be accessed through the web browser. The software and database reside on a central server rather than being installed on the desktop system and is accessed over a network (Shklar and Rosen, 2003). The tool will be web based so as to take advantage of today's technology to enhance an organizations productivity, efficiency because it gives one an opportunity to access business information from anywhere in the world at any time provided there is internet connectivity. Another significant advantage of building and maintaining using web applications is that they perform their function irrespective of the operating system and browsers running client side. Web applications are quickly deployed anywhere at no cost and without any installation requirements (almost) at the user's end.

1.1 Background to the Study

Recent major advances in information technology and increasing demands for health system accountability and patient choice have driven rapid advances in health system performance measurement (Grigg and Spiegelhalter, 2009). Health systems, however, are still in the relatively early stages of performance measurement, and major improvements are still needed in data collection, analytical methodologies, and policy development and implementation (Grigg and Spiegelhalter, 2009).

Computerized point-of-care health information systems, particularly web-based systems, have the potential to dramatically reduce the data collection burden by automating data aggregation and reporting (Goddard and Jacobs, 2012). These systems would also allow for real-time access to data (Goddard and Jacobs, 2012. Data from the present assessment indicate that this potential has not yet been reached as the electronic systems in place are incomplete, lack integration, are unreliable, and create a double reporting burden as data are often captured in both paper-based and electronic systems. While advances in information technology can enable large volumes of data to be processed and analyzed efficiently, the success is highly dependent on having adequate hardware, sufficient internet access, and common data architecture between systems, IT professionals, and support to ensure systems maintain functionality. These critical success factors remain a challenge in many resource-limited settings including Uganda (Kiberu et al, 2014).

An improved and harmonized health indicators reporting system is critical for health system strengthening since it can generate timely information for proper planning, monitoring and evaluation of service delivery at all levels of the health system (Theo and Rainer, 2011). However, in most developing countries, particularly in sub-Saharan Africa, health indicators reporting has been dominated by paper-based data collection and storage systems that tend to generate incomplete and inaccurate reports (Garrib et al). Evidence shows that the continued use of paper-based systems contributes to poor data quality in terms of reliability, availability, timeliness and completeness of reporting, and compromises health service delivery (Garrib et al). In Malawi, for instance, Makombe et al. found that the use of paper-based health facility reports to generate national summaries resulted in a twelve percent underreporting of persons on first-line antiretroviral treatment because many sites did not submit accurate data to the national level. In South Africa, Garrib et al found that two and half percent of the total data values that should have been collected at 10 primary health care clinics using a paper-based system were missing while 25% of the data were outside the minimum and maximum values specified for the facilities. These findings call for a need to deploy web-based health management information systems in order to minimize errors in health reports and improve precision and usability of health data

In Uganda, the ASSIST project supports the Ministry of Health (MOH), Districts Health Offices (DHOs) and health facilities in improving the quality of health care services. These services take care of HIV/AIDS, safe male circumcision, maternal, newborn, and child health, non-communicable diseases and chronic conditions. The various project teams collect data from the MOH that is required to compute and derive health indicators. There are over 100 health related indicators such as percentage of individuals counseled and tested for Human Immunodeficiency Virus (HIV), Number of HIV individuals assessed for Anti-Retroviral Therapy (ART) eligibility, percentage of HIV individuals assessed for ARV adherence etc. Each indicator is monitored by a specific program area. ASSIST's program are HIV Continuum of Response (CoR), Partnerships for HIV Free Survival (PHFS), Safe Male Circumcision (SMC), Saving Mothers Giving Life (SMGL), Family Planning (FP), Orphans and Vulnerable Children (OVC), HIV Chronic Care Impact Studies (CCIS). The project Quality Improvement Officers (QIO) (who must be medical personnel), collect the data using paper based assessment forms from the supported health facilities. The filled assessment forms are returned to the Monitoring and Evaluation Officer (MEO) who then migrates the data from the paper forms to various Microsoft Excel work sheets. An Excel spreadsheet file is created for each of the eight program areas. Each spreadsheet contains a number of sheets equivalent to the number of health facilities supported by the program .In each health facility sheet the rows hold an indicator definition that includes a numerator (the number of data elements being measured) and a denominator (total data elements available).The columns hold calendar months of the year.

Currently there are fifty (50) health facilities that are supported by different program areas. However a facility may be supported by more than one program area. Therefore the number of program areas supporting a facility will be the number of data sheet that exist in the existing record system just for that one facility. Because of this data storage structure the existing system has 400 data sheets. The sheets have the same structure, formats and embedded formulae. Identifying and consolidating the appropriate data from these numerous sheets is not efficient and effective. On a monthly basis, data is collected from all the supported health facilities. The Monitoring and Evaluation Officer (MEO) then updates the appropriate spreadsheets. However the MEO has other responsibilities other than data entry. Therefore at times the data collected accumulates to undesirable levels without the spread sheets being updated. A number of other options like hiring short term consultants to perform data entry and clear backlog has also been tried but situation hasn't helped. This eventually results into the required reports not being available on time and also probable compromise of security of the data since terms of reference for the consultants always require them to come along with personal computers that they use for the data entry.

In addition, DHIS2 and HealthWRQs also face other problems. These include'
The systems are not cost effective: Available options of DHIS2 and HealthWQRQS are not suitable because the solution is more costly than the problem. The costs of adoption, implementation, and maintenance are high. The high upfront costs, creates a barrier to adoption and implementation of these information systems, especially for a small organization like ASSIST.

Compromised security and privacy of information in the system due to situations that might require sending the system to the DHIS2 team in Oslo for technical support possess a breach of confidentiality. This is likely in the event of major software upgrades or failures, remedy is only available when the system is sent to the DHIS2 development team in Oslo. This is good for continuity but it presents the dilemma of having an organizations data shared with a third party

The above problem of security is also compounded by the lack of near established extension support centers yet users are expected to face technological and logistical obstacles on their quest to achieve meaningful use of DHIS2 and HealthWRQs, this means that if the organization faces a problem with systems that cannot be addressed locally, then they systems have to be sent abroad to the developers of the original systems for system rectification.

Because staff at the ASSIST project played no role in the development of the DHIS2 and the HealthWRQs, another disadvantage of these information systems to the staff would be disruption of work-flows, which results in temporary losses in productivity. This loss of productivity stems from the staff (end-users) learning the new system and may potentially lead to losses in results of what they are expected to accomplish.

The above background highlights the drawbacks associated with the current systems, which include the high upfront acquisition costs, ongoing maintenance costs, compromise in data confidentiality and disruptions to workflows that contribute to temporary losses in productivity that are the result of learning a new system

1.2 Problem Statement

Currently, data from over fifty (50) health facilities is entered into Microsoft Excel spread sheets. A data sheet of similar data structure is maintained for each health facility. In addition, a health facility will have a data sheet for each program area that is supported in that facility. As a result, the existing system has an unnecessary duplication of over four hundred data sheets with same formats and formulae although each one having different data. The consolidation of data from these sheets to generate indicator values is not efficient. This translates into delayed and sometimes in-accurate indicator reports and therefore delayed and at times wrong decision making. Also concurrent access and usage of Microsoft Excel files by different users is not possible. Therefore the system can only be accessed and used by one user at a time which means that personnel resources (users) are not utilized optimally. In addition to the above, available options that would have been exploited like usage of the District Health Information Software 2 (DHIS2) has its drawbacks associated with it, which includes, the costs of adoption, implementation, and maintenance which are high, the high upfront acquisition costs, compromised data confidentiality and disruptions to workflows that contribute to temporary losses in productivity that are the result of learning a new system. Moreover, these systems are associated with potential perceived privacy concerns among users.

This project addressed the above problems by developing a Web based Health Indicators Management tool that employed the Activity Theory and the User Centered Design (UCD) approach. Employing the Activity theory and the UCD approach ensured that users and their activities were the center of focus. The tool developed is anticipated to cause minimal disruptions to workflows as participants were heavily involved as such learnt a lot during the process and this in a way is expected to abate temporary losses in productivity as a result of learning a new system. Moreover, the systems will not be associated with potential of perceived privacy concerns among users as all the others reviewed presented such concerns.

The uniqueness of this project is that it attempts to fill in a part of the existing gap of limited literature on the synergetic results of employing both the User Centered Design approach and the Activity Theory in relation to health Information systems in Uganda.

1.3 Main Objective

The main objective of the project was to minimize the time required to manage health indicator data and improve on the accuracy of reports by developing a Health Indicator Management tool that be accessed and used by multiple users in different locations concurrently.

1.4 Specific objectives

The specific objectives were;

i) To review some of the related systems on the market that are used to manage health indicators in order to determine and adopt their strengths as well review literature related to such systems. ;

ii) To apply the Activity theory and the User Centered Design Approach to design a better solution to manage health indicators which design is a blueprint for the new system;

iii) To implement the solution with the aim of ensuring that the solution satisfies the main objective of the research and;

iv) To verify the tool in order to ascertain if it satisfies the objectives

1.5 Scope

The scope was divided into the geographical and the function scope.

The geographical scope:

The design of the web based tool was based on data collected from the USAID ASSIST Project operations in Kampala. It was limited to handling only two program areas of the ASSIST Project namely; Male Circumcision and HIV Continuum of Response. These two program areas were selected because they collect more indicators data than the others and from a wider geographical area.

The functional scope:

The tool has a functionality of data entry, aggregation, a number of filters to ease searches and visualization capabilities where derived indicator values are summarized pictorially also a system configuration section from where a number of settings can be implemented.

1.6 Significance of the study

It is anticipated that when the software tool is deployed it will help to reduce the time that is required to update, consolidate and analyze indicator-related data. The reports that are generated will be complete, accurate and on time. Therefore the necessary planning and decision-making will be in time and based on correct and complete reports.

Finally the researcher was able to gain valuable knowledge in the areas of academic research, theories, system development and health related programs.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews the relevant literature and its importance in relation to the project. It started with the Review of theory, a review of some web applications and their strengths and weaknesses. Health indicators were also reviewed particularly their importance and some types. As is the practice, indicators have to be analyzed so as to monitor their progress. Therefore, this research also reviewed some indicator management tools with the purpose of identifying strength that could be employed in this project. The researcher also reviewed, literature on the systems development processes so as to identify the best methodology to employ. This started with the review of requirements elicitation techniques, design methodologies, system implementation, testing and evaluation.

2.1 Review of web applications

A Web application is a software application that delivers its functionality to a user from a web server through a network such as the World Wide Web. The user views and manipulates the application through a web browser. This was initially achieved using scripts– small programs that could perform HTTP processing (they accept HTTP requests, do some processing on the server and then send back a response (Knight and Dai, 2002). This development is facilitated by the creation of a Common Gateway Interface standard (CGI), which standardizes how web servers interact and invoke scripts that carry out such tasks.

According to Kohn (2004), web applications are popular due to the presence of web browsers, and the convenience of using a web browser irrespective of the operating system and browsers running client side. The ability to update and maintain web applications without distributing and installing software on potentially thousands of client computers is a key reason for their popularity, as is the inherent support for cross-platform compatibility. The web has moved far from its roots as a simple text and image distribution system, to sophisticated web applications that can be a difficult and expensive process (Scotch 2007 et al). Common categories of web applications include webmail, online retail sales, online auctions, HMIS, and many others (Bailey 2008). Research reveals that health like other areas has been no exception in embracing use of web technologies.

In the work by Sharon and Moran (2004) on web based reporting systems, they state that the creation of an easy-to-use, readily accessible, centralized, and no punitive web-based reporting mechanism is typically one of the fundamental steps taken by organizations when implementing an overall patient health strategy. This is partly because of the numerous advantages that come with the use of web applications. According to McKinsey (2009), gives the following as some of the advantages of web applications; Cost Effective Development, Accessible anywhere, Accessible for a range of devices, improved interoperability, Easier installation and maintenance, Adaptable to increased workload, Security, Flexible core technologies

i. Cost Effective Development

With web-based applications, users access the system via a uniform environment—the web browser. While the user interaction with the application needs to be thoroughly tested on different web browsers, the application itself needs only be developed for a single operating system. There is no need to develop and test it on all possible operating system versions and configurations. This makes development and troubleshooting much easier, and for web applications that use a flash front end, testing and troubleshooting is even easier.

ii. Accessible anywhere

Unlike traditional applications, web systems are accessible anytime, anywhere, via a PC and a number of mobile devices with an Internet connection, giving the user the flexibility of where and when they access the application.

iii. Accessible for a range of devices

In addition to customizing content for user groups, content can also be customized for presentation on any device connected to the internet, including PDAs, mobile phones, etc., further extending the user's ability to receive and interact with information.

iv. Improved interoperability

Using internet technologies based on industry-wide standards, it's possible to achieve a far greater level of interoperability between applications than with isolated desktop systems. For example, it is much easier to integrate a web-based shopping cart system with a web-based accounting package than it is to get two proprietary systems to talk to each other. Web-based architecture makes it possible to rapidly integrate enterprise systems, improving work-flow and other business processes.

v. Easier installation and maintenance

Installation and maintenance becomes less complicated. Once a new version or upgrade is installed on the host server, all users can access it straight away. There is no need to upgrade each client PC. Rolling out new software can be accomplished more easily, requiring only that users have up-to-date browsers and plugins. And as the upgrades are only performed by an experienced professional to a single server, the results are more predictable and reliable.

vi. Adaptable to increased workload

Increasing processor capacity also becomes a far simpler operation. If an application requires more power to perform tasks, only the server hardware needs to be upgraded. The capacity of web-based software can be increased by "clustering" or running the software on several servers simultaneously. As workload increases, new servers can be added to the system easily—Google, for example, runs on thousands of inexpensive Linux servers. If a server fails, it can be replaced without affecting the overall performance of the application.

vii. Security

Web-based applications are typically deployed on dedicated servers, which are monitored and maintained by experienced server administrators. This is far more effective than monitoring hundreds or even thousands of client computers, as is the case with new desktop applications.

viii. Flexible core technologies

Any of three core technologies can be used for building web-based applications, depending on the requirements of the application. The Java-based solutions (J2EE) from Sun Microsystems involve technologies such as JSP and Servlets. The newer Microsoft .NET platform uses Active Server Pages, SQL Server and .NET scripting languages. The third option is the Open Source platform (predominantly PHP and MySQL), which is best suited to smaller websites and lower budget applications.

From the above review, it is observed that when developing web applications, one has to ensure that the many strengths web applications have like independence of operating systems, central management of updates, security among others have to be taken into consideration.

2.2 Health Indicators

A health indicator is a characteristic of a specific population, or environment which is subject to measurement (directly or indirectly) and can be used to describe one or more aspects of the health of an individual or population in terms of quality, quantity and time. (WHO, 2012).

Mainz's (2003) states that health indicators:

> Measure the extent to which set targets are achieved. They are expressed as numbers, rates, or averages that can provide a basis for clinicians, organizations, and planners aiming to achieve improvement in care and the processes by which patient care are provided. (2003, p87)

2.2.1 The importance of health indicators

The need for HIs emerged out of widespread concern about the quality and safety of care in health services across the world. As Mattke et al (2006) argue:

> The increased interest in measuring and reporting the quality of care has heightened efforts to develop quality indicators that can assess quality performance at multiple levels of the health care system. (2006, p27)

HIs can be used for multiple purposes depending on the user (managers, clinicians, regulators, patients) including to:

i. Document the quality of care
ii. Benchmark, that is make comparisons over time and between services
iii. Make judgment about services
iv. Set service or system priorities; organize care
v. Support accountability

vi. Regulation and accreditation
vii. Support quality improvement and
viii. Support patient choice of providers.

2.2.2 Types of indicators

USAID under its Demographic and Health Surveys (DHS) program provides a range of indicators that. The indicator values are derived from national level statistics or population subgroups such as those defined by age, education, marital status, economic status, urban/rural residence and region of the country. The WHO in its publication of the World Health Statistics 2013 on global health indicators part III also summarizes a broad range of key public health indicators. For this research, a sample of some indicators from DHS and WHO is summarized but emphasis for this project will be on process indicators because activities or processes within a health care organization contain two major components:

i. What is done (what care is provided), and
ii. How it is done (when, where, and by whom care is delivered).

Improvement can be achieved by addressing either component; however, the greatest impact for QI is when both are addressed at the same time (WHO, 2013).

The Table 2-1 below summarizes types of indicators relevant to this research and their description as given by WHO 2013

Table 2-1: Indicator Types

Types of Health indicators	Description
Input indicators	Refer to the resources needed for the implementation of an activity or intervention. Policies, human resources, materials, financial resources are examples of input indicators.
Process indicators	Measures of the quality of the care provided, including any element in the interaction with patients, such as diagnosis and treatment. The aim is to measure whether clinicians are adhering to (evidence based) practices which achieve the best outcome for patients.
Outcome indicators	Measures or approximations of the effects of care on the health status of patients and populations. As multiple factors contribute to health care outcomes, evaluations of outcome indicators take into account differences in case mix and controls over other covariates.
Generic indicators	Measures of aspects of care relevant to most patients.
Disease specific indicators	Measures of specific aspects of care related to predetermined diseases.
Type of care indicators	Measures of the quality and safety of different types of care including preventive, acute, chronic care.
Indicators of function	Measures of the quality and safety of healthcare functions including screening, diagnosis, treatment and or follow up.
Modality indicators	Measures of modalities including history taking, physical examination, laboratory/radiology study, the provision of medications etc.
Professional indicators	Measures of the quality of professional practice, such as nursing, mental health, nutrition, medicine etc.
Patient safety indicators	Measures of the safety of procedures or care provided to patients.
Health governance indicators	Measures of the safety and quality procedures implemented and enacted by healthcare services.

From the above review of literature on indicators, what they are and types, the researcher was helped to understand that indicators are measures. Basically a number or quantity that records a directly observable value or performance. Therefore the tool being developed should have capabilities of handling such values as numbers or percentages since they all relate to measures in relation to indicators. The relevancy of the indicator types will help the researcher in scoping the category of indicators that this project will handle.

2.2.3 Health indicator analysis tools

Collecting data is just the first step in any statistical evaluation of activities undertaken by a program or project. The data needs to be analyzed to produce statistics that will help you demonstrate efficacy and effectiveness of a given intervention. There are a number of different computer tools for effective analysis. (Newton, 2007). Some are proprietary and others are free software. (Microsoft 2013) defines free software as that can be freely used, modified, and redistributed with only one restriction: any redistributed version of the software must be distributed with the original terms of free use, modification, and distribution (known as copyleft). On the other hand, proprietary software is software that is owned by an individual or a company (usually the one that developed it). There are almost always major restrictions on its use, and its source code is almost always kept secret. Below is a review of some web based tools available for analysis of health indicators

2.2.4 HealthWRQS

The New Hampshire Health Web Reporting and Query System, or NH HealthWRQS, is a web-based data analysis system that allows public health practitioners the ability to query data and view reports instantly about the health of New Hampshire communities. The system is organized in a series of modules based on common community health indicators. Each module contains a user's guide which provides detailed, module-specific information and includes an introduction to the module, instructions on running and interpreting standard indicator reports, methodology and terminology used within the module, and detailed indicator lists with descriptions. The NH HealthWRQS website also contains information about the history and future of the system, training opportunities, and other sources of documentation.

To be able to access and use this tool, one applies to the directorate of health services of the state of New Hampshire. HealthWRQS reports are run by software that runs best with Internet

Explorer 6 or higher. Reports can be run using Mozilla Firefox; however, it has been observed for slower run-times. Unfortunately, the software is not currently compatible with Google's Chrome or Apple Safari browser; other browser and hardware combinations have not been tested, viewing of reports also requires one to install software like Adobe Reader. If one absolutely needs to use an incompatible browser, then they have got to contact the owners for help. Example of indicators handled include; Births, Death, Inpatient, outpatient, cancer incidences, environmental health, health care claims and behavior risk factors indicator reports

2.2.4.1 Strength of HealthWRQS

iii. NH HealthWRQS data analysis system allows public health practitioners the ability to query data and view reports instantly about the health of New Hampshire communities.

iv. The system is organized in a series of modules based on common community health indicators. Each module contains a user’s guide which provides detailed, module-specific information and includes an introduction to the module, instructions on running and interpreting standard indicator reports, methodology and terminology used within the module, and detailed indicator lists with descriptions.

2.2.4.2 Weakness of HealthWRQS.

HealthWRQS is a community health web reporting and querying system that available to only to New Hampshire Department of Health and Human Services and the Institute for Health Policy and Practice at the University of New Hampshire. Reviewing the HealthWRQS made the researcher appreciate important software development approaches not to ignore when developing tools like the one undertaken in this project. Literature reveals that the HealthWRQS was programmed in a modular way. Modular programming is an important and beneficial approach to programming problems. It makes program development easier. Breaking down a programming project into modules makes it more manageable (Trica, 2016). According to (Trica, 2016), the individual modules are easier to design, implement and test. Then you can use these modules to construct the overall program and enjoy other benefits like code reusability, program readability, distributed development.

Another aspect revealed from the literature is that HealthWRQS is well documented. The presence of documentation helps keep track of all aspects of an application and it improves on the quality of a software product. Its main focuses are development, maintenance and knowledge transfer to other developers. Successful documentation will make information easily accessible, provide a limited number of user entry points, help new users learn quickly, simplify the product and help cut support costs. Documentation is usually focused on the following components that make up an application: server environments, business rules, databases/files, troubleshooting, application installation and code deployment.

2.3 District Health Information Software 2 (DHIS2)

District Health Information Software 2 (DHIS2) is an open-source software initially developed by the Health Information Systems Programme (HISP) at the University of Oslo. Since then it has evolved into a globally distributed development strategy (Braa 2007). Today developers from many countries including Norway, India, Vietnam, Tanzania, and Ireland take part in the ongoing developments of the DHIS 2 platform (DHIS 2013).

In general, DHIS 2 can be described as a tool for collection, validation, analysis, and presentation of aggregate statistical data, tailored (but not limited) to integrated health information management activities (Braa et al. 2010). The users of DHIS 2 platform can customize the web based software package according to their health information needs without having to know or learn a complex programming language. This was made possible because DHIS 2 is a generic tool based on an open meta-data model and a flexible user interface (DHIS2 2013).

According to the official DHIS 2 website (dhis2.org), the software has been adapted for national Health Information Systems (HIS) deployment in seven countries - Kenya, Tanzania, Uganda, Rwanda, Ghana, Liberia, and Bangladesh (Braa et al. 2010). In addition, more than 20 countries, including Uganda, have made use of DHIS 2 at sub-national, program specific or at pilot levels.

Apart from being open source, the adaptability of DHIS 2 to the requirements of various countries has been supported by many different features integrated within the DHIS 2 platform. These features include, customized data entry, indicator defining, data visualizing through various types of graphs, web based pivot tabling, integrated GIS module, meta-data importing and exporting, custom data quality checks, user access control, integrating messaging system and DHIS 2 mobile solutions.

2.3.1 Strength of DHIS2

Manya et al. (54) explains gives the following as some of the strengths of DHIS2

1. The inbuilt validation rules and data quality checks have improved overall data quality.
2. Use of the cloud-based Central Server ensures that changes made in the system are available immediately to all user, and this setting also ensures that DHIS2 is available on a 24/7 basis.
3. Previously some of the HIS data was contained in parallel, mostly donor- sponsored systems which were not easily accessible to potential users; the DHIS2 data is however web-based and all interested users can now use web- browsers to access HIS reports from any location.
4. The implementation HTML5 standard allowing for offline data entry has made use of DHIS2 a reality even in rural parts of a country with poor internet connectivity.

2.3.2 Weaknesses of DHIS2

The challenges for DHIS2 implementation among others include the following according to

1. Political Leadership - It is essential to obtain highest level endorsement for DHIS2 implementation at National (MOH) and Provincial Level and to communicate such endorsement to everyone concerned and have the agreement of all stakeholders in writing prior to starting any project.

2. Project planning and financing - It is necessary to identify needs for DHIS2 implementation, plan the projects (including identifying the project team and indicating their roles clearly), identify financial requirements and projects to the annual plan of the MoH so that the projects are institutionalized and supported financially and otherwise.

3. Development of a DHIS2 support team - It is necessary to have a team of software developers who can customize DHIS2 to local needs as and when required. When an institution develops a project under the guidance of their own technical officers in Health Informatics and decide that it is implemented on a DHIS2

platform, there should be a team who can move in and do that work. This team can be a MOH Team.

4. Change Management - It is necessary to ensure engagement of all stake holders and appropriate training of users of new systems to ensure that they are comfortable with what is being done.

5. Capacity - User capacity to use DHIS2 effectively has also been a challenge because of the limited availability of skilled ICT work force in the health sector.

6. Too many data collecting and reporting tools (forms and registers) and lack of integration at the various levels. In addition, too many indicators defined to monitor the sector with inadequate data collection and reporting tools at the data collection points

2.4 Requirements elicitation

Requirements elicitation is the process of seeking, uncovering, acquiring, and elaborating requirements for computer based systems (Didar and Zowghi, 2008). It is generally understood that requirements are elicited rather than just captured or collected. This implies there are discovery, emergence, and development elements to the elicitation process. Requirements elicitation is a complex process involving many activities with a variety of available techniques, approaches, and tools for performing them (Didar and Zowghi, 2008). The relative strengths and weaknesses of these determine when each is appropriate depending on the context and situation. The following section presents some of the important aspects of the techniques and some challenges

2.4.1 Interviews

Interviews are the commonly used and most popular method for requirements elicitation (Julio and Paula 2006). In this method the analyst and the engineers of the requirements engineering process discuss with the different types of stake holders to understand the requirements of the system and the objective they have to fulfil in the system (Hove, 2009). There are typically two main types of interviews, which will be described in the following sections (Tira and Steve 2006).

1. Closed Interview: In this interview the requirements engineer prepares some predefined questions and he tries to get the answers for these questions from the stake holders.

2. Open interview: In this interview the requirements engineer does not prepare any predefined questions, and he tries to get the information from the stakeholders in open discussions. He mostly concentrates on finding the stake holders expectations on the system.

Generally the interviews start with the predefined questions (Julio and Paula 2006). However, in the process of the interview, a lot of different considerable things may arise, that leads to open discussion. Interviews are effective for understating the problems in the existing system and to find the general requirements of the stakeholders. But, it is difficult to decide the boundaries of the proposed system and the organization procedures using this method. To make the effective interview the requirement engineer and the stake holders has to perform in the following ways (Tira and Steve 2006).

1. Interviewer should be patient enough to listen to the stake holder's views and the requirements. He should be open-minded.
2. Stake holders should be expressive in the interview; they should express their views in definite context.

2.4.2 Observation

Observation is the method of collecting requirements by observing the people doing their normal work (Goguen and Linden 2009). This method is generally used to find the additional requirements needed by the user, when the user is unable to explain their expected requirements from the new product and problems with the existing product.

Observation is of four types (Goguen and Linden 2009; Stephen and Ian 2003. They are;

Passive observations- This is carried out without direct involvement of the observer in the society. The observation of the peoples work is carried out by recording using videotapes, video cameras and surveillance cameras. The documentation of the problems and the requirements are prepared from the recorded data.

Active observation- This observation is carried out with the direct involvement of the observer. The people are provided with the new product prototype or existing product to perform the operations on the product. The observer provides the domain knowledge to the user to work with the product and he makes the report of the requirements of the people by observing their work with the product.

Explanatory observations- In this type of observation, the users talk loudly, explaining what they are doing, while using the product. The observer takes notes using the explanation given by the user.

Ethnography- (Gustafson 2008; Hove 2009) - In this method the observer is completely immersed in the society. The observer goes through in depth observation of the society and their works. There is no particular formula to carry out this method but it is time consuming and expensive method to gather the requirements.

Interviews and observations as elicitation techniques have been used for a long time. An important part of requirements gathering is obtaining requirements from people: A step which this project undertook. Without an accurate understanding of what the stakeholders really want and need, projects cannot develop what the stakeholders' desire. Thus, requirements elicitation using these techniques is a crucial first step in the software development process (Kitapci and Boehm, 2007).

2.4.3 Focus group discussions (FGD)

Focus groups such as collaborative meetings are a very common and often default technique for requirements elicitation (Fray and Fontana 2003). Groups are particularly effective because they involve and commit the stakeholders directly and promote cooperation (Basch et al. 2000). The strength of FGD relies on allowing the participants to agree or disagree with each other so that it provides an insight into how a group thinks about an issue, about the range of opinion and ideas, and the inconsistencies and variation that exists in a particular community in terms of beliefs and their experiences and practices.

This research used the FGD in order to explore the meanings of findings that could not be explained statistically, and also get opinions/views on a topics of interest and to collect a wide variety of local terms. In bridging research and policy, FGD can be useful in providing an insight into different opinions among different parties involved in the change process, thus enabling the process to be managed more smoothly. It is also a good method to employ prior to designing questionnaires.

This method of requirements elicitation allowed the researcher to interact with the research participants which is important to appreciate users attributes and concerns that otherwise would not be collected using other methods like questionnaires that were used in this project.

2.4.4 Card sorting

Card sorting requires the stakeholders to sort a series of cards containing the names of domain entities into groups according to their own understanding. Furthermore the stakeholder is required to explain the rationale for the way in which the cards are sorted. It is important for effective card sorting that all entities are included in the process. Card sorting is a method that is used in UCD to determine how concepts for a project should be organized. It is a knowledge elicitation technique used to establish or assess the navigation hierarchy of a web site or software (Spencer, D 2004). The process involves asking participants to sort items into meaningful groups. Card sorting has various methods, such as open card sorting, closed card sorting and online versus offline card sorting. Cards sorting helped the researcher to organize web pages in the software tool as per the participants wish. This very critical in that it promotes buy in which minimizes resistance during system change over.

An insight from review of literature on requirements elicitation is that is that requirement elicitation determines the success or failure of a project and proper requirement elicitation is prerequisite for project success and therefore, without complete, clear and consistent requirement project is doomed to failure. The cost of a failed project is an enormous expense to firms (Sajjad and Hanif, 2010)

2.5 Design methodologies

A system development methodology refers to the framework that is used to structure, plan, and control the process of developing an information system (Hitchins, 2007). A wide variety of such frameworks have evolved over the years, each with its own recognized strengths and weaknesses. One system development methodology is not necessarily suitable for use by all projects. Each of the available methodologies is best suited to specific kinds of projects, based on various technical, organizational, project and team considerations. (CMS, 2008)

The arena of systems development has seen an explosion in the number of available Information systems development methodologies (ISDMs). There is no independent database that describes these ISDMs and it is not even clear exactly how many of these methodologies are in existence (CMS, 2008). Different types of development situation need different methodologies, thus Information Systems (IS) practitioners are faced with a selection problem

This project focused on development for usability which had to be followed to produce a useful and easy to use computer system. Any system designed for people to use should be easy to learn and remember, useful, that is, contain functions people really need in their work, and be easy and pleasant to use.

2.5.1 User Centered Design methodology

The term user-centered (system) design (UCD) was introduced by Norman and Draper (1986) in 1986. However, the meaning of the term has evolved: While the importance of having a good understanding of the users is stressed, the users' involvement in the design process is now also emphasized (Gulliksen et al. 2003). The ISO 9241-210 (2010) standard – formerly known as ISO 13407 (1999) – outlines UCD as a process for interactive system development with the focus to enhance usability of that system (Bevan 2009). Usability is defined in the standard as in the above-mentioned ISO 9241-11 standard. However, ISO 9241-210 does not provide a general accepted definition – only guidance for the planning and management of UCD. It also does not provide a detailed description of methods and techniques (Jokela et al. 2003). Nevertheless, UCD can be integrated into other established software development processes like the Rational Unified Process (RUP) and the family of Agile processes (Gulliksen et al. 2003).

2.5.2 Key principles of UCD

Gulliksen et al. (2003) identified twelve key principles that characterize a successful UCD process and that are not constrained to a particular development stage:

1. **User focus:** The focus should be on the users' needs – instead of technical issues – by ensuring that the development is guided by the goals and the context of use early on.

2. **Active user involvement:** Users that represent the intended user group should be, at an early stage, directly and continuously involved into the whole lifecycle and development of the system

3. **Evolutionary systems development:** The development of the system should be iterative and incremental as new and changing requirements occur.

4. **Simple design representations:** Users and all other stakeholders should be able to understand the language and representation of the design easily. Otherwise it will be difficult for them to understand the future use situation and their involvement would be sub-optimal.

5. **Prototyping:** Prototypes should be applied throughout the development in order to visualize and evaluate design ideas and solutions with real users.

6. **Evaluate use in context:** The development should be started at early stages and continuously guided by and evaluated against crucial usability goals and design criteria.

7. **Explicit and conscious design activities:** The development, especially of the user interface design and the interaction design, should be the consequence of design activities that are dedicated and conscious and not merely the byproduct of some coding or modelling activity

8. **Professionalism:** Effective multidisciplinary teams should perform the development and system design as each activity and part of the process requires a different skillset and qualifications.

9. **Usability champion:** Experienced usability designers with enough authority to decide matters concerning the system's usability should be included early and throughout the entire development process.

10. **Holistic design:** As software is interrelated with, amongst others, the activities, organization and practices of work, all facets that are affected by the system should be considered in the design process and modified and developed in parallel.

11. **Processes customization:** Since there is no UCD process that fits all situations, the contents of the process (used methods, order of activities etc.) must be adapted, customized and specified for each project.

12. **A user-centered attitude should always be established:** The development team and the client organization should be committed and aware to the value of usability

(Preece, et. al, 2004) summarizes the advantages of disadvantages of UCD in the Table 2-2 below

Table 2-2: Advantages and disadvantages of UCD

Advantages	**Disadvantages**
Products are more efficient, effective, and safe	It is more costly
Assists in managing users' expectations and levels of satisfaction with the product.	It takes more time
Users develop a sense of ownership for the product	May require the involvement of additional design team members (i.e. ethnographers, usability experts) and wide range of stakeholders
Products require less redesign and integrate into the environment more quickly	May be difficult to translate some types of data into design
The collaborative process generated more creative design solutions to problems.	The product may be too specific for more general use, thus not readily transferable to other clients; thus more costly

Reviewing the UCD methodology helped the researcher to understand the importance of focusing on designing for and involving users in the design of computerized systems. It was also learnt that the ways in which users participate varies. At one end of the spectrum involvement may be relatively light; they may be consulted about their needs, observed and participate in usability testing. At the other end of the spectrum involvement can be intensive with users participating throughout the design process as partners in the design. Involving users in design showed that it led to developing more usable satisfying designs.

2.6 Joint Application Development (JAD)

It is an organized and structured technique for requirements elicitation (Jarke and Kurki-Suonio, 2008). It involves the system owner and end users in the design and development of an application through a succession of collaborative workshops called JAD sessions. The participant in these sessions do not exceed 20 to 30 (Maiden and Rugg 2006).

The requirements engineers start the session by providing the general overview of the system. The discussion with the stakeholders and the users continues until the final requirements are gathered. This leads to elicitation of better requirements in the first attempt and it reduces the time spent on the requirements phase (Maiden and Rugg 2006). According to (Yihwa, 2009), the success of the JAD depends on; leader of the JAD session, developers, end-users and the stakeholders of the product and group involvement.

JAD is a useful process to gather cross function information and different opinions effectively. Although different people might have different understanding and application of JAD, the essence of JAD is the facilitated session. The basic components of JAD sessions are recognized and agreed-upon by JAD practitioners. They also provide some guide-lines for conducting JAD sessions. Properly following these guide-lines can increase the success of JAD sessions.

Reviewing literature on JAD helped the researcher to understand that employment of the JAD methodology enables a rapid development, and enhanced customer contentment, since the customer is continuously involved in the project. The requirements of the system are investigated, and the application is developed with the input from customer by a sequence of interviews. JAD sessions are usually used for multiple fields where customer agreement is required. Involvement of the customer is very critical as it minimizes project failure due to lack of but in.

2.7 Prototyping

Prototype is the representations or visualizations of the actual system parts (Kotonya and Somerville, 2006). The prototype is designed in the early stages of the implementation of the project. It provides the general idea of the actual system functions and the work flow. Prototyping is used to gather the requirements from the users by presenting GUI based system functions [Ian, 2006].

The main aim prototyping is to gather the requirements before the product is developed. But it is difficult to discover the additional requirements until it comes in to usage or somebody is actually using it (Kotonya and Somerville, 2006; Ian, 2006). The process of gathering the requirements from the stakeholders and the end users is limited and it is difficult to discover their expectations and the requirements on the new product without providing some model that resembles the appearance of the real product.

A prototype represents the actual product in both functional and graphical sense (Somerville, 2010). It provides the flexibility to the users and the stake holders to work with the initial version of the product to understand the system and discuss them to think of the additional and missed requirements. Prototyping is a most expensive than the all other methods of requirements elicitation (Ian, 2006).

Prototypes are generally developed in the early stages of the actual product development process. The software developers use these prototypes in the situations like,

1. When the users are unable to express their requirements.
2. If it is a new product and the users have no experience with this product.
3. Whenever the requirements analysis and feasibility studies is difficult.

These prototypes are typically of two types. They are (Luqi and Royce, 2007),

1. Throw-away prototypes: This type of prototype is not reusable and hence is discarded whenever the requirements elicitation process is complete.
2. Evolutionary prototypes: This type of prototypes is reusable. They are evolved or improved according to the feedback and is given as the original product.

Advantages of Prototyping

1. Reduces time of development.
2. Reduces cost of development.
3. The users provided with a visual representation, thus facilitating system implementation.
4. Provides high level of user satisfaction.
5. The ways in which the system can be enhanced in future is known.

Disadvantages of Prototyping

1. The users may expect the finished product to be the same as the prototype
2. Developers may be tempted to stop with the prototype.

3. Can lead to unfinished system implementation.

By reviewing the prototyping methodology, the researcher was able to appreciate the importance of providing customers with a general idea of the actual system functions and the work flow using visualizations. This in a way brings about the advantages of prototyping stated in this review. Therefore the prototyping approach will be used.

2.7.1 System Implementation

The implementation of new information systems is a significant investment for organizations. Since information systems are sociotechnical systems, development involves the joint design of activity systems and ICT systems (Davies, 2009). It is important to define the key stages of the information system implementation process. Consequently, Davies (2009) presented information system implementation stages which are concerned with a number of key activities in the process. In addition, this information system implementation process concept is similar to O'Brien (2004) who explained a five-step process called the information systems.

According to O'Brien (2004), the information systems implementation activities involve hardware and software acquisition, software development, testing of programs and procedures, development of documentation, and a variety of conversation alternatives. Also, education and training of end-users and specialists who will operate a new information system are involved.

2.7.2 Information System Implementation Challenges

Beaumaster (1999) identified and categorized problematic issues regarding the IT implementation. These issues create or worsen the implementation problems. The more specific categorizations of the issues can be viewed as: management process issues, organizational environment issues, leadership issues, technical systems issues, and personnel issues.

i. Management process issues speak to the functional operation of an organization such as budgeting, personnel, and general management.
ii. Organizational environment issues are identified as factors which are less tangible such as organizational culture, change, and behavior.
iii. Leadership issues relate to the areas which involve the interaction and direction of the organization executive.

iv. Technical systems issues are mainly those referring to the hardware and software considerations of information technologies.
v. Personnel issues are those issues surrounding each individual in the organization.

These issues impact the planning, procurement, and deployment of information systems in their organization

2.7.3 Key issues of Information Systems implementation Success

There are many investigations of IT project implementation success factors. One study from Slevin and Pinto (1986) presented a list of success factors which are the same as the Project Management Institute's Project Management Handbook (Pinto, 1998). Also, Tan (1996) .presented a set of success factors including technical characteristics, user involvement, communications, management support, project team characteristics, difference between technology provider and receiver, incentives, infrastructure support and obstacles, to identify their effects on external technology transfer project. A list of success factors are also drawn up by Milis and Mercken (2002), who found a large number of possible success factors and also provided an overview of the possible success factors regarding IT project implementation. However, in conclusion, they can group the success factors into four categories as follows. The first category integrates factors which influence goal congruency. The second category contains the components that relate to project team in order to improve the motivation and cooperation of the team. The third category concentrates on the acceptance of the project and the result. Finally, the fourth category is concerned with the implementation process which deals with implementation politics and planning.

The list below summarized some of the critical success factors that the Pinto and Slevin model (1987), which was further, expanded by Holland and Light (Holland & Light, 1999) suggested.

i. Top management support
ii. ERP strategy
iii. Business Process Reengineering
iv. Project team & change management
v. Retain the experienced employee
vi. Consultant and vendor support
vii. Monitoring and evaluation of performance

viii. Problems anticipation (troubleshooting, bugs, etc.)
ix. Organizational culture
x. Effective communication

To the researcher this was very important as it provided an insight on how the software tool developed would be implemented but importantly to also appreciate that sometimes challenges during implementation but there also proven critical success factors one can ride on for successful implementation. Most of the literature cited in here suggested that most challenges stem or are closely related to management. Understanding of management is very critical when implementing systems.

2.8 System testing

Software testing is a most often used technique for verifying and validating the quality of software (Shao, Khurshid & Perry, 2007). Software testing is the procedure of executing a program or system with the intent of finding faults (Myers et al. 2004). It is measured to be labor intensive and expensive, which accounts for more than 50 % of the total cost of software development (Jess, 2015). Software testing is a significant activity of the SDLC). It helps in developing the confidence of a developer that a program does what it is intended to do so. In other words, we can say it's a process of executing a program with intends to find errors (Biswal et al. 2010). In the language of Verification and Validation (V&V), black box testing is often used for validation (i.e. are we building the right software?) and white box testing is often used for verification (i.e. are we building the software right?) (Jess, 2015). The researcher conducted a literature review to obtain the reviews from state-of-art.

2.8.1 Testing approaches

Traditionally Software testing techniques can be broadly classified into black-box testing and white- box testing (Liu and Kuan, 2009). Black box testing is also called as functional testing, a functional testing technique that designs test cases based on the information from the specification (Liu and Kuan, 2009). With black box testing, the software tester should not (or does not) have access to the internal source code itself. Black box testing not concern with the internal mechanisms of a system; these are focus solely on the outputs generated in response to selected inputs and execution conditions (Liu and Kuan, 2009). The code is purely considered to be a “big black box” to the tester who can’t see inside the box. The software tester knows only that information can be input into the black box, and the black box will send something back out. This can be done purely based on the requirement specification knowledge; the tester knows what to expect the black box to send out and tests to make sure the black box sends out what it’s supposed to send out (Mitra and Ali, 2011)

On the other side white box testing is also called as structural testing or glass box testing, structural testing technique that designs test cases based on the information derived from source code (Liu and Kuan, 2009). The white box tester (most often the developer of the code) knows what the code looks like and writes test cases by executing methods with certain parameters (Mitra and Ali, 2011). White box testing is concern with the internal mechanism of a systems, it mainly focus on control flow or data flow of a programs (Saglietti, Oster and Pinter, 2008).

White-box and black-box testing are considered corresponding to each other. Many researchers underline that, to test software more correctly, it is essential to cover both specification and code actions (Saglietti, Oster and Pinter, 2008).

Strengths of white box testing

i. More efficient automated testing. Unit tests can be defined that isolate particular areas of the code, and they can be tested independently. This enables faster test suite processing

ii. More efficient debugging of problems. When a regression error is introduced during development, the source of the error can be more efficiently found – the tests that identify an error are closely related (or directly tied) to the troublesome code. This reduces the effort required to find the bug.

Weaknesses

i. Harder to use to validate requirements. White box tests incorporate (and often focus on) how something is implemented, not why it is implemented. Since product requirements express “full system” outputs, black box tests are better suited to validating requirements. Careful white box tests can be designed to test requirements.

ii. Hard to catch misinterpretation of requirements. Developers read the requirements. They also design the tests. If they implement the wrong idea in the code because the requirement is ambiguous, the white box test will also check for the wrong thing. Specifically, the developers risk testing that the wrong requirement is properly implemented.

iii. Hard to test unpredictable behavior. Users will do the strangest things. If they aren't anticipated, a white box test won't catch them.

From the literature above, it therefore very important to perform tests to a software. Software testing is a significant activity of the SDLC. It helps in developing the confidence of a developer that a program does what it is intended to do so. In other words, we can say it's a process of executing a program with intent to find errors

2.9 Information System Evaluation

Due to the prevalent use of IS in modern organizations nowadays, evaluation research in this field is becoming more and more important. In light of this, a set of rigorous methodologies were developed and used by IS researchers and practitioners to evaluate the increasingly complex IS implementation used. Moreover, different types of IS and different focusing perspectives of the evaluation require the selection and use of different evaluation approaches and methodologies. This section aims to identify, explore, investigate and discuss the various key methodologies that can be used in IS evaluation from different perspectives, namely in nature (e.g. summative vs. formative evaluation) and in strategy (e.g. goal-based, goal-free and criteria-based evaluation).

Despite its importance in guaranteeing IS success, evaluation is never an easy and straightforward task (Cronholm and Goldkuhl, 2003). In particular, there is a range of IS evaluation methodologies, each one having its own strengths and limitations. Moreover, different stages of the IS lifecycle are associated with different goals, changes and outcomes. As a result, the aims and focuses of evaluation at different stages will also vary. Faced with this diversity and complexity, practitioners and evaluators may often find it difficult to select which methodology is the most suitable one for evaluating a particular IS project or a particular stage of the project.

2.9.1 Formative and Summative Evaluation in IS Research

One of the most prevalent and fundamental classifications between types of evaluation was introduced by Scriven in 1967 as acknowledged by Clarke (1999). In particular, Scriven (1967) used the terms 'formative' and 'summative' to describe the two distinct approaches being applied in the evaluation of educational curricula. 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 IS, in order to suggest ways of improvement and help in the development of the change, innovation or intervention. 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 (Bennett, 2003:10).

2.9.2 Goal-Based and Goal-Free Evaluation in Information Systems Research

Although formative and summative approaches provide clear indication about when assessment should be carried out, these two methodologies do not contain sufficient guidelines on how evaluation can be done (e.g. what strategy to adopt in the evaluation? what methods to use? should any measurement criteria be set up prior to evaluation? If so, how can these criteria be set up, and more importantly, how can they be applied in the evaluation process?). In response to these limitations, Bennett, (2003) proposes to use an alternative set of evaluation methodologies, as proposed by Cronholm and Goldkuhl (2003), in conjunction with formative and summative approaches, namely goal-based evaluation, goal-free evaluation, and criteria-based evaluation.

2.9.2.1 Goal-based evaluation

Evaluation researchers traditionally believe that a social welfare program cannot be evaluated without specifying some measureable goals (Rossi and Williams, 1972) reinforces that the goal must be clear so that the evaluator knows what to look for. The goal-based approach evaluation was first developed by Tyler (1942) as a deductive methodology, in which a set of clear, specific and measurable goals are derived from an organizational context prior to evaluation (Cronholm and Goldkuhl, 2003). The evaluators will then need to measure to which extent these predefined goals are achieved in the program or intervention (Cronholm and Goldkuhl, 2003a).

2.9.2.2 Goal-free evaluation

Goal-free evaluation is an inductive methodology, which aims at gathering data on a large amount of actual effects and then assessing the importance of these effects in meeting demonstrated needs of the socio- technical environment in which the IS is to produce change or innovation (Cronholm and Goldkuhl, 2003). Both quantitative and qualitative methods can be used in this evaluation approach. Scriven (1972) highlight a number of reasons and advantages for doing goal-free evaluation, such as avoiding the risk of narrowly studying the pre-specified goals and thus missing unanticipated aspects, eliminating evaluation biases introduced potentially by knowledge of goals, and maintaining evaluator objectivity and independence through goal-free conditions.

IS evaluation research processes may vary in the nature of the process, that is, evaluation may be formative or summative. This distinction results from a difference in the implementation of the evaluation in terms of the point in time in relation to the design and development cycle of the IS; formative during the process of design and development; summative at the end of this process. 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. 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.

2.10 Review of theory

This sub section aims to provide a useful introduction to Activity Theory, especially in the field of information systems development, information systems in organizations, health care, and education. Activity Theory is a theoretical framework for the analysis and understanding of human interaction through their use of tools and artefacts. Activity Theory is particularly relevant in situations that have a significant historical and cultural context and where the participants, their purposes and their tools are in a process of rapid and constant change. The paper begins with an overview and background to the theory. Then, after explicating the practical value of its use, the paper concludes with a summary of some recent research which has used the method for analysis and discovery

2.11 Activity Theory

Activity theory is based upon the work of Vygotski and his student Leont'ev from their studies of cultural-historical psychology in the 1920s (Verenikina, 2001). "Activity theory is a conceptual framework based on the idea that activity is primary, that doing precedes thinking, that goals, images, cognitive models, intentions, and abstract notions like "definition" and "determinant" grow out of people doing things" (Morf & Weber, 2000).

Activity Theory uses the whole work activity as the unit of analysis, where the activity is broken into the analytical components of subject, tool and object, where the subject is the person being studied, the object is the intended activity, and the tool is the mediating device by which the action is executed (Hasan, 1998). Engestrom's modification of Vygostky's original theory provides for two additional units of analysis, which have an implicit effect on work activities. The first is rules, these are sets of conditions that help to determine how and why individuals may act, and are a result of social conditioning. The second is division of labour, this provides for the distribution of actions and operations among a community of workers. These, two elements affect a new plane of reality known as community, and through this, groups of activities and teams of workers are anchored, and can be analyzed (Hyland, 1998; Verenikina, 2001).

Engeström (1996) states that the work activity system is comprised of the following components:

i. Individual workers, their colleagues and co-workers
ii. The conceptual models, tools and equipment they use in their work
iii. The rules that govern how they work, and
iv. the purpose to which members of the workplace community direct their activity.

2.11.1 The practical value of Activity Theory

The value of activity theory stems from the analysis of the individual, in pursuance of their activity and objective through an examination of their tools and its mediation through rules, community and history. The assumption is that the artefact "attains its qualities of function, aesthetics, and ethics as it is integrated into the actual activity; only in practice does it become a tool. In other words to become a tool is to become part of someone's activity" (Christiansen, 1996). While observation and interviewing may reveal the explicit aspects of the participant's actions, they will not assist in the understanding the implicit motivation of actions and operations. While it is not always possible for people to articulate what they do:

Nardi, 1996 state that;
"it is certainly very difficult to say how you type, or how you see the winning pattern on the chessboard, or how you know when you have written a sentence that communicates well" it is possible to gain some understanding of actions and objectives when they are executed at a higher level

Activity Theory, however, through the examination of artefacts can render explicit the more tacit elements of an action. Dancers, for example, use imagery and other verbal techniques to teach dance skills that are extremely difficult to verbalize. The ability to bring operations to a conscious level, even if only partially, is an aspect of the dynamism of the levels of activity as posited by activity theory (Nardi, 1996).

2.11.2 Application of Activity Theory in Information Systems

A key attribute of Activity Theory is its focus on argumentative (dialectic) analysis on the interaction between people (human) and their mediated tools or artefacts (purpose) which have been shaped by human activity (technical elements). With the advancement of the Internet, information systems and computer-based technologies Wartofsky (1979) proposes these information systems as tools of mediated human activities which have several characteristics: They can be primary – tangible, external or physical, secondary – internal, semiotic or mental, or tertiary – schematics where mind and culture act together such as environments or ecosystems. An activity comprises set of actions which aim for specific goals and operations, these actions are indicated clearly in the information systems domain and can be found in the routines and cognitive or behavioral processes which are a common element of activities involving information systems.

The human side of Information Systems is commonly referred to as Human Computer Interaction. This interaction involves the juxtaposition of the computer and its suite of supporting tools such as software applications and communications tools such as the Internet to ease and improve human working activities and communication processes. In the 1990s, researchers began to recognize the importance and relevance of Activity Theory to the study in Information Systems and Human Computer Interaction and many studies have proceeded (Kuutti, 1996).

An early study on Human Computer Interaction was carried out by Bodker (1990). In his study Activity Theory was used to analyze levels of interaction using a tertiary tool in the knowledge creation processes. The research focused on interaction between activities of information technology developers and the activities of users of their products.

In another study, Korpela et al. (2002) analyzed the Activity Theory framework in Information Systems Development as a work activity in context. They found the framework added value to their analysis through the enhancement and natural evolution of real-life data which can be applied instantly and is more easily grasped by people.

In later research by Hakkinen and Korpela (2006), Activity Theory was used to understand the practices of information management within a maternity care activity network (in health care application and software design). They found that the use of Activity Theory proved useful not only in understanding user group activities in their development of information systems, it also allowed a multi-faceted analysis of the information and its users and the dynamics between them.

Extending from the research of Korpela et al, Karlsson and Wistrand (2006) studied the coupling of Activity Theory with method engineering as a theoretical framework for the analysis of systems development. In this context, method engineering from an activity theory perspective can be distinguished through collective of actors following different rules and activities in form of methods in order to guide and further improvements in work processes to gain better outcomes or results. As systems development is a socially collaborative activity, activity theory works well with method engineering which has benefits as a theoretical exercise and a practical tool.

As these research projects have shown, Activity Theory is not merely a methodology it is a theoretical framework valuable in the analysis of human practices on the multiple dimensions of individual activities and social interaction (Kuutti, 1996). Crawford and Hasan (2006) add to this with their claims that Activity Theory provides a rich, holistic understanding of how people do things together with the assistance of sophisticated tools in complex dynamic environments where socially- constructed, collective knowledge is the predominant source of learning, creativity and innovation. Indeed, Activity Theory is geared towards a practice which embodies a qualitative approach that offers a different lens for analyzing learning processes and their outcomes. It quite neatly focuses on human activities in areas such as those in the field of education.

2.11.3 Conclusion

Many researchers in information systems have found that activity theory provides a worthwhile framework for understanding their field of study. Activity theory is useful because it describes activities as hierarchical in nature and provides a model for decomposing activities into actions and operations. It insists that activity is mediated by tools, which helps to explain relationships between the user and the tool. Activity theory views activity not as a simple individual action but as being culturally and historically located. In other words, activity theory stems from its fundamental view of purposeful activity in a cultural historical context as the fundamental unit for the study of human behavior. Activity Theory is an approach which underpins the complex and dynamic human problems of research and practice. Hence, Activity Theory is geared towards a practice which embodies a qualitative approach that offers a different lens for analyzing processes and the outcomes.

CHAPTER THREE

METHODOLOGY

This chapter gives the methodology that was to review the existing system, to identify the requirements of the new system, and those methodologies that were applied to design and implement the new system and finally the testing.

3.1 Review of the Existing System

This phase incorporated the change strategies from Kotter's first four stages (establishing a sense of urgency, creating a guiding coalition, developing a vision and strategy, and communicating the vision) along with the knowledge, persuasion, and decision phases of the Innovation Diffusion Theory. In this phase, the theories state that it's important to take time to understand end users of a system. The researcher used document reviews, focus groups and interviews to gain an understanding of the needs, wants and expectations of the users

The existing system for processing the health indicators was reviewed in order to identify its strengths weaknesses and gaps. This helped to identify what should be maintained, what should be avoided and what should be added in the new system. The methods applied to review the current system were document review, questionnaires and focus group discussions.

3.1.1 Document Review

This was done in order to gather background information regarding the operations related the data collection process, tools used and how the data was being managed.

The review of the existing system started with examining;

i. the data collection tools currently being used to record data from the field. These tools are; the SMC Indicators data collection for HFs tool, The HIV CoR Data Collection Tool, USAID ASSIST Implementing Partner Geographic Coverage Sheets, A sample of these tools is given in Appendix I
ii. the spreadsheets (structure, formulae, validation functions etc) into which the data from the collection tools is migrated to.

iii. the key reports namely; HF specific Monthly and quarterly reports, HF indicator specific reports, and
iv. the data presentation standards document

The purpose of reviewing data collection tools was for the researcher to understand the nature of data collected, frequency of collection, persons responsible. Reviewing the excel sheets enabled the researcher to understand the data structure, formulae, validation rules, functions and other business rules. The keys helped the researcher to understand especially results that come from the data collected and analyzed that's is presented in the reports

3.1.2 Questionnaire

A questionnaire as shown in Appendix II was then designed to capture the following information;

i. the categories of users of the new system
ii. the users' tasks and responsibilities
iii. levels of experience with the existing system

The above information was very important in understanding characteristics of potential users and, information needs and their levels of interaction with their existing system.

The questionnaire was administered to eight QIOs, one MEO and one administrator. These numbers were based on whoever was available during the administration of the questionnaire and these numbers are 79% of the staff population. According to Survey monkey (2014) this percentage will give a margin of error of 5% and a confidence level of 90%. This is a satisfactory range.

3.1.3 Focus Group Discussion

A Group Discussion Guide was designed as shown in Appendix III. The information that was required to be gathered from the discussion was;

i. the functionalities that the users need from the system,
ii. the user's needs, and the form and format that it should be availed,
iii. what the users think about the system and how they expect it to work and
iv. the normal and extreme operational environments

The same staff sample that was given a questionnaire (eight QIOs, one MEO and one Administrator) was constituted into a focus group and the group was asked to carry out a discussion based on the Discussion Guide

3.2 System Requirements

To identify the user requirements, a requirements collection prototype approach was employed. The interactive prototype system was based on the information that was gathered when reviewing the system. A User-Centered Design (UCD) process was followed. UCD philosophy optimizes the product around how users can, want, or need to use the product, rather than forcing the users to change their behavior to accommodate the product. The goal of UCD is to produce products that have a high degree of usability which is 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. Therefore during requirements identification the focus was on the following areas of concern. That the product;

i. achieves the goal and does the tasks needed by the user,
ii. is easy to use based on speed of performance, error rates and forgiveness,
iii. is easy to learn and re-learn within a predetermined period of training and
iv. meets the users perceptions, feelings, opinions and expectations

Following the International Usability Standard, ISO 13407, the design was based upon an explicit understanding of users, tasks and environments. This was achieved by involving users throughout design and development. Also at appropriate stages the design was refined based on user-centered evaluations. Therefore the process was iterative and utilized the user experiences.

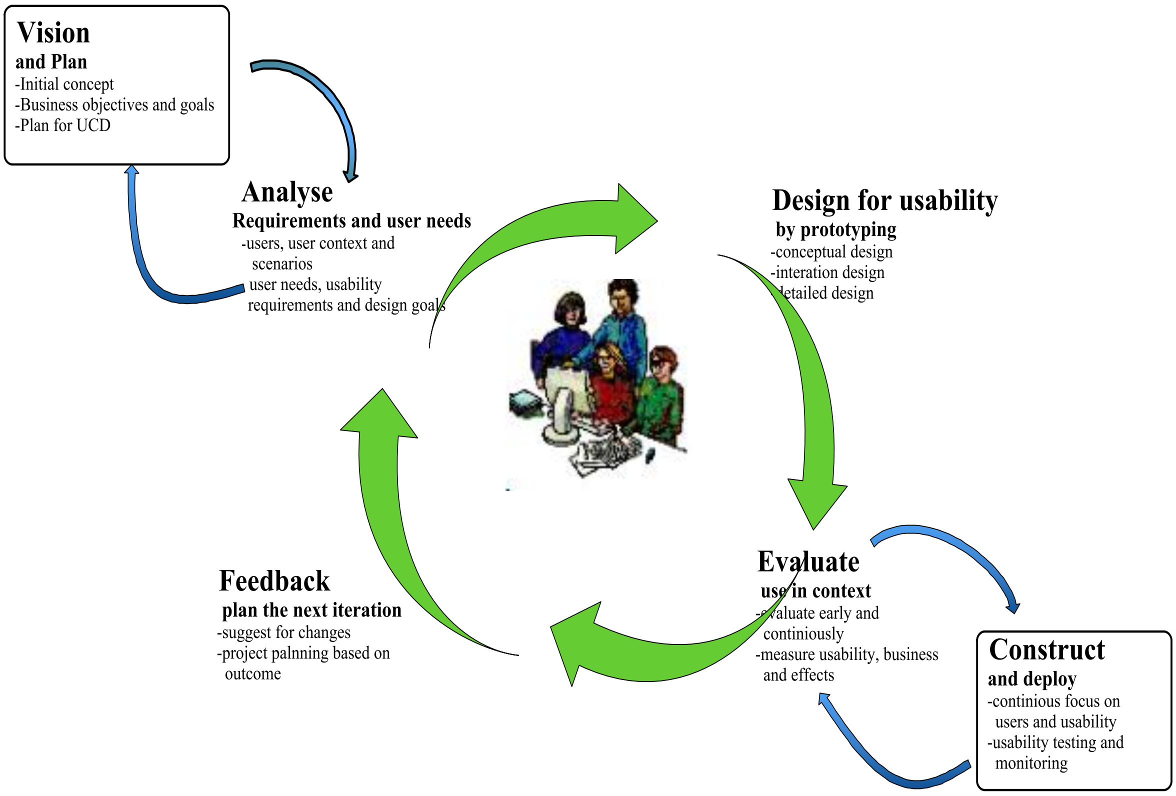


Figure 3-1: User Centred System Design Process (Jan Gulliksen2003)

3.2.1 Design for usability

Before executing the UCD processes, the intended users of the system were identified based on the questionnaire responses and the group discussion. For each user or group of users the operating environment was established. This environment was established based on the data they need, how they work on it and what they should produce from this data (inputs, processing, output). This also established those tasks a user is to perform on the tool.

3.2.1.1 Conceptual design

Use Case modeling was used to model and define the interactions between a role (an "actor") and the system, to achieve a goal. In addition Entity Relationship Diagrams (ERDs) were developed to depict the relationships between the various entities in the new system. The appropriate attributes for each entity were then identified. This constituted the conceptual design of the tool.

A logical model of the database was then derived by mapping the conceptual model into a relational data model and normalizing it to Boyce Code Normal form. Finally the relational data model was mapped into a physical data model anchored on MySql database management system.

3.2.1.2 Interaction Design

Sketches on papers were used to make ideas visible to the potential users and facilitated efficient communication with them. This minimized the possibility of reworking the product in later stages of the lifecycle and therefore avoiding the associated costs and time that result from reworking the product.

During this stage emphasis was put on the creation of ideas, concepts and solutions in communion with the potential users. . It not only concentrated on the graphical design, but also the information architecture, the interaction design, information visualization, etc. A requirements collection prototype method was adapted to identify user centered requirements. Two techniques were adapted to achieve user participation in developing these requirements. The techniques were;

Card sorting- This is a method that is used to determine how concepts for a project should be organized. The goal of card sorting is to help the users know how to best organize a website or software application so that the structure of information will be logical for the largest number of users.

In the card sorting process, the researcher wrote down words of possible labels for the various system menu on sticky notes. Participants were given a number of sticky notes, each containing a different word and were asked to organize the sticky notes in their best possible arrangement. The results were recorded and the card sorting process was repeated with a more set of test participants. It is this information that the researcher used in the creation of navigation elements. This helped to get user input on how to label categories contents and also to understand how users thought about researcher's information and its relevance to them.

Paper prototyping- Is a technique that consists of creating hand drawings of user interfaces in order to enable clarification of requirements and enable draft interaction designs and screen designs to be very rapidly simulated and tested. The technique features the use of simple materials and equipment in order to create a paper-based simulation of an interface or system. Interface elements such as menus, windows, dialogues and icons can be sketched on paper or created in advance using card, acetate, pens etc.

The researcher with the help of four potential users sat around a table and sketched possible screens in a brainstorming environment. The names of the suggested screens were written down. Using one user at a time, the researcher read out likely tasks and asked them to carryout realistic tasks like selecting an options on a given screen upon which the researcher kept on explaining what would happen by either pointing or presenting the next screen. Different sessions were conducted by manipulating the paper prototype as the users worked through the tasks. The researcher took notes as participants went through the activities. Summaries of all design implications and recommendations for improvements were noted and the team was debriefed and thanked for taking part in the activities. This was important as it encouraged the stakeholders, more specifically the users to play an active role in developing the requirements, terminology, navigation and page layout. This ensured that people could complete the critical user journeys with the interface (Desiree, 2007). The end result of this step was production of design solutions that included mockups and sketches of the layouts, structures and interaction possibilities that later guided the creation of the new design.

3.3 Evaluating the Design

In this activity of the lifecycle, the design solutions were evaluated. The goal-based formative evaluation, a combination of the goal-based evaluation and formative evaluation type was used. The goal-based formative evaluation was mainly used during the design and development of the software tool and it provided a crucial contribution to ensure quality, usefulness and acceptance of the tool. This type of evaluation is often associated with IT and SW centered evaluation processes, an approach used on this project. The aim was to generate feedback to further improve the product and to determine if the design fulfilled the specified user requirements, usability goals and complied with general usability guidelines (Benyon 2010). The cycle of the UCD activities continued as long as the usability objectives had not been met. To achieve this, the participant-based methods involving potential users to use the system was be used. These included, observation and laboratory studies

3.4 Designing the Best Solution

After selecting the best solution, the Unified Modeling Language (UML) was used to model a detailed system behavior. Use cases and sequence diagrams were used to represent the key components, interactions of the various objects in the system and the dynamics and expected performance of the system processes. UML was be used because it is extensible, method independent and facilitates construction of models that are used to reason about the system behavior (Robert, 2003).

3.5 Implementation

In this phase, the design was used to develop a functional system. Usability testing was done throughout the implementation to ensure continuous user involvement. The indicator analysis tool was implemented on the Microsoft Windows operating system platform and anchored on web based technologies. Therefore the tool is accessible using any Web Browser application.

The database component of the system was implemented using MySQL database management system. MySQL was among other database management systems because it is an Open Source software and therefore using it does not require licenses and the associated costs. In addition Apache web server application was used to provide the web server services. PHP scripting language was used for creating the web pages and implementing the business logic that is required to attain the required system functionalities. The reasons for selecting PHP is that works well with HTML and allows the use of a single inexpensive server.

3.6 Testing

A set of test data and test plan was developed and is shown in Appendix IV

Three different methods were used to test the selected aspects of the software. The methods were namely White Box, Black Box and Grey Box testing methods.

a) White Box Testing - This method was employed on those software code fragments which are critical to other sections of the software. Investigation of the internal logic and structure of these code fragments was carried out to trace and ascertain their internal working. Fragments that were behaving inappropriately were revised.

b) Black Box Testing – Different modules were subjected to this test mainly by the users since they did not have any knowledge about the internal working of the code. The test was carried out by a tester interacting with the system's user interface to provide inputs and examining the outputs without knowing how and where the inputs are worked upon. The same test was carried out after compiling the modules into one product, to establish that the modules work together as one unit.

c) Grey Box Testing - Unlike black box testing, where the tester only tested the application's user interface, in Grey Box testing, the tester had access to design documents and the database. Having this knowledge, the tester was able to better prepare test data and test scenarios when making the test plan.

3.6.1 System Tests Carried Out

The system tests that were carried out during the testing phase are;

i. Functionality tests provided comprehensive testing over the full range of the established user requirements.

ii. Module and Integration Tests verified that all the modules function individually as desired, and properly function together as a single unit.

iii. Inter-operability tests determined whether the system can inter-operate with other third party products namely Microsoft Word and Microsoft Excel.

iv. Basic tests which provided an evidence that the system can be installed, configured and be brought to an operational state.

v. Security Tests – These were carried out to verify that the system meets the security requirements for confidentiality, integrity and availability of data. Confidentiality ensured that data and system processes are protected from unauthorized parties. Integrity ensured data and process are protected from unauthorized modification.

Availability ensured that data and processes are protected from the denial of service to authorized users.

vi. Upgrade and Downgrade tests that verified that the software can be upgraded or downgraded (rollback) in a graceful manner**.**

CHAPTER FOUR

SYSTEM ANALYSIS, DESIGN AND IMPLEMENTATION

This chapter gives the details the analysis that was done on the data that was collected. The analysis resulted into establishing the user and system requirements. These requirements were then used to implement the system.

4.1 System Analysis

From the data that was obtained using the questionnaires and the focus group discussion, the users of the current working environment and indicator processing system, was understood. Other areas assessed included; staff ability to perform data analysis, a description of their data management process, challenges faced with the current system and how such challenges are being addressed, and finally the strengths of the current system.

a) Users

Basing on the focus group attendance sheet and self-introductions it was discovered that all officers present were University graduates. Ten (10) of them (constituting 84%) were graduates of medicine and 8%were graduates of Statistics and 8% of them were graduates of Management Studies. All the twelve members of staff are computer and internet literate. It was discovered that all 12 (100%) participants selected were computer literate and had ability to use internet. Analysis also revealed that each officer spent 60% their working time in a month in the field and only spent 40% of their time office. These results show that the training time that will be required is minimal and that it is highly likely that the tool will be accepted by the users since they are all computer literate and with an urgent need to be able to monitor health indicators even when out of the office

b) Staff ability to perform data analysis

It was found out that all the twelve officers in the focus group are capable of performing data analysis to the expectation of the project data presentation norms. However, the practice is that all the data collected is handed to the MEO who is the one with a responsibility of analysis the data. It was also established that the MEO ably analyzes data as per the needs of the organization to produce Summary tables, Graphs and Frequency tables

c) **Data management process**

When asked how data was managed. The researcher analyzed the information provided and came up results as summarized in Figure 4-1 below.

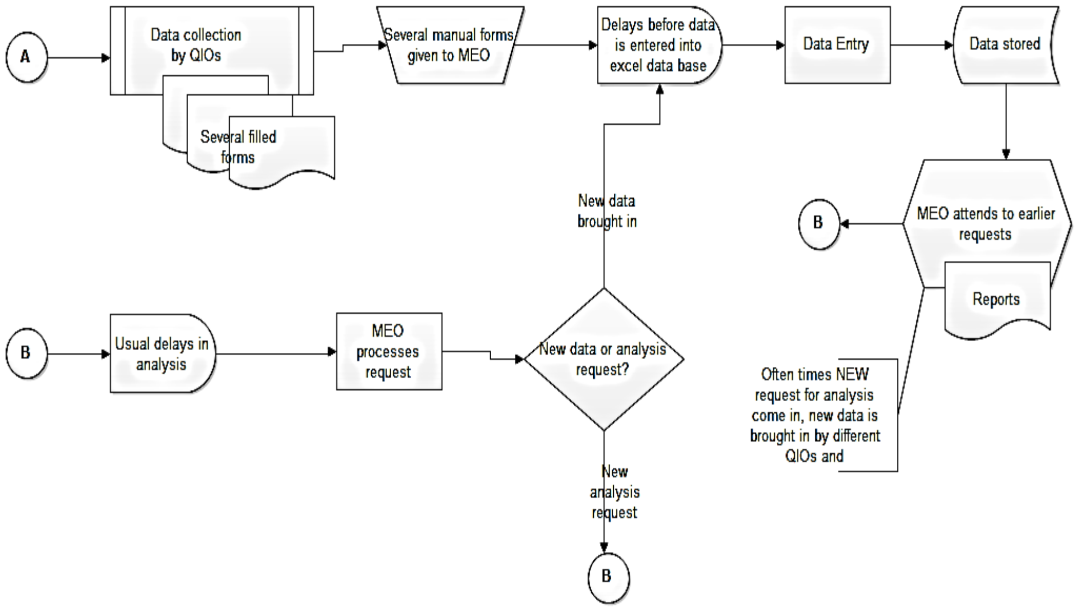


Figure 4-1: ASSIST Data management process

d) **Challenges with the existing management and data analysis tool.**

All members in the sample expressed concerns about the existing system. These concerns were of a functional character and therefore were useful in identifying some of the functional requirements. Below are some of the challenges expressed

1. They are not able to have access to an updated database anytime they need to. Therefore they cannot perform their own analysis any time

2. All members in the sample complained that it was difficult to have timely analysis especially, when there were numerous requests made to one person.

3. The MEO reported that it was very cumbersome to find and query out certain trends that satisfied a certain criteria because of the way the data was stored in the database.

4. The MEO also reported the challenges encountered when integrating data into the master database especially when data entry is carried out by temporary staff. These including manually copying and pasting until all the integration was completed

5. Another challenge mentioned was the maintenance of several databases. The officer reported that he manages a number of databases as per the program technical areas. The more the technical areas covered, the more databases that would be maintained

e) Addressing the Challenges by staff

When asked how the above challenges were overcome, different staff had different ways of managing the challenges.

i. Seven out of the twelve Quality Improvement Officer (QIOs) (58%) reported that they always simply wait or send numerous reminders to the MEO. However, below are some of the other responses.

ii. Five out of twelve (48%) of the QIOs reported that before handing in the filled data collection tools to the MEO, they photocopied and performed their 'own' entry and data analysis to avoid delays as their subsequent monthly coaching activities are based on results collected earlier.

iii. All the twelve (100%) of the members reported working beyond official closing hours in a bid to catch up with unfinished businesses caused by unavailable complete and updated data

iv. The Monitoring and Evaluation Officer (MEO) reported that the program hires temporary staff to help with data entry.

v. Upon completion of data entry, the MEO reported that he manually merges the data from the various sheets

It therefore became clear that the researcher had to design a system that would minimize the above drawbacks.

f) Strengths in the Current System as reported the staff

The MEO is a full time user of the existing system. Therefore this user was best in providing most of the functional strengths in the current system. However, others members who are simply recipients of the products from the existing system also gave some qualitative aspects. The strengths identified by the two categories of users are summarized as;

i. It performs aggregation of data effectively though not efficiently
ii. navigation of the excel sheets is easy
iii. modification of database and data is easy
iv. the graphs generated are clear and attractive

The researcher therefore learnt that new proposed system would have to maintain or further improve on the strength of the old system

4.2 Requirements analysis

The main objective of this project was to develop a system. Therefore systems requirements needed to be identified and defined. The requirements were grouped into two categories, that is, functional and non-functional requirements.

a) Functional requirements

Functional requirements defined the basic functions that system must have in order to be able to satisfy the user requirements. The functional requirements identified were that the system should;

i) Be web driven to address issues related to fragmented storage and access
ii) Accept data from users through use of interactive graphical user interfaces,
iii) Be able to process and effectively retrieve data and information,
iv) Generate indicator performance reports

b) Non-functional requirements

Nonfunctional requirements are those that improve the use of the system but do not have to be there for the system to satisfy the objectives. The nonfunctional requirements are that the system should;

i) Provide security to the database by use of passwords.

ii) Enable backups to be performed at pre-determined specific times;

iii) Be accessible on any computer as long it has internet connection through any browser;

iv) Be fast enough to satisfy database update and retrieval processes;

v) Permit multiple (concurrent) accesses and

vi) Be easy to learn and to use.

4.3 Application of User Centered Design and the Activity Theory

This subsection is outlined in close similarity to the activity cycle of ISO 13407 (1999), as it is illustrated in Figure 3-1. Hence it starts with understanding and specifying the context of use, followed by specifying the user and organizational requirement and ends with the production of design solution, which is closely coupled with the evaluation of the designs.

4.3.1 Specifying the context of use

As described in the ISO standard the first step of the UCD process is about understanding and specifying the context of use Thus at first the users and their tasks had to be identified and the environment in which they performed the tasks had to be described. However, before the users, the tasks and the environment for the prospective system are covered, the currently used system is briefly described; including the problems the user's face with it and the expectations they have for a new system.

In activity theory, it was very important to clarify the purpose of the activity system. Context is not persistent and fixed information. Continuous construction goes on between the components of an activity system. Humans not only use tools, they also continuously renew and develop them either consciously or unconsciously. They not only use rules, but also transform them. In the design, it was important to understand how things got done in a context and why. This is because different contexts impose different practices. To analyze context, the researcher needed to know the assumptions, models and methods commonly held the users, how individuals referred their experiences in other groups, what tools they found helpful in completing their problems

Since there was no pre-existing explicit knowledge about the tasks performed by the users of the old system, a very explorative research approach had to be chosen. To gain the needed knowledge about the tasks and processes between the various users, interviews were conducted. Twelve (12) members were purposively sampled. Twelve (12) respondents were targeted by the researcher because of not only the keen interest they had in the new anticipated innovation but also because of the key positions they hold in the organization which would help influence the others. It's these twelve that participated in the interviews.

The interviews questions were both open and qualitative. Till the interview outline reached the form presented in Appendix III, it underwent several iterations to optimize its structure and phrasing. The partial standardization introduced by using an interview outline allowed comparing the conducted interviews and ensured that all relevant topics were covered during the interview.

The interview questions were designed to be open to allow the participants to answer freely. This has according to Mayring (2002) the distinct advantage that the interviewees reveal their very subjective perspectives, views and interpretations and are able to develop independently bigger coherences. Since the interviewee shouldn't feel squeezed, the questions were phrased to be friendly and unthreatening. Additionally, a relaxed atmosphere was induced as much as possible by performing some small talk at the beginning of the interview (Bortz & Döring 2006). The interviews were conducted in person and recorded. Since the prospective system is supposed to replace the old system based on using Ms Excel to manage health indicators data, the current context of use is summarized before the context of use for the new system is defined.

Currently the excel system has three users: the Monitoring and Evaluation Officer (MEO), the Quality Improvement Officers (QIOs) and locum staff. If MEO wants to (among other things) analyze data and produce a certain report, he first has to enter the data into the excel database, then perform the necessary analysis like producing run charts or graphs. However, because of other responsibilities charged to him, sometimes the data entry is not done in time which leads to accumulation of un-entered data and as such the QIOs cannot get results in time

In such cases, the MEO makes use of locum staff (temporary staff) to help with data entry. When more than one locum is employed, each uses a separate but similar database for data entry and it is from these independent databases that the MEO updates the main database by coping and pasting from the various ones used by the locum. So requests from the QIOs are sometimes delayed because of the lack of multiple accesses.

QIOs cannot update database themselves even when they wish to help because of the way the database is maintained, an excel work book with several sheets equivalent to the number health units supported under that program areas is maintained. All these sheets have a similar structure (Fig: 4-2, HFs circled red)

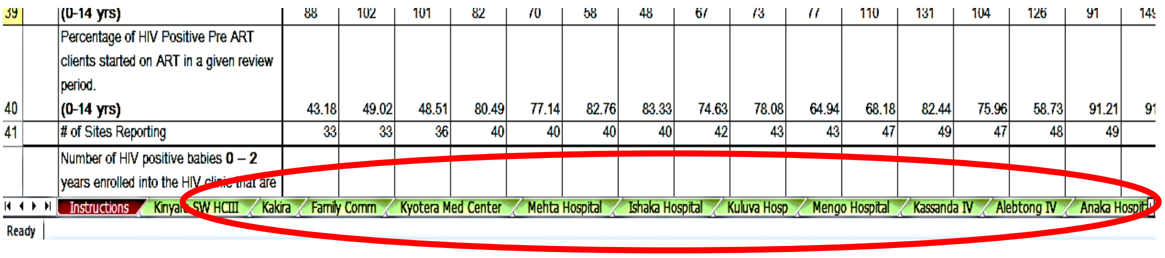


Figure 4-2:   Sample database currently used

In case the QIO needs a report, an email will be sent the MEO. The response time into which a request is serviced depends on a number of other factors, like the number earlier un- serviced requests and the others tasks the MEO has to perform. When is a report is finally made, the MEO copies the results and pastes them into a word document and mails back to the requestor

The foundation of any UCD process is to understand the intended users of the product, their environment of use, and the tasks they are using the product for. Therefore, a typical UCD process starts with identifying the users. This includes secondary and indirect users. The emphasis is on identifying the characteristics of the users and user groups rather than individual people. Following the identification of prospective users follows the identification of the tasks the users are to perform. The description should include the overall goals of the use of the system. The tasks should not be merely described as functions and features but include description of the characteristics that influence usability, such as frequency and duration of use. For specifying and understanding the context of use, it is important to describe the environment in which the users use the product. This also includes used equipment – e.g. software, hardware and other material. Furthermore, the description should include relevant characteristics of the social and physical environment

.

1. **Identifying the Users**

From the interviews conducted, there are three user groups who will use the system directly. These are; the Quality Improvement Officers (QIOs), the Monitoring and Evaluation Officer (MEO) and Program Heads. All are university graduates and with ability to use computers and the internet. The Program Heads can be regarded as indirect users of the system. They are not involved in the actual data collection, entry or analysis. But their requests trigger the need for reports and they are naturally very interested in the outcome of that request Following the identification of prospective users follows the identification of the tasks the users are to perform

2. **Identifying the Tasks**

The MEO must be able to create user groups, user roles, system users, permissions, program areas, indicator categories, indicators and all these should have all the necessary information required Both the QIOs and the MEO must be able to perform the various data management activities like data entry; both must be able to perform analysis any time retrieve reports anytime All user groups stated that they need to search and find data; including already saved analysis results. For specifying and understanding the context of use, it is important to describe the environment in which the users use the product. This also includes used equipment – e.g. software, hardware and other material

3. **Description of the environment and equipment**

The working area from which the new system will be expected to be used included individuals who are computer literate each with a functional personal computer Each individual user has at least one laptop available with at least one display (with the physical screen size of 17" and a resolution of (1600 X 1200), a wireless mouse. Some laptops run the Windows 7 operating system others the Windows 8 Desktop Operation system. All users have a recent version of the Internet Explorer 11 and Fire Fox to access websites in the Internet and Intranet. The Offices have full time internet access using both LAN and wireless technologies. Internet explorer is not used as much as the Fire Fox. The web browser is usually run with its window size maximized.

When in the field for some officers, they still move along with the same laptops used in office, and internet access is through the 4G Mobile wireless Modems provided by the offices that ensures that at all times officers have access to internet.

4.3.2 Specifying the requirement

The second activity of specifying the user and organizational requirements is about structuring the information collected in the previous step. Various methods to accomplish this task are presented by several authors (Constantine and Lockwood,1999). For this research, User roles, scenarios and use cases were used.

1. User Roles

Constantine and Lockwood (1999) define a user role as "an abstract collection of needs, interests, expectations, behaviors, and responsibilities characterizing a relationship between a class or kind of users and a system." A single user can take on several roles. Each role can be played by any number of users. Following were the identified user roles:

a) Monitoring and Evaluation Officer (MEO)-User role

Frequent and regular, almost daily use; numerous requests per week; Analyses to provide reports; postpones some requests for later processing; full time access; criteria: efficiency in use; reliability in use.

b) Quality Improvement Officer's (QIO) –User role

Provides data for entry per month; performs entry, requests reports; searches for reports using various criteria; criteria: learnability

The above two user roles can be regarded as the most common or typical one. Even though, it is merely an indirect user the role of the Program Head, it will also be presented, in order to provide an utmost holistic view upon all users of the system.

c) Program Head's-User role

Seldom indirect use; initiates request via QIO.

2. Scenarios

Scenarios are narrative description of an activity or activities (Constantine & Lockwood, 1999). The scenarios depicted in the next paragraphs are quite abstract, as this lets them to be particularly useful for generating design ideas and for understanding the requirements of the system (Benyon,2010). The scenarios depicted in the next paragraphs are quite abstract, as this lets them to be particularly useful for generating design ideas and for understanding the requirements of the system. They include; one for adding health indicators, analyzing,

a) Adding health indicators data

An officer with access or permission to system identifies himself, he specifies the areas whose data is to be added, he then selects a required form and enters the required data from the form used to collect it. After performing data entry, he saves the data. If changes are required, the officer selects an option that permits making changes and then saves

b) Analysing health indicators data

The MEO/ QIO accesses system to identify him, they check if all necessary information is available and up-to-date. The analysis option is selected, required criteria is in put and a required report is generated

c) Producing reports

The MEO access the system and selects the reports sections, selects desired report, inserts desired reporting period, checks if all necessary information is available, a selects to produce desired report.

3. Use cases

A use case is a case of use and expressed as a narrative description of interaction between a user – in some role – and some system (Constantine and Lockwood, 1999). They are often formulated in a linear continuous sequence. Constantine and Lockwood differentiate between use cases and essential use cases. Essential use cases focus more on the purpose or intentions of a user than the non-essential (or respectively, conventional) use case, which contain too many premature assumptions. Since they recommend the use of essential use cases, that kind of use cases will be employed for this work.

The following Table 4-1 indicates the use cases in this application based on the tasks that were identified during findings presented in earlier sections

Table 4-1: Use Cases

	User task	System response
1	Add new user	Present form for user profile data entry and save
2	Add new program area	Present form to add program area details and save
3	Add new health facility	Present form to add health facility details and save
4	Add new indicator	Present form to add indicator details and save
5	Select required form for data entry	Present a form that permits selection of required form
6	Enter data from data collection form into appropriate form	Add and save
7	View list of data entered	Present required data
8	Analyze a particular data set to get report	Allow user to enter desired criteria and provide results

Each 'textal' use case was then blown into its own 'user manual' style document detailing the dialogue between the 'system that was being developed and the 'actors' (people, things or other software that interact with your software

A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved (Marakas, 2006). A use case diagram can identify the different types of users of a system and the different use cases and will often be accompanied by other types of diagrams as well (Benyon, 2010). The following Figures 4-3 and 4-4 illustrate how the Monitoring and Evaluation Officer (MEO) and the Quality Improvement Officer (QIO) interact with the system respectively

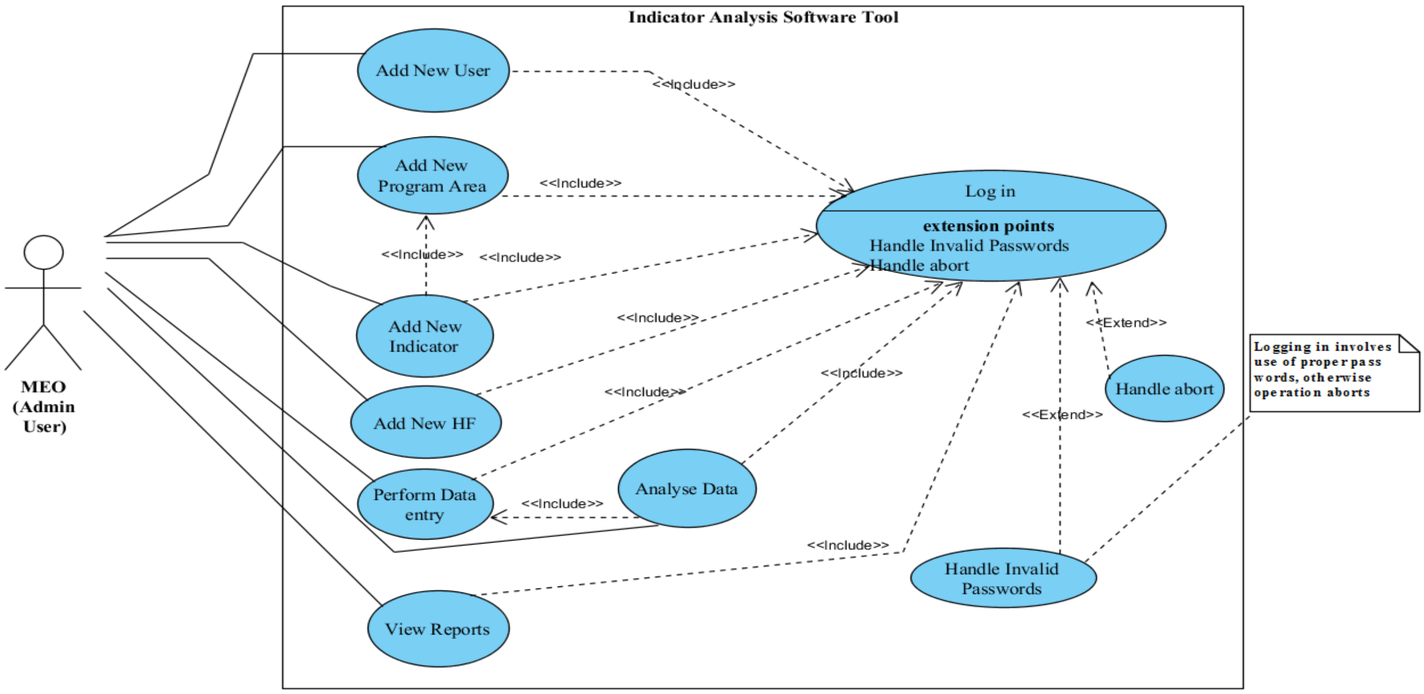


Figure 4-3: Monitoring and Evaluation Officer's Use Case Diagram

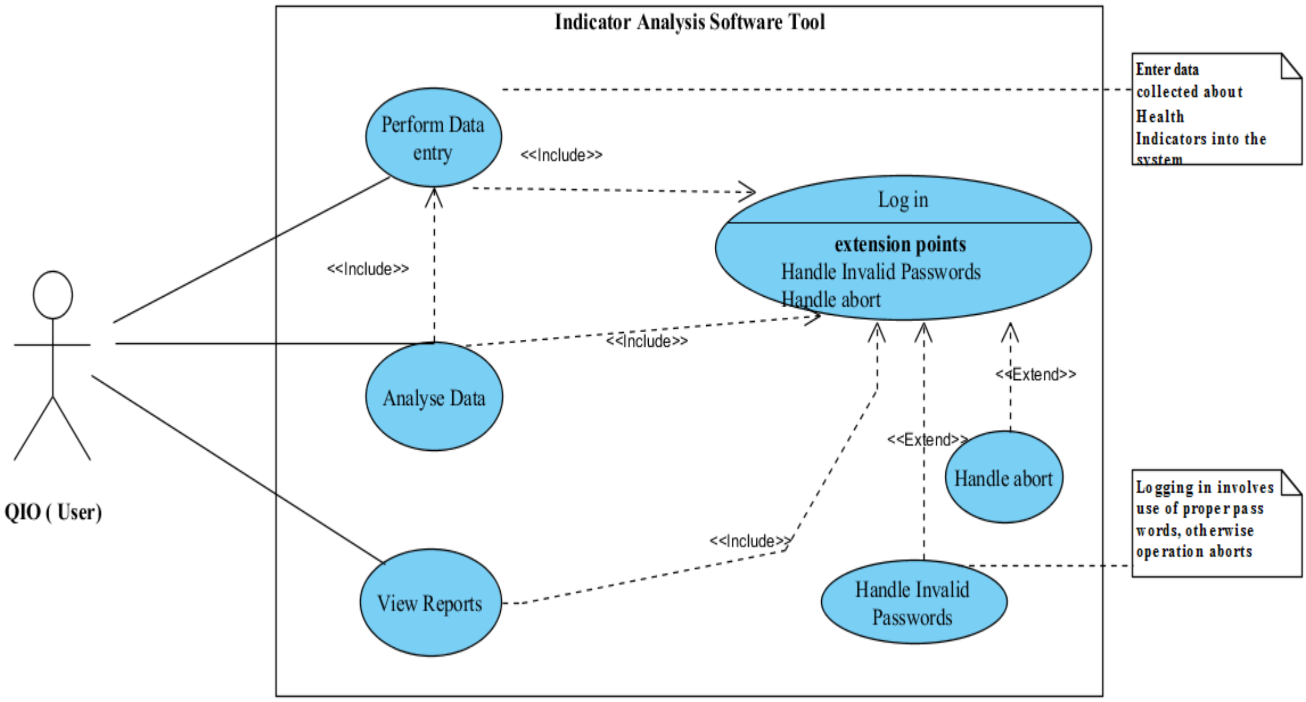


Figure 4-4: Quality Improvement Officer's Use Case diagram

To be able to show how the objects interacted with others in a particular scenario of a use case, a sequence diagrams were developed as shown in Figures 4-3, 4-4, 4-5. The diagrams depicts the collaboration of objects based on time and sequence.

Sequence diagram for adding new indicator

In Figure 4-5, a user logins in through a user interface by inserting user credentials, the system validates details that the user has provided with the ones stored in the database. When the validation process is successful, the system retrieves the list of available programs and returns the list to the user who then selects a required program area. The user then enters the new indicator, then the system updates the indicator details.

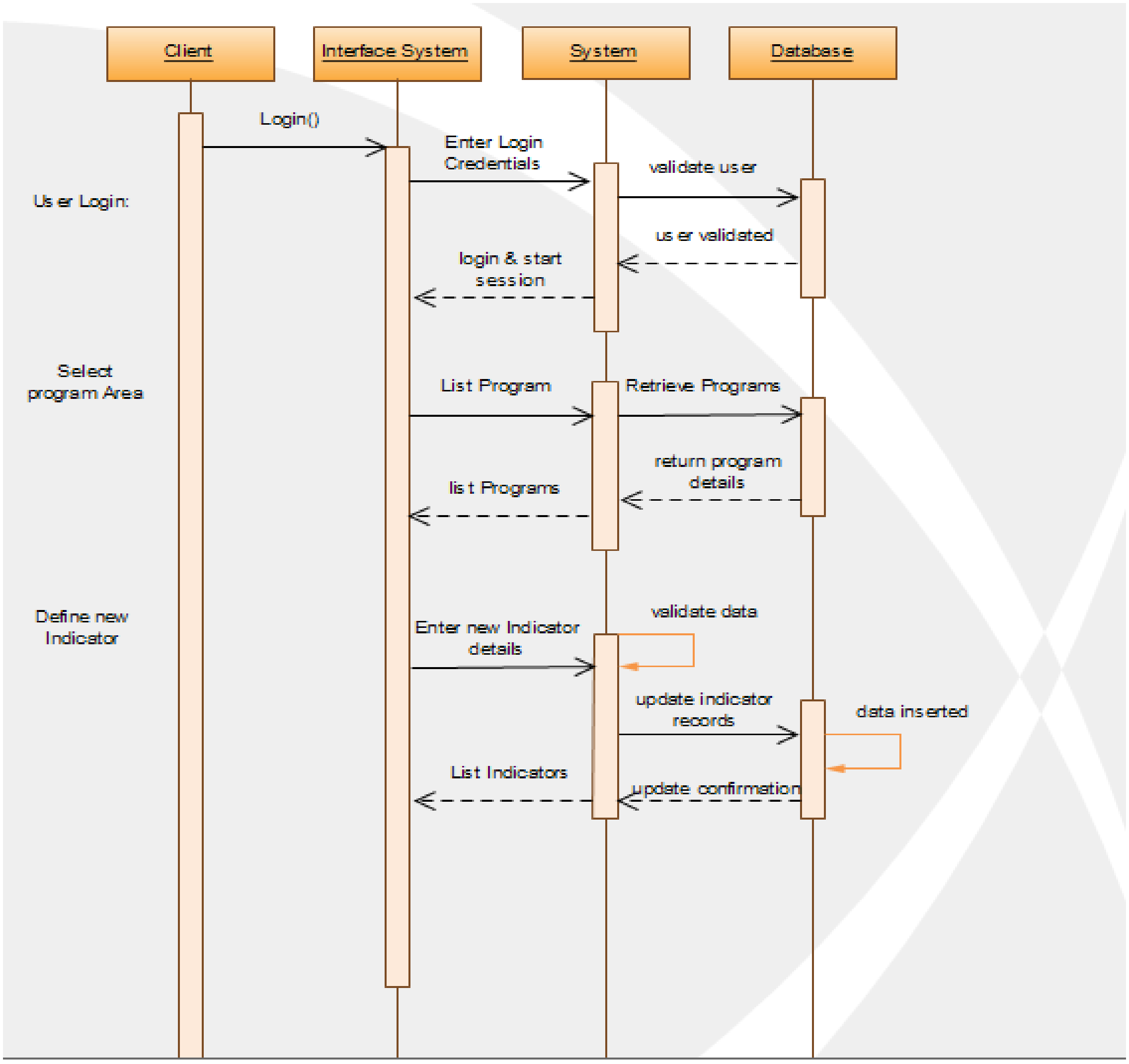


Figure 4-5: Steps taken to add a new indicator

Sequence diagram for adding a new health facility

In Figure 4-6, a user logins in through a user interface by inserting user credentials. The system validates details provided by the user with those that are stored in the database. Once the validation is successful, the user selects a new form for healthy facility data entry, submits the forms and the health facility details are updated in the database.

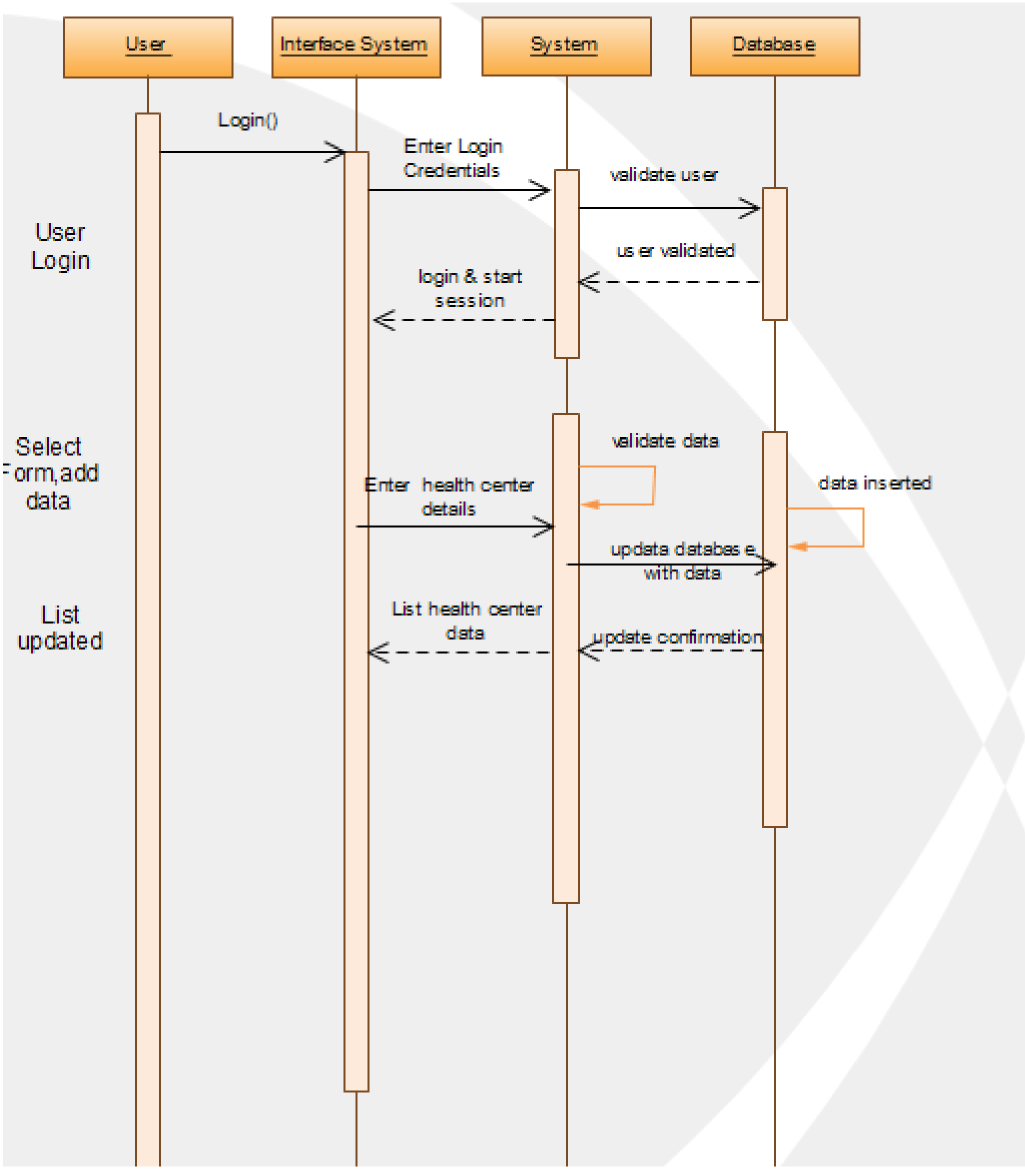


Figure 4-6: Adding a new health facility

Sequence diagram for Analyzing data

In Figure 4-7, a user logins in through a user interface by inserting user credentials, the system validates details provided with the database ones. Once validation is done, the user selects a program area, the system retrieves the list of available programs and returns it to the user who then selects an indicator category, sets analysis criteria, and then the system retrieves the details and returns the report.

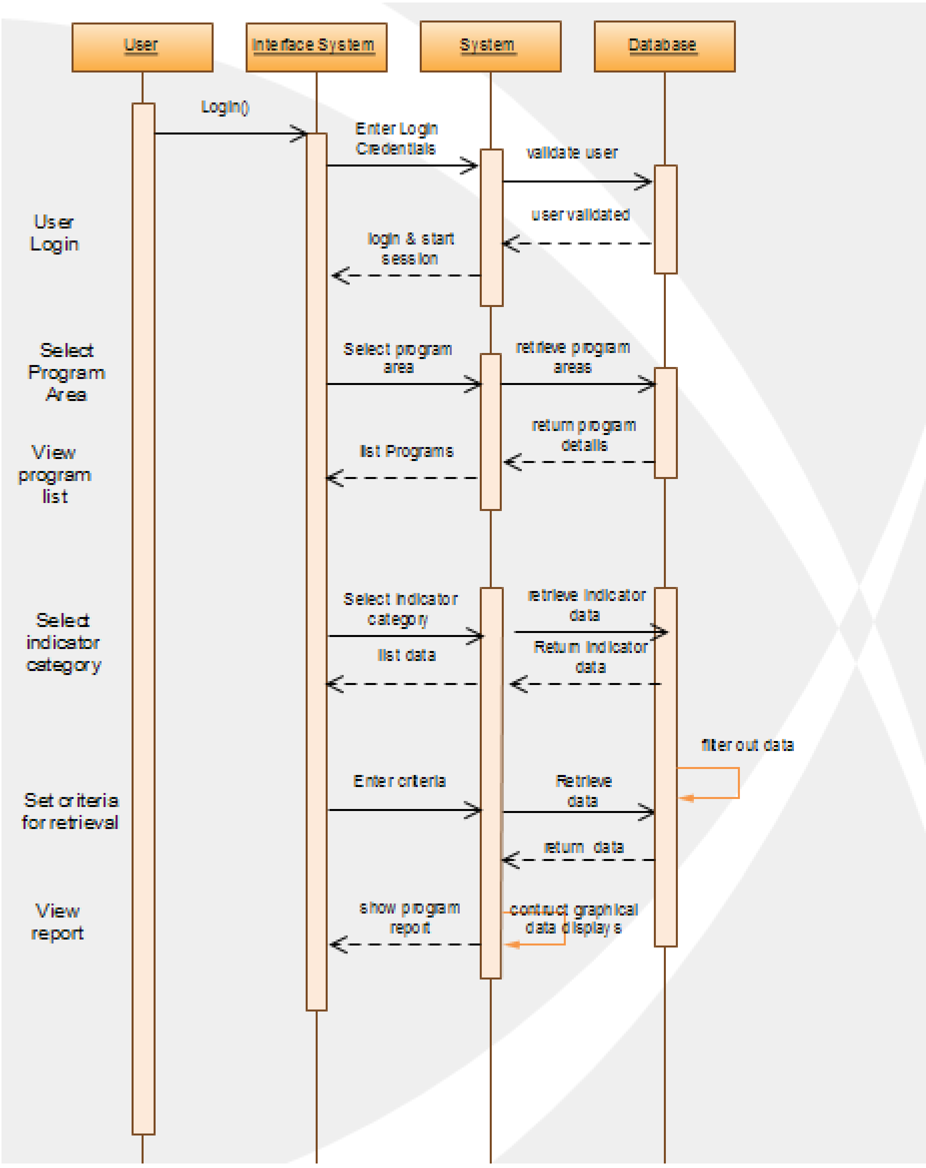


Figure 4-7: User Centered System Design Process

4.3.3 Analysis of activity and actions

The hierarchical task analysis technique was typically used to represent the actions that users perform during an activity. In hierarchical task analysis, the tasks were gradually broken down into subtasks and eventually into actions that define how the user actually performs the step. To do this, two main types of refinements were used: the structural and the temporal refinements. The structural refinement decomposes a complex task into a set of independent simpler subtasks. The temporal refinement, moreover, provides constraints for ordering subtasks according to the parent task logic. The main advantage of this mode of analysis is that it provided the researcher with models for task execution, enabling them to envisage the goals, tasks, subtasks, operations and plans essential to users' activities.

The purpose of a task model was to create a hierarchical analysis of the task structure or model the mental states and operations of the principle actors. It also describes the interactions between the people and their tools and resources. To analyze how people externalize their work, the task model was used describe:

The main actors and their activity systems;

i. How the actors employ tools and resources to mediate their interaction and to externalize cognition;
ii. Methods and techniques that the actors employ;
iii. The contexts in which work occurs; and
iv. The actors' conception of their work, including sources of difficulty and breakdown in activity and their attitudes towards the Web application.

The hierarchical decomposition was used to create a taxonomy which described the actions that must be performed to achieve an activity. The root of the task taxonomy is considered to be the activity under analysis and the lower levels of the taxonomy are considered to be the different actions that must be performed to achieve the activity. In this way, an activity is decomposed into actions and an action can be decomposed into simpler actions.

The structural refinement (represented by solid lines in Figure 4-8) is used to decompose an action into a set of individual simpler actions. The temporal refinement (represented by dashed lines in Figure 4-8) is used to decompose an action into a set of simpler actions that must be performed in a cooperative way. The cooperation is represented by temporal constrains among actions. The temporal constraints used in task analysis techniques are also valid for activity analysis. For reasons of brevity, the following present only the constraints used in the case study.

1. A1 >> A2, Enabling: the action A2 must be performed after the action A1 is performed.
2. A1 []>> A2, enabling with information passing: the action A2 must be performed after the action A1 is performed. In addition, A1 provides a value for A2.
3. A1 |> A2, Suspend-Resume: The action A1 can be interrupted by the action A2. When A2 is performed, A1 can be resumed.

To hierarchically represent an activity, we make users describe how this activity must be performed. Considering the activity of analyzing data, let us suppose that user's s provide us with the following description:

To analyze health indicator data, a user must be able to enter new data or use already existing data into the system. During the process of adding data users must also be able to consult the state of their data at any time. Once users have finished adding data to into the system, they must formalize the purchase by going through the checkout. To do this, users must first identify themselves as registered clients and then send a purchase order.

From this description we can identify which actions shoppers perform consciously. These actions constitute the hierarchical description. In a next step, we analyze this hierarchical description to identify those operations that users perform for each action without consciousness of them. (This analysis is presented in next section.)

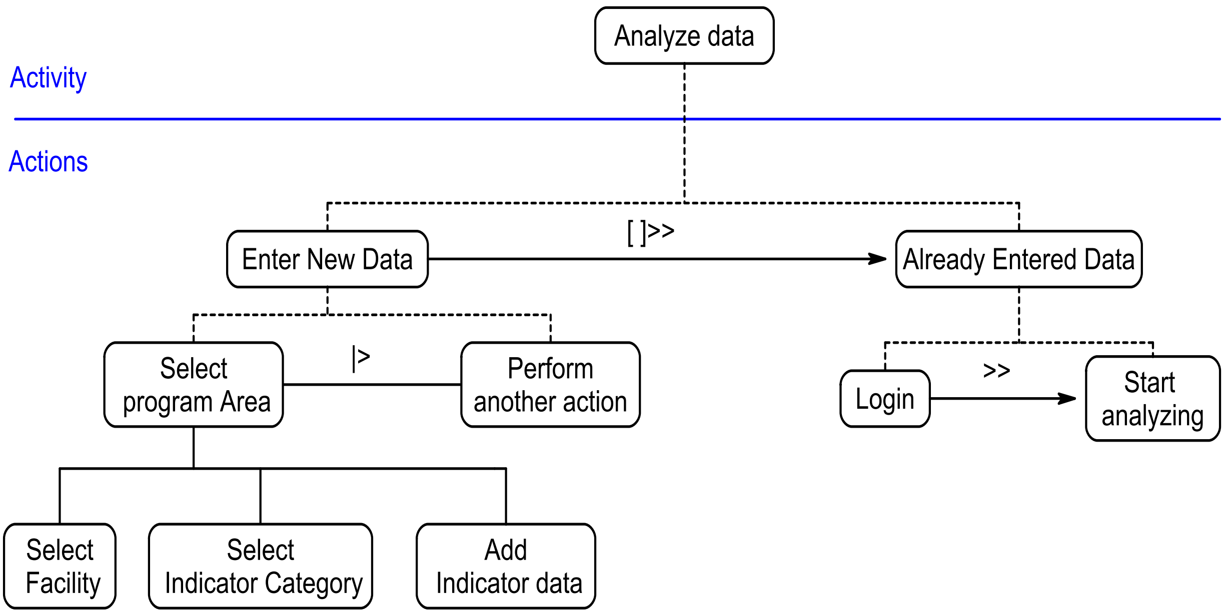


Figure 4-8: Hierarchical decomposition of an activity into actions

Following is a brief description of the taxonomy in Figure 4-9:

i. The activity we are analyzing is the analysis of data. To achieve this activity two actions must be performed Enter New data or use already existing data. These actions are two cooperative actions. The temporal constraint defined between both is enabling with information passing. First the Data must exist in the system as new or as already there before the analysis can be made. The information that needs to be exchanged is the analyzed data.
ii. Analyze data is decomposed into two simpler cooperative actions: Enter new data (which can be repeated) and Use Already Existing data. The temporal constraint defined between the two actions is suspend-resume, which indicates that Enter new data to the system can be interrupted at any point by use Already Entered data. It will be reactivated from the state reached before the interruption once the action use Already Entered data is performed.
iii. The action Select program area is decomposed into three individual actions: Select Facility, Select Indicator category and Add Indicator data.
iv. The Already entered data is decomposed into two simpler cooperative actions: Login and Start analyzing. The temporal constraint defined between the two actions is enabling, which indicates users must identify themselves before analyzing data.

Note that temporal constraints are inherited. For instance, in Figure 4-9, the action Add Indicator data can be suspended by the action Perform another action because the action Select Program Areas (parent action of Add Indicator data) has defined this constraint.

4.3.4 Required Data

Some Quality Improvement Officers (QIOs) presented a need for information on certain focus areas to perform analysis. This information is collected by the QIOs ad-hoc or routinely. The following list gives that information needed by these users.

1. District in which the project is located
2. Facility which is supported
3. Program areas supported at a district
4. Implementing partners supported by the project who are based in the districts and

support HFs

5. HIV CoR Indicators- categorized as general, TB, HIV Positive Pregnant and lactating mothers, Retention and the Cascade indicators
6. SMC indicators categorized as counseling and Testing(CT) and Quality Improvement (QI) ones

4.3.5 Enhanced Entity Relationship Diagram (EERD)

An Entity Relationship Diagram (EERD) was developed to depict the entities in the system, their respective attributes and the relationships between the entities. The diagram also gives the super classes and child classes and the interaction between the two classes. Figure 4-9 summarizes the various entities, their relationships and constraints

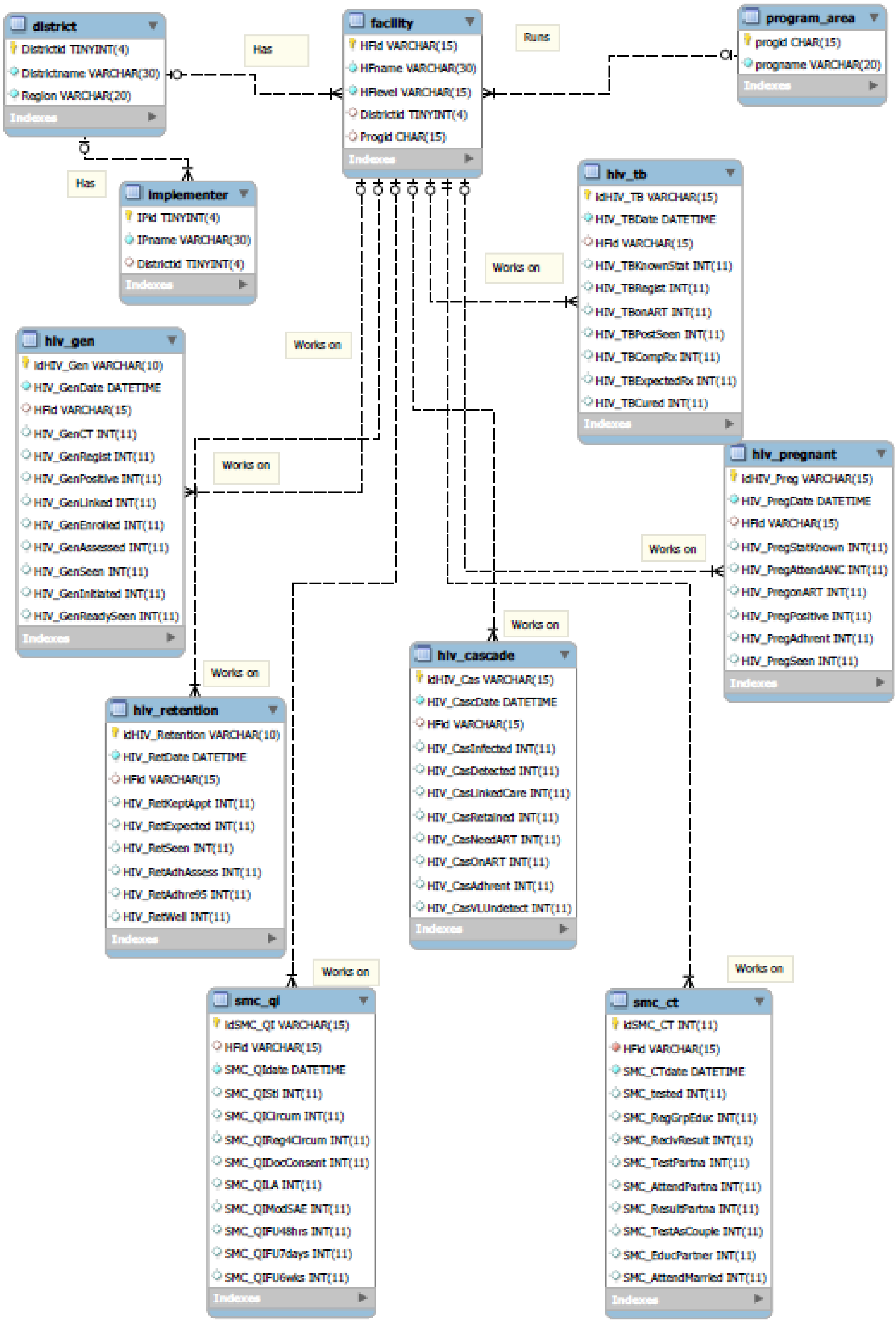


Figure 4-9: Enhanced Entity Relationship Diagram for the system

4.3.6 Physical data model

The Physical data model was obtained by mapping Logical data into MySQL database management system. The resulting data dictionary is shown in the Tables 4-4 to 4-14 below. But first normalization had to be enforced. Normalization is the process of efficiently organizing data in a database.

When you normalization of data was done, the following goals were achieved;

i. Data was arranged into logical groupings such that each group described a small part of the whole.

ii. Minimized the amount of duplicate data stored in a database.

iii. Organized the data such that, when you modify it, you make the change in only one place.

iv. Built a database in which one can access and manipulate the data quickly and efficiently without compromising the integrity of the data in storage.

Table 4-2 shows the Shows the entity District, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-2: District table

Field	**Type**	**Size**	**Description**
District id	Numeric	4	Primary key of the District table
District name	String	30	Name of the district where project works
Region	String	20	Name of the geographical region the district is found e.g Western

Table 4-3 shows the Shows the entity Health Facility, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-3: Health Facility table

Field	Type	Size	Description
HFid	String	15	Unique identifier of the Health facility
HFname	String	30	Name of the health facility supported
HFlevel	String	15	Type of health facility e.g Hospital or HC IV
Districtid	Numeric	4	Field that links health facility to district
Progid	String	15	Field that links health facility to a program area

Table 4-4 shows the Shows the entity Program Area, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-4: Program Area table

Field	Type	Size	Description
Progid	String	15	Unique identifier of the Program area
Program	String	20	Name of the program area supported e.g SMC or HIV CoR

Table 4-5 shows the Shows the entity Implementer, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-5: Implementer table

Field	Type	Size	Description
IPid	Numeric	4	Unique identifier of the Implementing partner
IPname	String	30	Name of the program area supported e.g SMC or HIV CoR
Districtid	Numeric	4	Field that links the Implementing partner to the district they support

Table 4-6 shows the Shows the entity HIV General Indicator, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-6: HIV general indicators table

Field	Type	Size	Description
idHIV_Gen	String	10	Unique identifier of the general indicator
HIV_GenDate	Date		Date and time indicator data is collected
HFid	String	15	Field that links Health Facility to General indicator table
HIV_GenCT	Numeral	11	Number of clients counseled and tested for HIV at a given time
HIV_GenRegist	Numeric	11	Number of clients registered for group education
HIV_GenPositive	Numeric	11	Number of clients testing HIV Positive
HIV_GenLinked	Numeric	11	Number of newly tested HIV+ patients linked to HIV care
HIV_GenEnrolled	Numeric	11	Number of HIV clients enrolled into care
HIV_GenAssessed	Numeric	11	Number of HIV+ pre ART clients that are assessed for ART eligibility
HIV_GenSeen	Numeric	11	Number of HIV+ pre ART clients seen in a month
HIV_GenInitiated	Numeric	11	Number of HIV+ pre ART clients that are initiated on ART
HIV_GenReadySeen	Numeric	11	Number of HIV+ pre ART clients that are eligible and ready for ART seen in a month

Table 4-7 shows the Shows the entity HIV Retention Indicator, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-7: HIV Retention indicators table

Field	Type	Size	Description
idHIV_Retention	String	10	Unique identifier of the Retention indicator
HIV_RetDate	Date		Date and time indicator data is collected
HFid	String	15	Field that links Health Facility to Retention indicator table
HIV_RetKeptAppt	Numeral	11	Number of No. of clients (ART& or Pre ART)who have kept their clinic appointment
HIV_RetExpected	Numeric	11	Number of clients (ART& or Pre ART) scheduled to visit

Field	Type	Size	Description
HIV_RetSeen	Numeric	11	Total number of ART patients who visited the clinic that month
HIV_RetAdhAssess	Numeric	11	Patients seen in a month on ART that are assessed for ART adherence in a month
HIV_RetAdhre95	Numeric	11	Number of ART patients seen in a month with adherence to ART of ≥ 95%
HIV_RetWell	Numeric	11	Number of ART clients clinically well/stable

Table 4-8 shows the Shows the entity HIV Pregnancy Indicators, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-8: HIV Pregnancy Indicators table

Field	Type	Size	Description
idHIV_Preg	String	15	Unique identifier of the Pregnancy indicator table
HIV_PregDate	Date		Date and time indicator data is collected
HFid	String	15	Field that links Health Facility to Pregnancy indicator table
HIV_PregStatKnown	Numeric	11	Number of pregnant women attending ANC with known HIV status
HIV_PregAttendANC	Numeric	11	Total No of pregnant women attending ANC in the month.
HIV_PregonART	Numeric	11	Number of HIV positive pre ART pregnant women started on Option B+ in a month
HIV_PregPositive	Numeric	11	Total No of HIV positive pre ART pregnant women attending ANC in a month
HIV_PregAdhrent	Numeric	11	Number of HIV positive pregnant and lactating mothers on ART seen in a month that are adherent to their ARV medicines
HIV_PregSeen	Numeric	11	Total No of HIV positive pregnant and lactating mothers on ART seen in a month

Table 4-9 shows the Shows the entity HIV TB Indicators, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-9: HIV TB Indicators table

Field	Type	Size	Description
idHIV_TB	String	15	Unique identifier of the TB indicator table
HIV_TBDate	Date		Date and time indicator data is collected
HFid	String	15	Field that links Health Facility to TB indicator table
HIV_TBKnownStat	Numeric	11	Number of TB patients registered in the TB clinic in the month that have a known HIV status
HIV_TBRegist	Numeric	11	Number of TB patients registered in the TB clinic in the month
HIV_TBonART	Numeric	11	Number of TB patients who are HIV positive and ever started on ART that were seen in a month
HIV_TBPostSeen	Numeric	11	Number of patients in the TB register that are HIV positive and seen in the month
HIV_TBCompRx	Numeric	11	Number of patients in the TB register that have completed treatment seen in the month
HIV_TBExpectedRx	Numeric	11	Number of patients in the TB register that are expected have completed treatment in the month
HIV_TBCure	Numeric	11	Number of patients in the TB that have been cured of TB

Table 4-10 shows the Shows the entity SMC-CT Indicators, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-10: SMC- CT indicators table

Field	Type	Size	Description
idSMC_CT	Numeric	11	Unique identifier of the SMC CT indicator table
SMC_CTDate	Date		Date and time indicator data is collected
HFid	String	15	Field that links Health Facility to SMC_CT indicator table
SMC_tested	Numeric	11	Number counseled and tested for HIV
SMC_RegGrpEduc	Numeric	11	Number registered for group education
SMC_RecivResults	Numeric	11	Number that receive HIV test result
SMC_TestPartna	Numeric	11	Number that attend group education with partners
SMC_AttendPartna	Numeric	11	Number that attend group education who are married/cohabiting
SMC_ResultPartna	Numeric	11	Number that receive HIV test results as couples
SMC_TestAsCouple	Numeric	11	Number counseled and tested together as a couple
SMC_EducPartner	Numeric	11	Number who are counseled and tested with partners

Table 4-11 shows the Shows the entity SMC-QI Indicators, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-11: SMC- QI indicators table

Field	Type	Size	Description
idSMC_QI	Numeric	11	Unique identifier of the SMC QI indicator table
SMC_CTDate	Date		Date and time indicator data is collected
HFid	String	15	Field that links Health Facility to SMC_QI indicator table
SMC_QISti	Numeric	11	Number assessed for STI
SMC_QICircum	Numeric	11	Number circumcised
SMC_QIReg4Circum	Numeric	11	Number registered for SMC (males registered)
SMC_QIDocConsent	Numeric	11	Number with documented consent
SMC_QILA	Numeric	11	Number circumcised under local anesthesia
SMC_QIModSAE	Numeric	11	Number with moderate to severe adverse events
SMC_QIFU48hrs	Numeric	11	Number that return for follow up in 48hrs
SMC_QIFU7days	Numeric	11	Number that return within 7days of surgery
SMC_QIFU6wks	Numeric	11	Number that return at or after 6 weeks post operation

Table 4-12 shows the Shows the entity HIV Cascade Indicators, its attributes, data type information including primary and foreign key relationships, the number of characters allowed and the descriptions of each attribute

Table 4-12: HIV Cascade indicators table

Field	Type	Size	Description
idHIV_Cas	Numeric	11	Unique identifier of the HIV Cascade indicator table
HIV_CascDate	Date		Date and time indicator data is collected
HFid	String	15	Field that links Health Facility to HIV Cascade indicator table
HIV _CasInfected	Numeric	11	Estimated number of people infected with HIV
HIV_CasDetected	Numeric	11	Number detected with HIV
HIV_CasLinked	Numeric	11	Number HIV Positive linked to care
HIV_CasRetained	Numeric	11	Number of HIV Positive clients retained in care
HIV_CasNeedART	Numeric	11	Number of HIV Positive clients that need ART
HIV_CasonART	Numeric	11	Number of HIV Positive clients that are on ART
HIV_CasAdherent	Numeric	11	Number of HIV Positive clients that are adherent ART
HIV_CasVLUndetect	Numeric	11	Number with undetectable Viral load

4.3.7 Hardware and Software Requirements

The tool was developed on a Windows platform. The development tools were MySQL database management system and PHP because PHP offers increased efficiency and usability, compatibility with other operating systems, faster data processing and easy to upload into HTML. Therefore the minimum hardware and software requirements for the new system were derived by taking the industrial recommended specifications for Windows and each development tool and then picking out the maximum value for a specification and they are summarized below in Table 4-13

Table 4-13: System requirements

Hardware	Recommended
Processor	2.5GHz
RAM	1GB(32bit) or 2 GB(64bit)
Internet speed	3Mb/s or higher
Hard disk space	16GB (32bit) or 20 GB (64bit)

4.3.8 Producing design solutions

The process of creating a design solution started with very low-fidelity (Low-fi) prototypes. For instance, the positioning of elements in an application screen was scribbled on pieces of paper (Figures 4-10 and 4-11) before a more high-fidelity (high –fi) version of that particular application screen was produced. Using sketches and other forms of low-fi prototypes allowed a fast and quite inexpensive design of the interaction concepts for the product and initial determination of which information to present, its location of presentation and in which order the information would be presented in respect to the other information.

Each design artifact was evaluated after its creation against its compliance with the guidelines and principles and its performance in a rather superficial heuristic evaluation.

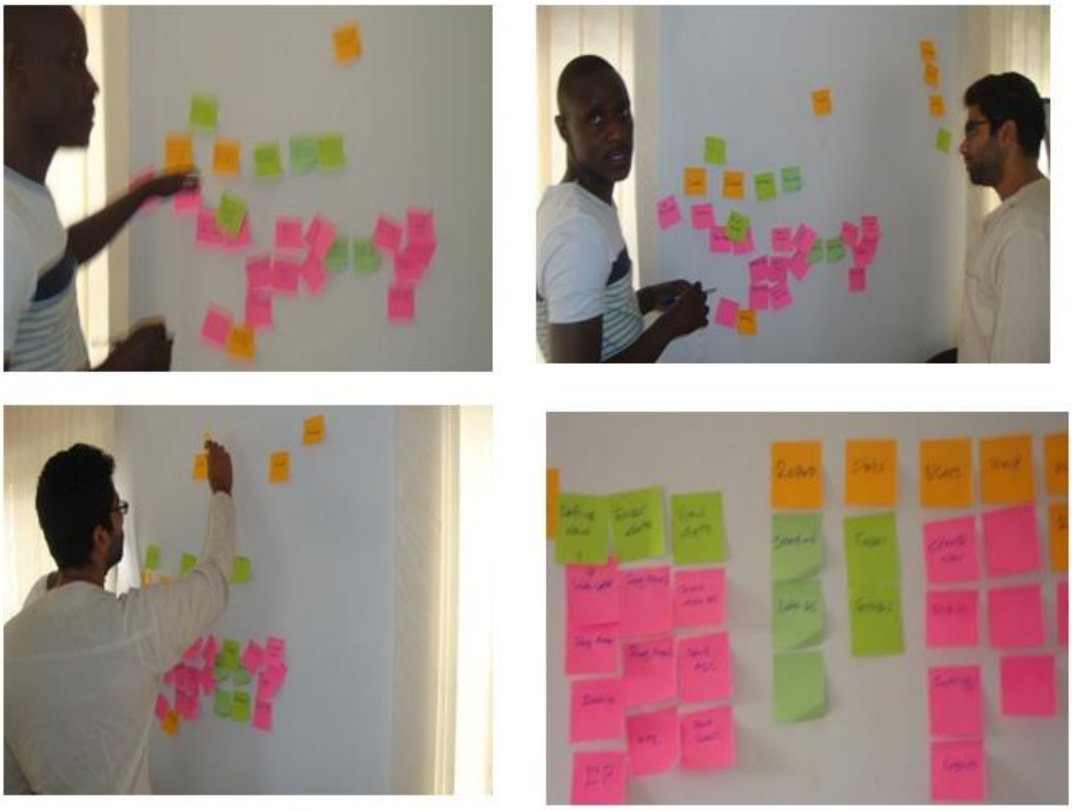


Figure 4-10: Card sorting during derivation of the user interfaces

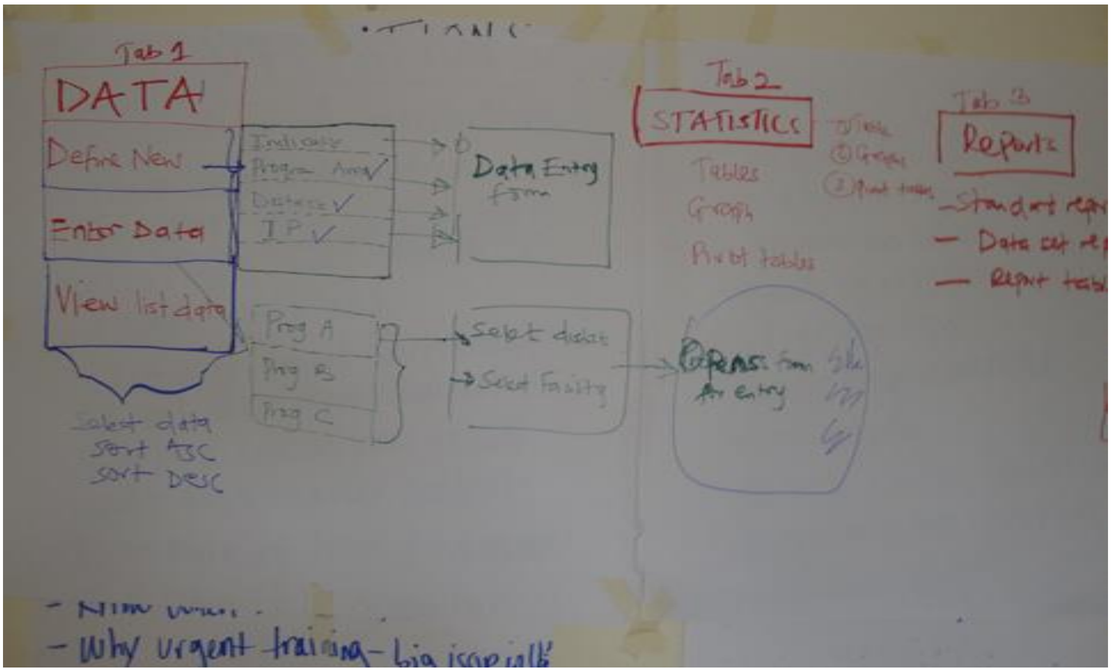


Figure 4-11: Paper prototyping

The physical software tool was realized by implementing the physical design. The implementation followed a modular approach by first developing the individual modules and then integrating them. The following sections present some of the features that the new system has. It includes brief descriptions of ; navigation, activity theory application, Drop down lists snapshot, Indicators data entry form, Advanced Search Feature, Indicator analysis view, Data visualization module, Export option, Summary option

a) Navigation

The first two navigation levels – the horizontal bar on top and the vertical menu on the left – are static throughout the entire application. A link, or respectively, a menu entry is added to the menu on the left. This link will direct the user to the application. It was a conscious decision not to add any menu hierarchies to the application, as this would have cluttered the interface. Especially, considering that the mockups with a third menu do not add any usability to the application compared with the current design solutions, strongly supports this decision.

b) Activity theory application for extracting navigational semantics from activity descriptions

According to the Activity Theory, the analysis of the activities that users must perform by interacting with a Web application were used to derive which navigational structure should present this Web application. This navigational structure must be that which properly support users in the performance of the activities.

In this context, descriptions of Web applications performed by means of the technique of Dynamic transformations between levels was used to systematically derive the navigational structure of Web applications. The navigational structure of a Web application was defined from the mechanisms that allowed users to navigate the information. These mechanisms were basically Web pages, links and access information facilities such as search engines. In order to derive these elements from activity descriptions we had to define a set of guidelines. Following are some of the as a representative guideline examples:

Guideline 1. Exchange operations represent acts in which the system provides the user with information or vice versa. In a Web application these exchanges of information are performed throughout Web pages. Thus, we can derive a Web page for each information exchange operation that is defined in an action description.

Guideline 2. In the same way, if two information exchange operations are performed sequentially we can infer that the corresponding Web pages must be connected throughout a link. This link allows users to access one page from the other and thus provides support to the sequence of information exchanges defined in the action description.

Guideline 3. Search system operations are those performed by the system to query the system state. However, these operations are activated by users through a message. Thus, we can derive from these operations search engines that allow users to start a search for information.

Guideline 4. We can also derive navigational information from the temporal relationship defined between actions. For instance, if users can suspend the action *Cancel* in order to perform the action *Add new record* we can infer that Web pages derived from the operations of the first action must provide access to the Web pages provided by the operations of the second actions, and vice versa. An explanation of more detailed navigation paths will be given in the following descriptions of each screen.

c) Drop down lists snapshot

With the drop down lists the user can click the downwards facing arrow to see all valid and available items for this form field. This is very useful for new and occasional users as no memorization of all available options is required. The user can choose the preferred option by the by mouse click. Figure 4-12 shows some of the drop down lists available on one of the forms

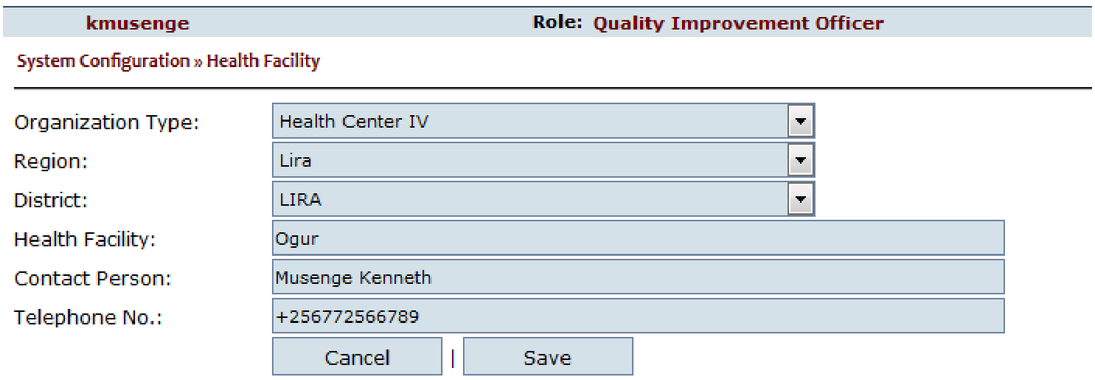


Figure 4-3: Dropdown-List with Fast Item Selection

d) Indicators data entry form

An example of a form that is used to enter data is shown below. A form is available for the various indicator groups that we presented during the requirements gathering. For example this form in Figure 4-13 is used to capture data on indicators that were categorized as HIV general indicators. All the data entry forms have options for Adding new data, saving, deleting, exiting, and navigating by way of scrolling.

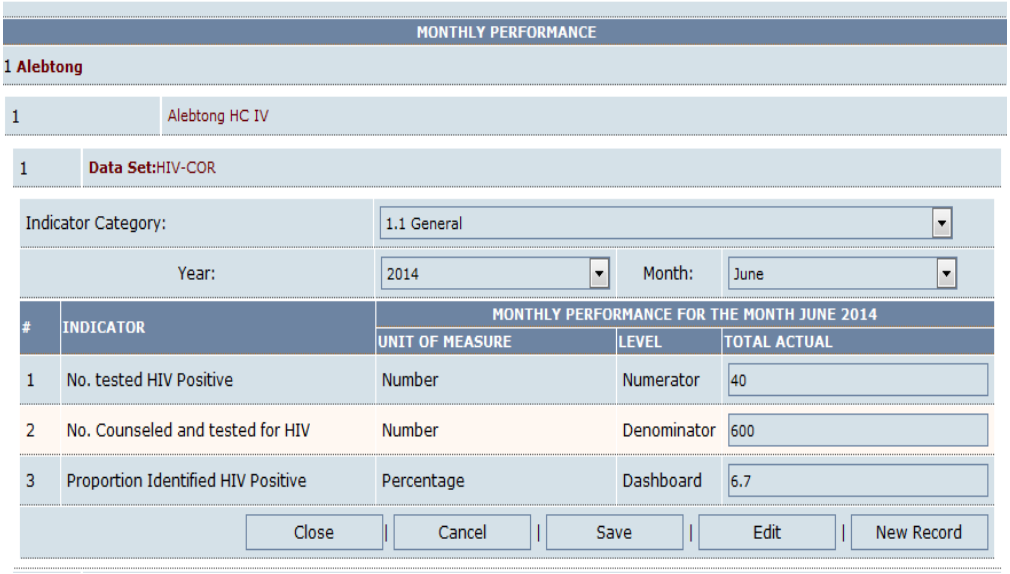


Figure 4-4: Data Entry form

If a user modifies any record already saved, a message notifying the user that data has been updated will be displayed as shown in Figure 4.14.

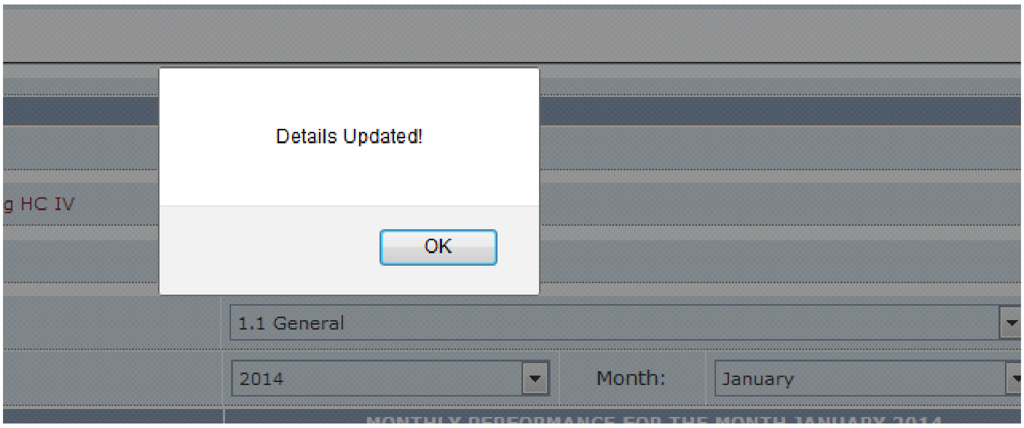


Figure 4-5: Data modification message

If the user clicks the Delete button, the user will be prompted to confirm or to cancel the operation as shown in Figure 4.15

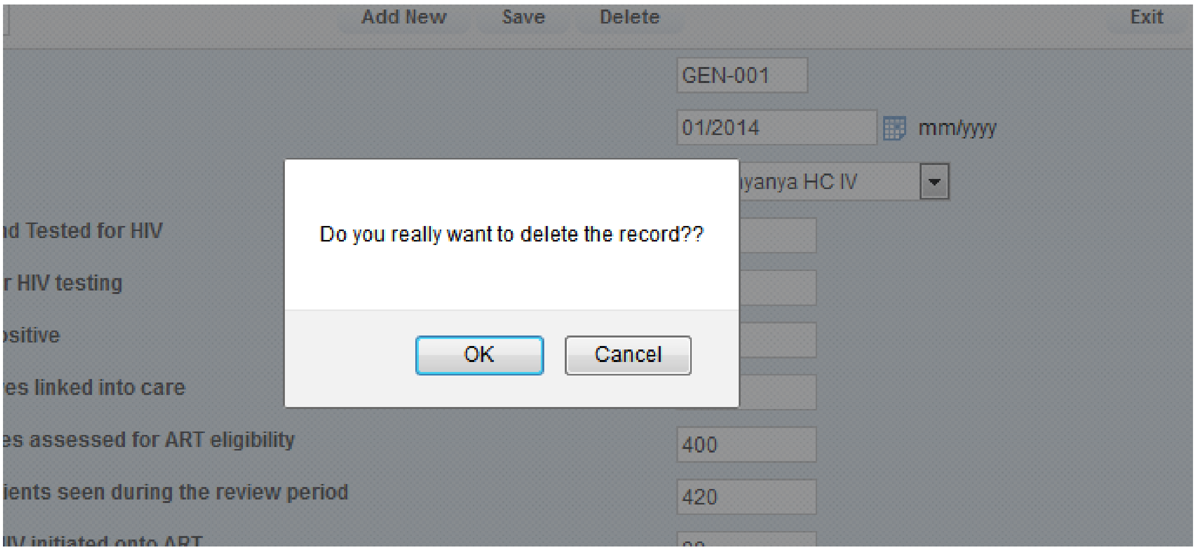
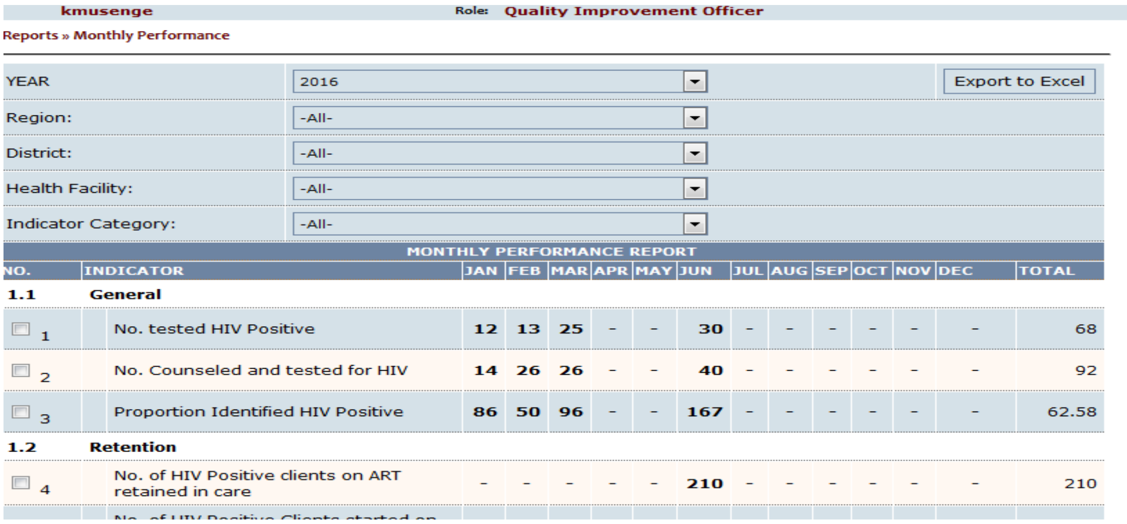


Figure 4-6: Prompt for deletion

A semi-transparent layer masks the elements in the background. A click on Cancel will close the inline screen and remove the semitransparent layer.

e) Advanced Search Feature

A good implementation of the advanced search feature is of utmost importance. It ensures the retrieval of data when the system is hosting large numbers of indicators' data. The search options are displayed when the user clicks on the Search Option as shown in Figure 4.16 below.



NO.	INDICATOR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1.1	**General**													
1	No. tested HIV Positive	12	13	25	-	-	30	-	-	-	-	-	-	68
2	No. Counseled and tested for HIV	14	26	26	-	-	40	-	-	-	-	-	-	92
3	Proportion Identified HIV Positive	86	50	96	-	-	167	-	-	-	-	-	-	62.58
1.2	**Retention**													
4	No. of HIV Positive clients on ART retained in care	-	-	-	-	-	210	-	-	-	-	-	-	210

Figure 4-7: Advanced Search Options.

For fields with search criteria, all dropdown lists will offer the options to select. For example the **Health facility** will allow a user to select all or a particular facility and the like. But it also provides a text auto complete option that suggest as a user types.

For the **Indicator category, the** a user is provided with options like from which a selection can be made

f) Indicator analysis view

The indicator analysis view of a selected indictor category is shown when the user clicks on one in the analysis menu options. It shows all the information associated with the program area. In this view the user can select which program area whose indicators he needs to analyze. Users in a given program area will only be able to access options available to them. The view illustrated in Figure 4.17 is for the analysis of HIV Treatment Cascade indicators. The view provides the user with a number of options in which data can be analyzed.

The view also allows a user to set criteria for the results required. Drop down list are provided for achieving this. This is very useful for new and occasional users as no memorization of all available options is required. The user can choose the preferred option by the by mouse click.

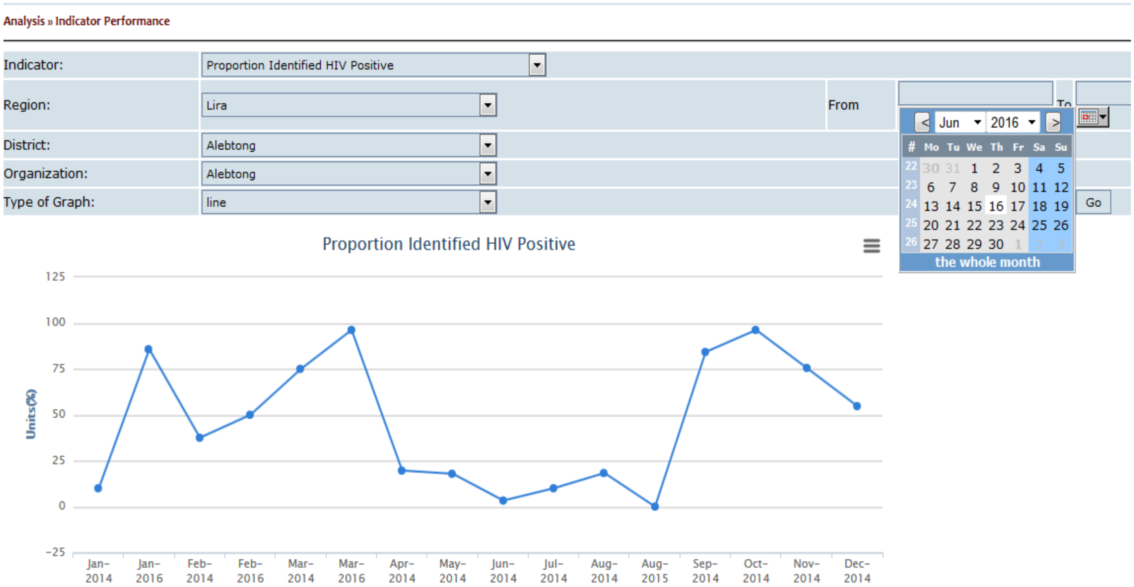


Figure 4-8: Screenshot of a Detailed View of indicator analysis report.

g) Data visualization module

Another great feature of the summary tool is the ability to create a graph of a given column by simply making a selection as shown in Figure 4.14 Sample results are shown below in Figure 5.19. A bar of graph for instance of Positives identified is shown below. Most importantly, is the flexibility provided by the tools that allows a user to change the chart type by simply selecting the options of the chart types provided

After a user has finishing setting criteria for results to be seen, a visualization feature that allows a user to select a type of graph is provided. As seen in Figure 4.18, a user can visualize

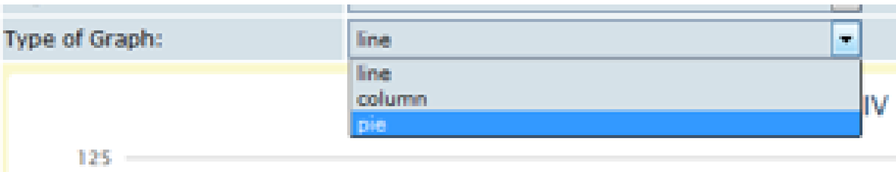


Figure 4-9: Select column options**.**

Analysis results by producing a line or column chart or pie chart. Figure 4-19 shows an example typical results

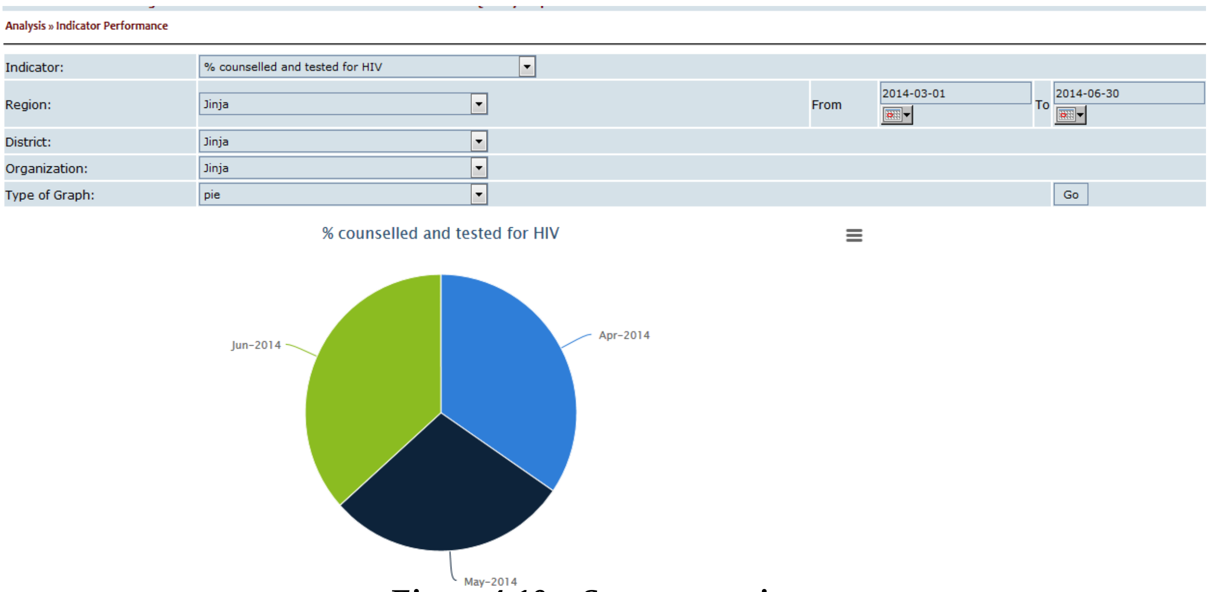


Figure 4-10: Summary options.

h) Group by Option

When selected, the behavior is similar to the columns options .When selected a semitransparent layer masks the elements in the background and a select column dialog box opens. This allows a user to make a choice of how he would indicators to be grouped. For this case, results can be grouped by Dates and Health facilities. Once ok is clicked on, the results are displayed. Exit returns the user the main analysis page of the selected group of indicators.

i) Date criteria Option

When selected, it allows a user to select a period for which results are required. A data picker as shown in Figure 4.20 is provided. A user simply clicks on the date picker icon and a calendar pulls out that permits one to make a selection. After making a selection for the From and To, one clicks on the Go button and results are returned

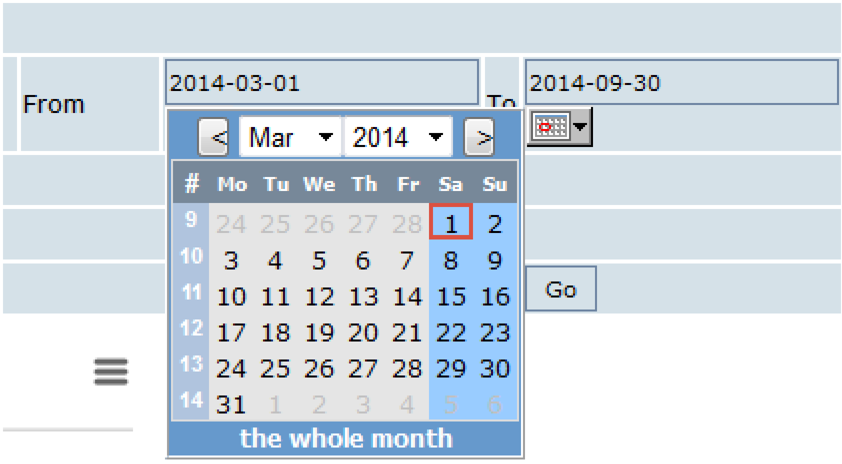


Figure 4-11: Date Picker option

j) Export option

One of the important functionalities of the analysis tool is the ability it offers to users to export analysis results to excel. When selected, the option permits a user to transfer the results to an excel file where more manipulation may be done where necessary.

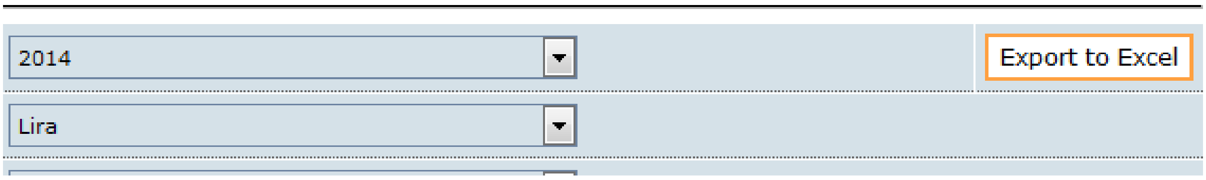


Figure 4-12: Excel export functionality.

made, processing takes place and a dialogue appears that informs the user that an excel file has been generated(Figure 4.21) upon which a user can select to *view*, *download* or move *back* to the main view

k) Summary option

Another important option of analysis is the production of summaries. When a user selects summaries, a tabular summarized report of all selected indicators is provided.

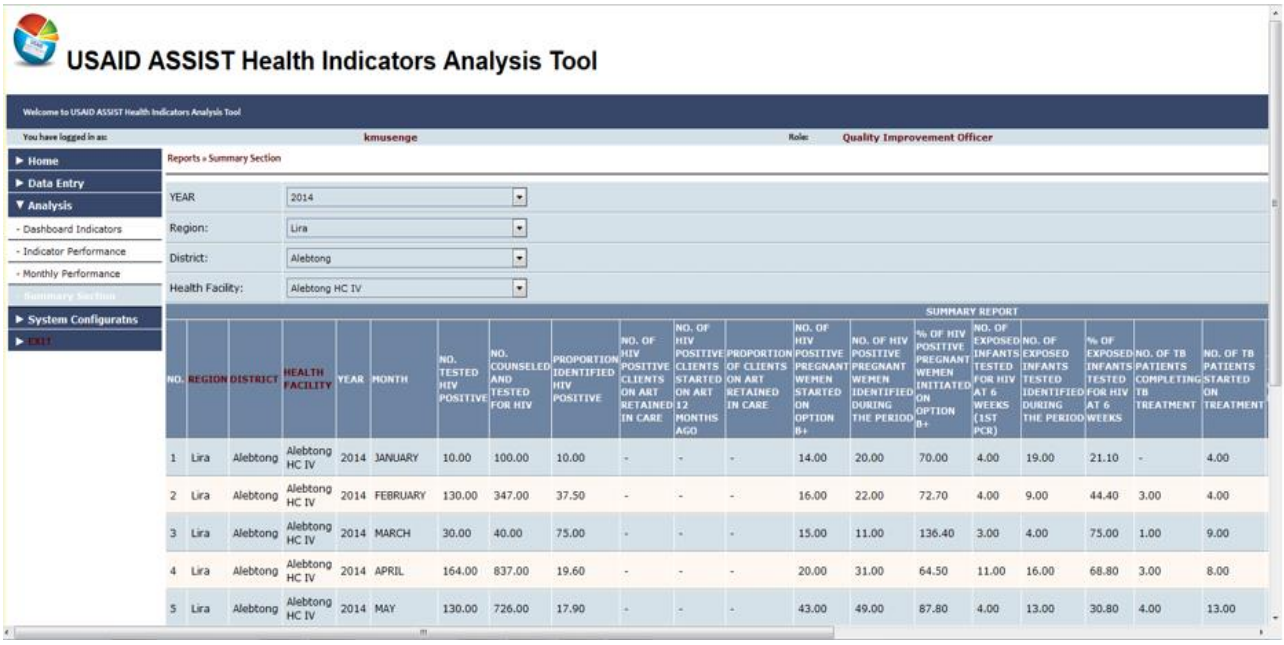


Figure 4-13: Summary options.

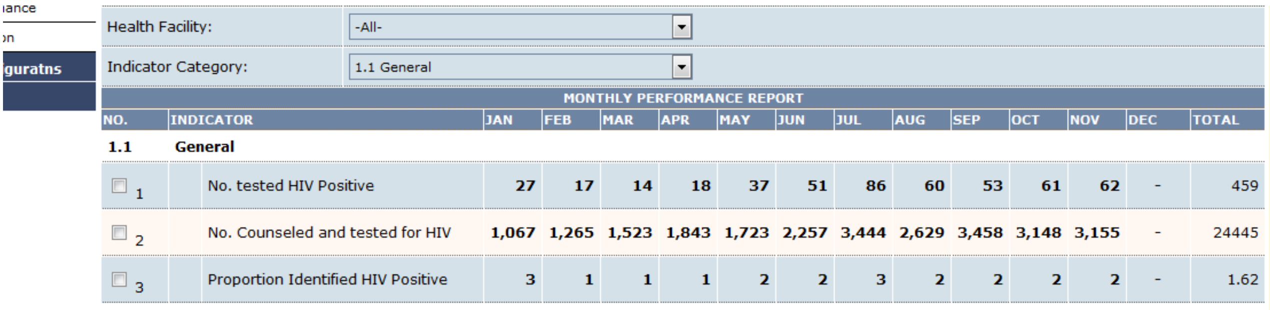
l) System testing and validation

A test plan shown in Appendix IV was used to carry out validation and testing of the system Unit module testing was carried out by entering test data into the system. Table 4-14 below contains the test data that was used to test the system whether it met the expected output.

Table 4-14: Unit testing data

	Buwenge HC IV	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13
N	No. tested HIV Positive	27	17	14	18	37	51	86	60	53	61	62
D	No counseled and tested for HIV during the month	1067	1265	1523	1843	1723	2257	3444	2629	3458	3148	3155
2	**Proportion identified HIV Positive**	2.5%	1.3%	0.9%	1.0%	2.1%	2.3%	2.5%	2.3%	1.5%	1.9%	2.0%

The system produced output similar to test data as shown in Figure 4-23. The results were validated with manual results from the same data. The results were the same and therefore the system generates correct results.



Health Facility: -All-

Indicator Category: 1.1 General

MONTHLY PERFORMANCE REPORT

NO.	INDICATOR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1.1	General													
1	No. tested HIV Positive	27	17	14	18	37	51	86	60	53	61	62	-	459
2	No. Counseled and tested for HIV	1,067	1,265	1,523	1,843	1,723	2,257	3,444	2,629	3,458	3,148	3,155	-	24445
3	Proportion Identified HIV Positive	3	1	1	1	2	2	3	2	2	2	2	-	1.62

Figure 4-143: System out of test data

Integration testing was carried out by supplying the system with the following data as shown in Table 4-15

Table 4-15: User credentials used for testing

User ID	kmusenge
Password	kmusenge

Results show that after entering the details of the user, the system tests the details and gives the following feedback (Indicated by red circling).

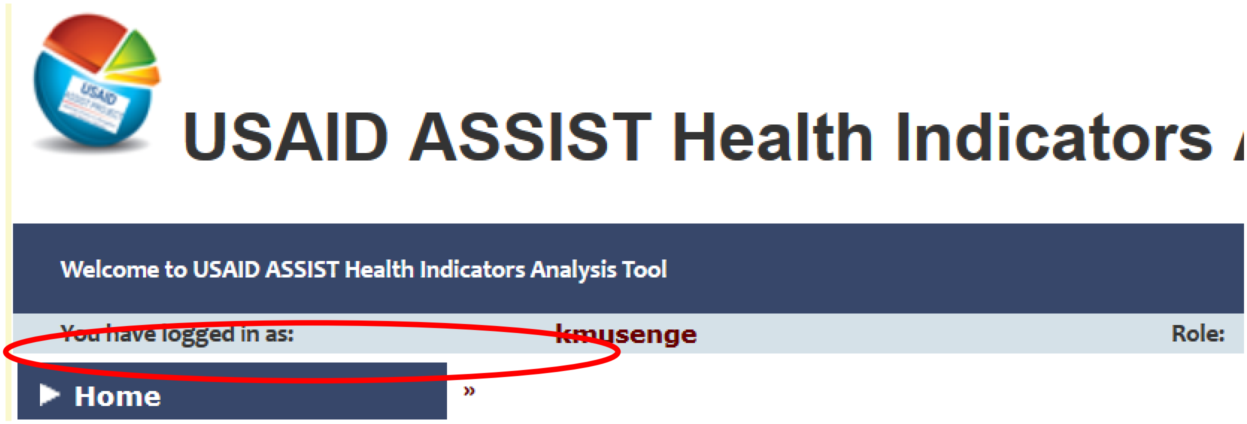


Figure 4-154: Successful login

In case a user entered an invalid User ID and password, the system returns the error message below (red circle) in Figure 4-25

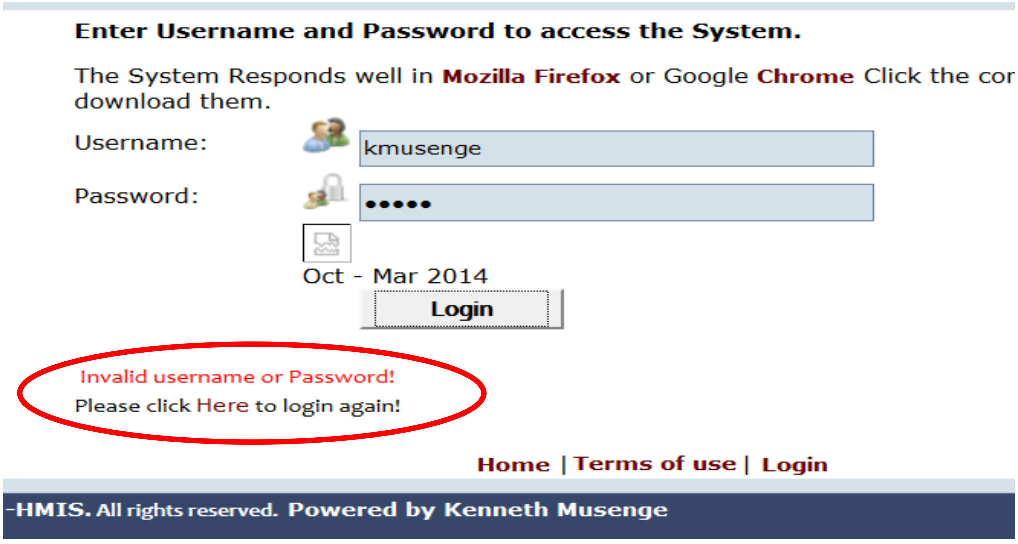


Figure 4-165: Unsuccessful login

The system test was carried out by testing the form that captures SMC QI indicators data, the test data below was used to test if the system would accept improper fractions i.e. numerators greater than numerators. When the data circled red in Figure 4.26 was posted to the database, the system performs logical tests for normal fractions and therefore returns the following message shown on the form.

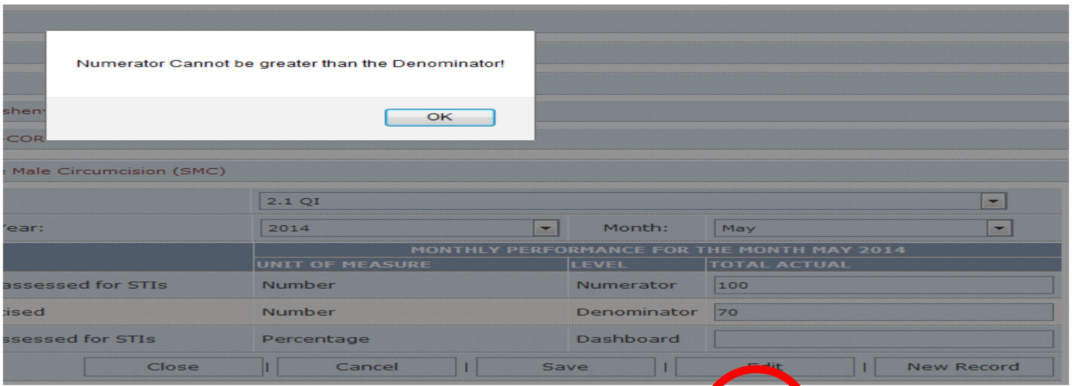
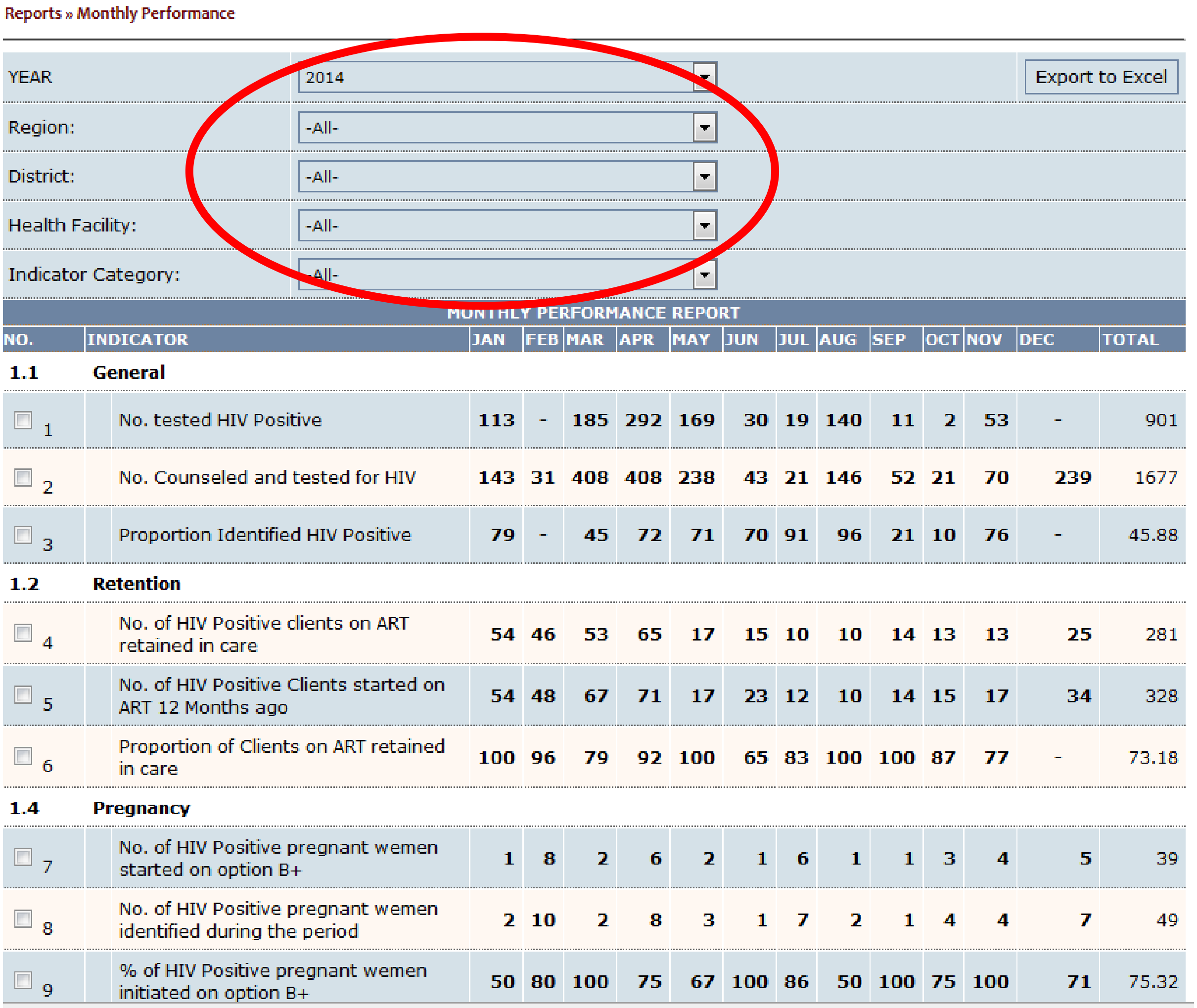


Figure 4-176: Validation checks

Acceptance testing was also carried when retrieving health facility reporting details from the database. The user selected from the database needed information such year, region and district, health facility and indicator category. This was done to check if the system was capable of data retrieval. The screen short below illustrates results before retrieval. When left at default values as *-All-* for the year 2014 (Figure 4.27), all details could be seen



Reports » Monthly Performance

YEAR	2014	Export to Excel
Region:	-All-	
District:	-All-	
Health Facility:	-All-	
Indicator Category:	-All-	

MONTHLY PERFORMANCE REPORT

NO.	INDICATOR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1.1	**General**													
1	No. tested HIV Positive	113	-	185	292	169	30	19	140	11	2	53	-	901
2	No. Counseled and tested for HIV	143	31	408	408	238	43	21	146	52	21	70	239	1677
3	Proportion Identified HIV Positive	79	-	45	72	71	70	91	96	21	10	76	-	45.88
1.2	**Retention**													
4	No. of HIV Positive clients on ART retained in care	54	46	53	65	17	15	10	10	14	13	13	25	281
5	No. of HIV Positive Clients started on ART 12 Months ago	54	48	67	71	17	23	12	10	14	15	17	34	328
6	Proportion of Clients on ART retained in care	100	96	79	92	100	65	83	100	100	87	77	-	73.18
1.4	**Pregnancy**													
7	No. of HIV Positive pregnant wemen started on option B+	1	8	2	6	2	1	6	1	1	3	4	5	39
8	No. of HIV Positive pregnant wemen identified during the period	2	10	2	8	3	1	7	2	1	4	4	7	49
9	% of HIV Positive pregnant wemen initiated on option B+	50	80	100	75	67	100	86	50	100	75	100	71	75.32

Figure 4-187: Before retrieval

The screen shot of Figure 4.28 shows the report generated. It displayed information about the requested health facility and indicator category. This showed that the system was actually capable of retrieving and displaying data from the database

Reports » Monthly Performance

YEAR	2014
Region:	Jinja
District:	Jinja
Health Facility:	Kakira SW Hospital
Indicator Category:	3.2 Testing

MONTHLY PERFORMANCE REPORT

NO.	INDICATOR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
3.2	**Testing**											
1	No. counseled and tested for HIV	**4,941**	**5,016**	-	**6,037**	**6,127**	**6,664**	**6,891**	**6,848**	**3,906**	**3,195**	**4,960**
2	No. registered for HCT	**7,970**	**6,219**	-	**7,345**	**8,928**	**7,645**	**7,710**	**7,598**	**4,261**	**3,721**	**5,458**
3	% counselled and tested for HIV	**62**	**81**	-	**82**	**69**	**87**	**89**	**90**	**92**	**86**	**91**

Figure 4-198: Retrieval results

4.3.9 Evaluation of the system

In this activity of the UCD lifecycle, the design solutions were evaluated by the researcher and the users who participated in the design. This activity was closely coupled with the creation of design solutions but had to occur in all stages of the system lifecycle. The aim was to generate feedback to further improve the product and to determine whether the design fulfilled the specified user requirement, usability goals and complied with the general usability guidelines (Benyon 2010). For this research cognitive walkthrough and an evaluation based on the participants was used.

a) Cognitive walkthrough

Throughout the entire development process, the researcher evaluated early mockups of the design so as to identify some of the problems that could have arisen in interactions with the system. Earlier critical design flaws detected were fixed by the researcher.

b) Participants based method

In order to establish real use situations, the system was deployed and performed typical tasks that were required of the system. After, an evaluation tool (Appendix II)was offered to 12 users, 10 of whom had participated in the requirements gathering process and 2 were completely new users. The areas assessed included their satisfaction with the system, ease of use and perceived benefits.

Presented below were the summaries of the results.

1. End User satisfaction

From the results presented in Table 4-16 below, it was concluded that majority of users were satisfied that the tool could be used with much thinking, terminologies used were understandable, sequencing of the screens wasn't confusing and everything seemed to be straight forward. The only exceptions were generally from users that had not participated in the design process.

Table 4-16: End user satisfaction

End user satisfaction	Strongly Agree	Agree	Disagree	Strongly Disagree
Web based analysis tool can be used without too much thinking	00.0%	83.3%	16.7%	00.0%
Terminologies related to the task are not understandable	00.0%	08.3%	91.7%	00.0%
The sequence of screens are confusing	00.0%	00.0%	100%	00.0%
Performing tasks are not straight forward	8.3%	8.3%	83.3%	00.0%
You can explore Web based analysis tool features using Trial and Error	00.0%	75%	25%	00.0%

2. Learning effectiveness

From the results presented in Table 4-17 it was deduced that the tool was easy to use, navigation was easy, enjoyable and easily learnable after training.

Table 4-17: Results of learning effectiveness

Learning Effectiveness	End user satisfaction	Strongly Agree	Agree	Disagree
Web based analysis tool is easy to use	16.7%	75.0%	8.3%	00.0%
It is not easy to navigate Web based analysis tool	00.0%	83.3%	16.7%	00.0%
Web based analysis tool is enjoyable to use	08.3%	75.0%	16.7%	00.0%
Web based analysis tool is easy to learn after training	33.3%	66.7%	00.0%	00.0%

3. Perceived Benefits

From results seen in Table 4-18, it concluded that perceived benefits of analysis tool were met. The users were satisfied with the ease that the tool provided in terms of sharing their analysis results and reports. The functions that facilitated the process of sharing were also found easy and this was also true for most of features of the tool.

Table 4-18: Results concerning the perceived benefits

Perceived Benefits	End user satisfaction	Strongly Agree	Agree	Disagree
Web based analysis tool may make sharing my results and reports easier	16.7%	83.3%	00.0%	00.0%
Web based analysis tool functions facilitates the ease with which my records can be shared	08.3%	83.3%	08.3%	00.0%
It is easy to understand the features provided by Web based analysis tool	00.0%	91.7%	08.3%	00.0%

From the table above, it concluded that perceived benefits of analysis tool were met. The users were satisfied with the ease that the tool provided in terms of sharing their analysis results and reports. The functions that facilitated the process of sharing were also found easy and this was also true for most of features of the tool.

4.3.10 Conclusion

The cognitive walkthroughs performed by the researcher throughout the development process greatly ensured that the final product was acceptable and truly represented the expectations of the users. Also, the involvement of some users in the final evaluation showed that the analysis tool met expectations of the majority of the users.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

The Health Indicator Monitoring tool was developed based on the user requirements that were identified from the requirements collection phase. This application is anticipated to replace the existing Microsoft Excel system so as to improve the productivity by maximizing the efficiency and effectiveness of processing indicator values. After evaluating the new system it was concluded that the system is usable and was accepted by the users. The web based system has an advantage of being fast, accurate and reliable when processing indicator values. In addition it has also the advantage of being able to be accessed by different users at the same time. It will be used to get indicator values in time and this will improve the planning and decision making in the organization.

The proposed design solutions incorporated the usability heuristics of Nielsen (1994) and the eight golden rules by Shneiderman (2009) and consideration as per the Activity Theory. The use of dropdown lists with fast item selection satisfied the two heuristics recognition rather than recall and flexibility and efficiency of use. The former states that the users' memory load must be minimized. This was clearly accomplished as the users did not have to memorize almost any input data because all valid inputs were displayed in the dropdown list. However, since it was also possible to input the information by typing, the latter heuristic was also met.
Nielsen's heuristics offer or prevention and user control and freedom and Shneiderman's golden rule of permitting easy reversal factions is satisfied by providing undo functionalities throughout the entire application. For instance, an unmeant deletion of data can be easily undone by clicking cancel immediately after the removal has been ordered. Using such an unobtrusive mechanic eliminates the need for various intrusive confirmation dialogs. Integrating already existing databases into the application can even increase the error prevention further.

5.1 Conclusion

The main objective of this study was to develop a web health indicator management tool that would enable the healthcare administrators manage health indicators so as to minimize on the time of report production, produce accurate reports so that data needed for improvement of quality of health care is readily is retrievable. The system was successfully designed, developed, tested and evaluated by both the researcher and potential users. Whereas the system may require further development and enhancements, it provided a proof of concept that health indicators data can be analyzed using web based tools.

It was also the task of this project to design a user centered indicator analysis tool that is flexible, extensible and maintainable by the technical officers of USAID ASSIST Project. Indeed the User Centered Design approach was used and it was reaffirmed that application of this approach in development of a software increases the software usability. While having a good understanding of users is stressed, their involvement is in the design process is very critical as it enhances usability notwithstanding the approach’s strength in offering a more accurate way of defining requirements. It was also confirmed that usage of card sorting and paper based prototypes increases the users’ memorability of the system functionality.

The objective of ensuring that report production is efficient and effective was achieved. It will not only be a one officer’s role to produce reports but any one that has the authority to access the system will play this role. However, much as accessibility is now improved, the accuracy of such reports is not completely guaranteed as it will be dependent on the quality of data collected. So the tool does have controls to manage wrong data.

Finally, the objective of ensuring that the system is tested and validated was also achieved by performing both cognitive walkthroughs by the researcher and lab tests t using actual users who were eventually interviewed on usability measures of satisfaction, effectiveness and efficiency to which results showed that this objective was met. However, the laboratory testing was only done at the projects head office in Kampala. The environment in Kampala is quite different from that in the field where most users spend over 60% of their time.

5.2 Recommendation and Future Work

Throughout the development of the tool, the researcher ensured that the tool was easily usable to all various groups of users but it was discovered a little late through the project that further developments and enhancements like key board shortcuts were not included. Therefore, to further improve the efficiency for expert and frequent users, keyboard shortcuts should be introduced throughout the entire application. If done properly, the users should not need to lift their hands from the keyboard to the mouse-pointing device.

Finally, to yield thoroughly valid results that satisfy scientific requirements the evaluations have to be performed in the field environment to make sure that the tool can be used well even outside the Kampala office where conditions may not be as good as the other side

REFERENCES

A. N. Leont'ev's Activity Theory. *Canadian Psychology May*, 41, pp. 81-93.
Aaron, G. (2013) *Adaptive Web Design: Crafting Rich Experiences with Progressive Enhancements. Easyreaders* [Online]. Available at: http://easy-readers.net/ (Accessed: June 2016).

Abouzahr, C. and Boerma, T. (2007). Health information systems: the foundations of public health. *Bulleting of World Health Organisation*, [online] 83(8), p.6. Available at: http://www.scielosp.org/scielo.php?pid=S0042-96862005000800010&script=sci_arttext&tlng=pt [Accessed 30 May. 2014].
Abrams, R, (2001). Successful Business Research: Straight to the Numbers You Need—Fast, Oxford: Oxford Press.

Agarwal,R.,Tanniru,M.R.(1990):KnowledgeAcquisitionUsingStructuredInter-viewing:AnEmpiricalInvestigation.JournalofManagementInformationSystems,7(1),pp.123-140.

Alan Bryman. (2008). Triangulation. Available: http://www.referenceworld.com/sage/socialscience/triangulation.pdf. Last accessed 30 august 2013.

Allard, et al., Statistical Software Applications Used in Health Services Research: Analysis of Published Studies in the U.S 2011, [online] Available at http://www.biomedcentral.com/content/pdf/1472-6963-11-252.pdf [Accessed 10 August 2013.].

Australian Council on Healthcare Standards. Clinical indicators. Sydney: Australian Council on Healthcare Standards, 2009. Accessed on 19 August 2013, accessed at http://www.achs.org.au/ClinicalIndicators.

B. A. Nardi (Ed.), Context and Consciousness: activity theory and human- computer interaction (pp. 175-198). Cambridge: MIT Press.
Bailey, C. and Boucher, P.(2008) Interoperability Standards for Health Information Systems.[online] Available at: http://www.ehealthconnection.org/files/confaterials/Interoperability%20Standards%20for%20Health%20Information%20Systems.pdf [Accessed 10 August 2014].

Bailey, C., Boucher, P.,Kibbe, D., Lubinski, D.J., Spohr, M., Whitaker, P. (2008, August). Interoperability Standards for Health Information Systems. Retrieved December 3, 2008, from Baskerville, R (2010) 'Investigating Information Systems with Action Research', Communications of AIS , 2(19), pp. 9-10

Beisheim, M. (2015). Reviewing the Post-2015 Sustainable Development Goals and Partnerships. a Proposal for a multi-level Review at the high-level Political forum. SwP

Research Paper 2015/RP1. Stiftung wissenschaft und . Available: http://www.icsu.org/publications/reports-and-reviews/review-of-targets-for-the-sustainable-development-goals-the-science-perspective-2015/SDG-Report.pdf. Last accessed 25th June 2016.

Bennett, J. (2005) Evaluation method in research. EBSCO [Online]. Available at: http://www.nap.edu/catalog/13269/health-it-and-patient-safety-building-safer-systems-for-better (Accessed: 30 August 2015).

Bernard, H.R. 2002. Research Methods in Anthropology: Qualitative and quantitative methods. 3rd edition. AltaMiraPress ,Walnut Creek, California.

Bevan, N. 2009, International Standards for Usability Should Be More Widely Used, [online] Available at: http://www.usabilityprofessionals.org/upa_publications/jus/2009may/bevan1.html [Accessed 02 June 2014.]

Bhowmick T, Griffin AL, MacEachren AM, Kluhsman BC, Lengerich EJ, 2008. Informing geospatial toolset design: understanding the process of cancer data exploration andanalysis. Health Place 14, 576-607.

Bodker, S. (1990). Through the Interface: A Human Activity Approach to User Interface Design. Hillsdale, NJ: Erlbaum.

Braa, J.M., Kanter, A.S, Lesh, N., Crichton, R., Jolliffe, B. (2010) 'Comprehensive yet scalable health information systems for low resource settings: a collaborative effort in Sierra Leone', American Medical Informatics Association, (), pp. 372-376..

Braa,M.J. (2007) Building collaborative networks in Africa on health information systems and open source software development-experiences from the HISP/BEANISH Network, Oslo: IST Africa.

Burnes, B (2009) Managing Change: A Strategic Approach to Organisational Dynamics, 5th edn., Canade: Pearson Education.

Campbell, R. J. (2008). Change management in health care. Health Care Manager, 27(1), 23-39.

CDC…. Centers for Disease Control and Prevention. Updated Guidelines for Evaluating Public Health Surveillance Systems. MMWR. July 27, 2001; 50 (No. RR-13):1-35.

Center for Medicare and Mediaids . (2008). Selecting a development approach. Available: http://www.cms.gov/Research-Statistics-Data-and-Systems/CMS-Information-Technology/XLC/Downloads/SelectingDevelopmentApproach.pdf. Last accessed 30 august 2013.

Christiansen, E. (1996). Tamed by a Rose: Computers as Tools in Human Activity. In

Crawford,G (2006). Measuring Ambulatory Care Quality." Presented at "Information Mastery: Applying Evidence- Based Medicine in Daily Practice" Continuing Medical Education

Program. Disease Management [online]. 11, p.30. Available from: <http://jdc.jefferson.edu/albert_crawford/cv.pdf>. [Accessed 10 July 2014].

Cronholm, S. and G. Goldkuhl (2003) 'Strategies for information systems evaluation: six generic types. ', Electronic Journal of Information Systems Evaluation, 6(2), pp. 65-74.

Denise, M., Ruth, A., Perrin, M., Steven, R., Joanne, M., Stevens, R and John G., 2004. Informatics Resources to Support Health Care Quality Improvement in the Veterans Health Administration[Online] available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC516240/ [Accessed on 03 Aug 2013].

Desiree,S. (2007). Adapting Usability Investigations for Agile User-Centered Design. Journal of Usability Studies. 2 (3), 112-132.

DHIS2 (2016) DHIS 2 is developed and used in a global basis, Available at: http://dhis2.org/node/6 (Accessed: 20th July 2016).

Didar,Z. and Chad,C. (2007) 'Requirements Elicitation: A Survey of Techniques, Approaches, and Tools', Information Systems, 11(28), pp. [Online]. Available at: http://epress.lib.uts.edu.au/research/bitstream/handle/10453/11626/2005003295.pdf?sequence=1 (Accessed: 28th August 2014).

Duane, D., (1996). Business research for decision making. 4th edition. Belmont: Duxbury Press. ISBN 053493295.
Ehn, P (1991). Word-oriented design of computer artifacts. New Jersey: Lawrence Erlbaum Associates. 100-111.

Foddy,W.(1994)ConstructingQuestionsforInterviewsandQuestionnaires,Cam-bridgeUniversityPress:Cambridge.

Garrib, A., Stoops, N., McKenzie, N., Dlamini, L., Govender, T., Rohde, J. and Herbst, K. (2010) 'An evaluation of the District Health Information System in rural South Africa', South Africa Medical Journal, (98), pp. 549–552.

Goddard M, Jacobs R. Using composite indicators to measure performance in health care. In: Smith PC et al., eds. Performance measurement for health system improvement: experiences, challenges and prospects. Cambridge, Cambridge University Press (in press).

Goguen,J.A.,Linde,C.(1993):TechniquesforRequirementsElicitation,ProceedingsoftheIEEEInternationalSymposiumonRequirementsEngineering,pp.152-164,January4-6,SanDiego,CA.

Gulliksen, J et al. 2003, C. (2005). 'Key Principles for User-Centered Systems Design. Behaviour& Information Technology, [online] 22 (6), pp.397-409. Available at: http:// http://libguides.jcu.edu.au/content.php?pid=82408&sid=774836 [Accessed 20 May. 2014].

Haines, A. and Cassels, A. (2004). Can the millennium development goals be attained? BMJ, [online] 329(7462), pp.394-397. Available at: http://dx.doi.org/10.1136/bmj.329.7462.394 [Accessed 4 Jun. 2014].

Hasan, H. (1998). Activity Theory: a Basis for the Contextual study of Information Systems in Organisations. In H. Hasan, E. Gould & P. N. Hyland (Eds.), Information Systems and Activity Theory: Tools in Context (pp. 19-38). Wollongong: University of Wollongong Press.

Heeks,R (2008). ICT4D 2.0: The Next Phase of Applying ICT for International Development. Computer [online]. 41, p.26-33. Available from: <http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4548169>. [Accessed 15 July 2014].
Hitchins,D.K (2007) Systems Methodology, available at http:// www.hitchins.net/SysMethodology.html

Hofmeister, RL. (2005). describing software archictecture. Available: http://www.users.abo.fi/lpetre/SA10/paper99.pdf. Last accessed 27 sept 2013.
Hult, M. and Lennung, S. (1980). Towards A Definition of Action Research: A Note and Bibliography. Journal of Management Studies [online]. 17, p.241-250. Available from: <https://ccar.wikispaces.com/Action Research>. [Accessed 13 June 2014]

Hyland, P. N. (1998). Exploring some Problems in Information Retrieval: an Activity Theory Approach. In H. Hasan, E. Gould & P. N. Hyland (Eds.), Information Systems and Activity Theory: Tools in Context (pp. 93-108). Wollongong: University of Wollongong Press.

Ian Graham (2004) 'Structured prototyping for requirements specification in expert systems and conventional IT project', IEEE, 2(9), pp. 82-89.

ISO 13407 1999, 'Human-Centred Design Processes for Interactive Systems', International Organization for Standardization, Geneva.

ISO 9241-11 1998, 'Guidance on usability', International Organization for Standardization, Geneva.

ISO 9241-210 2010, 'Human-Centred Design Process for Interactive Systems', International Organization for Standardization, Geneva.

Jarke, M., Kurki-Suonio, R. (2008) 'Special issue on Scenario Management. IEEE Transactions on Software Engineering', IEEE, 24(12), pp. 1033-1035.

Jean,Y.H (2014) 'ICT4D a nd the Human Development and Capabilities Approach: The Potentials of Information and Commu nication Technology', , 2(4), pp. 10.

Jess (2015) http://www.jessrules.com, Available at: http://www.jessrules.com (Accessed: 20th May 2016

Jokela, et al., 'The Standard of User-Centered Design and the Standard Definition of Usability: Analyzing ISO 13407 against ISO 9241-11, [online] Available at http://mcom.cit.ie/staff/Computing/prothwell/HCI/papers/ISO%20Standards%20Analysis%202003%20Jokela.pdf [Accessed 29 May 2014.].

Joseph, F. and Arthur, H. (2006). Research Methods for Business. CA: Sage Publishers .

Julio, C.H. , Paula,P.G. (2006) Requirements Elicitation Driven by Interviews: The Use of Viewpoints. AISeL [Online]. Available at: http://aisel.aisnet.org/ (Accessed: 20th May 2016).

Karim, A. (2011). The Significance of Management Information Systems for Enhancing Strategic and Tactical Planning. JISTEM, [online] 8(2), pp.459-470. Available at: http://dx.doi.org/10.4301/s1807-17752011000200011 [Accessed 5 Jun. 2014].

Karlsson, F., & Wistrand, K. (2006). Combining method engineering with activity theory: theoretical grounding of the method component concept. European Journal of Information Systems, 15, p. 82.

Kimaro, H. and Nhampossa, J. (2005). Analyzing the problem of unsustainable health information systems in less-developed economies: Case studies from Tanzania and Mozambique. Information Technology for Development, [online] 11(3), pp.273-298. Available at: http://dx.doi.org/10.1002/itdj.20016 [Accessed 29 May. 2014].

Knight A., Dai, N. 2002. Objects and the Web. IEEE Software. March/April 2002, pp.51-59. IEEE.

Korpela, M., Mursu, A., & Soriyan, H. A. (2002). Information Systems Development as an Activity. Computer Supported Cooperative Work (CSCW), 11, pp. 111- 128.

Kothari, C.R (2004) Research Methodology: Methods and Techniques" New Age International. Suza [Online]. Available at: http://www.suza.ac.tz/saris/download/132376585119680689-Research-MethodologyMethods-and-Techniques-by-CR-Kothari.pdf%202.pdf (Accessed: 20th July 2016).

Kotonya, G., Somerville,I. (2006) Requirements engineering process and techniques, 8th edn., : Willey.

Krogstie, J. (2011) Frameworks for Developing Efficient Information Systems: Models, Theory, and Practice, 3rd edn., Norway: Norwegian University of Science and Technology (NTNU).

Kuutti, K. (1996). Activity Theory as a Potential Framework for Human-Computer Interaction Research. In B. A. Nardi (Ed.), Context and Consciousness: Activity Theory and Human-Computer Interaction (pp. 17-44). Cambridge, MA: MIT Press.

Lachlan, M., MacKinnon and Trinder, P.,2006. Types of Information System,
Laudon, K. and Laudon J. , 2010. Management Information Systems: International Edition, 11/E, Pearson Higher Education.

Lewis, J.L. & S.R.J. Sheppard. 2006. Culture and communication: can landscape visualization improve forest management consultation with indigenous communities? Landscape and Urban Planning 77:291–313.

Mainz, J. (2003). Defining and classifying clinical indicators for quality improvement. Journal for Quality in Health Care. 15 (6), 523-530.

Makombe S.D., Hochgesang M, Jahn A., Tweya H., Hedt B., Chuka S., Yu J.K, Aberle-Grace J, Pasulani O, Bailey C, Kamoto K, Schouten E.J and Harries A.D (2008) Assessing the quality of data aggregated by antiretroviral treatment clinics in Malawi. Bull World Health Organ. 2008;86:310–314

Manya, A., Braa, J., Øverland, L., Titlestad, O., Mumo, J., Nzioka, C. (2012) National Roll out of District Health Information Software (DHIS 2) in Kenya , 2011 – Central Server and Cloud based Infrastructure, : IST Africa.

Marakas, George M. (2006) System Analysis and Design. McGraw-Hill Irwin. New York

McKinsey,Q (2016) How companies are benefiting from Web 2.0: McKinsey Global Survey results, Available at: http://www.mckinsey.com/business-functions/business-technology/our-insights/how-companies-are-benefiting-from-web-20-mckinsey-global-survey-results (Accessed: 27 June 2016).

McNamara, C. (2011). Field Guide to consulting and organizational development. Available: http://managementhelp.org/commskls/qustning/qustning.htm. Last accessed 30 august 2013.

Morf, M. E., & Weber, W. G. (2000). I/O Psychology and the Bridging Potential of

Muenchen RA: The popularity of data analysis software, [online] Available at : http://sites. google.com/site/r4statistics/popularity [Accessed 15 August 2013].

Muller, M.J (1991) PICTIVE-An exploration in participatory design, xxx[Online] available at www.ecole-commod.sc.chula.ac.th/download/doc2006_06.../dos015.pd *[Accessed] 31 May 2014*.].

Murray, C. (2007). Towards good practice for health statistics: lessons from the Millennium Development Goal health indicators. The Lancet, [online] 369(9564), pp.862-873. Available at: http://dx.doi.org/10.1016/s0140-6736(07)60415-2 [Accessed 4 Jun. 2014].

Myers, G.A., Badgett, T.,Thomas, T. M. and Sandler, C. (2004) The Art of Software Testing, 5 edn., 2004: Willey.

Nardi, B. A. (1996). Studying context: a comparison of activity theory, situated action models and distributed cognition, Context and Consciousness: activity theory and human-computer interaction (pp. 69-102). Cambridge: MIT Press.

Newson ,M. 2004, Computer Tools Used for Data Analysis, [online] Available at : http://cwd.aphsa.org/statetostate/docs/Computertools.pdf [Accessed 15 August 2013.].

Nielsen ,J. 1993, Usability Engineering [online] Available at : http://www. Nngroup.com/books/usability/usability-engineering/>. [Accessed 31 May 2014.]

Preece, J. and Rogers, Y. (2003). Interaction design: Beyond human-computer interaction. Human Design. 2, pp.17-19.

Robert, CM. (2003). UML. In: Robert, A. Engineering Note Book. London: Note Book Colums. 39-61.

Rossi, P.H, Williams, W. (1972) Evaluating Social Programs: Theory, Practice, and Politics., New York: Seminar Press.

Scotch et al., Exploring the role of GIS during community health assessment. International Journal of Health Geographics 2006, 5(36):1-10.

Shamoo, A.E., Resnik, B.R. (2003). Responsible Conduct of Research. Oxford University Press.

Shao, D.S., Khurshid, and Perry,D.E. (2007) 'A Case for White-box Testing Using Declarative Specifications Poster Abstract," in Testing: Academic and Industrial Conference Practice and Research Techniques', TAICPART-MUTATION , 3(17), pp. 137.

Sharon, K.U, Sheryl, L.M (2004) 'Ten Conditions for Easing the Transition to a Web Based Patient Safety Reporting System', eHealth, 3(1), pp. 21-23.

Shklar, L. and Rosen R. , 2003. Web Application Archictecture. Principles, Protocols and Practices: Chister, John Wiley and Sons Ltd

Shneiderman, B. and Plaisant, C. (2005). Designing the User Interface. Information Visualization, [online] 14(5), pp.2580-603. Available at: http://dx.doi.org/10.1002/itdj.20016 [Accessed 23 May. 2014].

Somerville Ian (2010) Software Engineering, 9th edn., Addison: Addison Wesley.
Spencer, D. (2004). Card Sorting: Designing Usable Categories. Available: www.amazon.com/gp/product/1933820020/ref=as_li_ss_tl?ie=UTF8&camp=1789&creative =390957&creativeASIN=1933820020&linkCode=as2&tag=uxma09-

20#reader_1933820020/gp/product/1933820020/ref=as_li_ss_tl?ie=UTF. Last accessed 15 May 2014.

Theo, L., Rainer S. (2011) A framework for designing Health Information Systems. 2000, : Libdoc

Thomson R, Lally J. Clinical indicators: Do we know what we're doing? Quality in Health Care 2006;7(3):122.

Tudor,LG (1993). A participatory design technique for high-level task analysis, critique and redesign: The CARD method. In:Procedings of the Human Factors and ergonometrics Society, 20 May 1993, Seattle.

Verenikina, I. (2001). Cultural-Historical Psychology and Activity Theory in Everyday Practice. In H. Hasan, E. Gould, P. Larkin & L. Vrazalic (Eds.), Information Systems and Activity Theory: Volume 2 Theory and Practice (pp. 23-38). Wollongong: University of Wollongong Press.

Wartofsky, M. W. (1979). Perception, Representation, and the Forms of Action: Towards an Historical Epistemology, Models, Representation and the Scientific Understanding (pp. 188-209). Boston: D. Reidel Publishing Co.

Wood-Harper, T. (1985). Research Methods in Information Systems: Using Action Research. IS. 1, pp.169-191.

World Health Organization, 2012 Quality Improvement for Health. Department of Mental Health and Substance Abuse.

Zoran, Ć., Lazar,R. (2010) 'Change Management in Information System Development and Implementation Projects', Management Information Systems, 5(2), pp. 2

APPENDIX I: THE SMC DATA COLLECTION TOOL

Facility Name:	
Facility District:	
Facility Type:	Hospital (fill in type) ________ Health Center ______ Other (please fill in)________ Telephone ______________
Primary Contact Person at site:	Telephone ____________ Email ___________
Completion Date	
Individuals present by name and position (use back side if more space needed)	Name ________________ Position ______________ Tel_______________ Name ________________ Position ______________ Tel_______________ Name ________________ Position ______________ Tel_______________
Completed by	Name______________________________ HQ Team member _____
Care Delivery	Is the SMC delivered at a separate clinic or integrated into primary care? ______Separate location and time ______Separate only by time ______Fully Integrated into primary care
Access	How many days per week is SMC provided including? _______ # days per week
Partner Involvement	List partners who have a **significant** role in supporting the SMC activities

	Area of support provided						
Partner	**Staff**	**Training**	**M&E**	**QI**	**Other Data Mgt**	**Drugs**	**Other Detail**

SAFE MALE CIRCUMCISION **Name of the facility: ______________________________**

	Indicator	Numerator/Denominator	Data source	Month	Month	Month	Month
1.	Number circumcised	Number circumcised	SMC register				
2.	Proportion counseled and tested for HIV	Number counseled and tested for HIV	HCT register				
		Number registered for group education	Group education Register				
3.	Proportion counseled tested and receiving results	Number that receive HIV test result	HCT register				
		Number tested for HIV	HCT register				
4.	Proportion that attend group education with partners	Number that attend group education with partners	Group education register				
		Number that attend group education who are married/cohabiting	Group education register				
5.	Proportion that attend HIV counseling and testing with partners	Number who are counseled and tested with partners	HCT register				
		Number that attend group education with partners	Group education register				
6	Proportion that receive HIV test results with partners	Number that receive HIV test results as couples	HCT register				
		Number counseled and tested together as a couple	HCT register				
7	Number who tested HIV positive		HCT register				
8	Proportion assessed for STI	Number assessed for STI	Client forms				
		Number registered for SMC (males registered)	Group education register				

SAFE MALE CIRCUMCISION **Name of the facility:** ______________________________

9	Proportion with signed consent	Number with documented consent	**Client forms**				
		Number circumcised	**Client forms/ SMC register**				
10	Proportion circumcised under LA	Number circumcised under LA	**Client form/ SMC register**				
		Number circumcised	**SMC register**				
11	Proportion that experience moderate to severe adverse events	Number with moderate to severe adverse events	**Client form/ SMC register**				
		Number circumcised	**SMC register**				
12	Proportion that return within 48 hrs post op	Number that return for follow up in 48hrs	**Client form/ SMC register**				
		Number circumcised	**SMC register**				
13	Proportion that return after 1 week follow up	Number that return within 7days of surgery	**Client form/ SMC register**				
		Number circumcised	**SMC register**				
14	Proportion that return after 6 week	Number that return at or after 6 weeks post op	**Client form/ SMC register**				
		Number circumcised	**SMC register**				
15	Proportion that come back for follow up at 48hrs that had attended with partners	Number of males that come back for follow up at 48hrs that had attended with partners	**Client form/ SMC register/group education register**				
		Number that had attended group education with their partners	**Group education register**				
16	Proportion that come back for follow up at 7days that had attended with	Number of males that come back for follow up at 7days that had attended with partners	**Client form/ SMC register/group**				

APPENDIX II: QUESTIONNAIRE

PROJECT: WEB BASED SOFTWARE TOOL TO ANALYZE HEALTH INDICATORS

A Case Study of USAID ASSIST Project

Dear Respondent,

I am a second year student of Masters of Science Information Systems of Uganda Martyrs University. This interview will aid the development of a web based software tool for analysing Health Indicators.

The purpose this activity is to document and verify information about the users, their current work, and the vision of their work when the new software is in place. This information will feed into the Design phase.

Section1: User Profile

Questionnaire ID:	
Program Area name:	
Date:	
Job title or Role	
Telephone	

Section 2: User categories

		Yes	No
2.1	Do you have access to a computer?	☐	☐
2.2	Do you have Internet access via this computer?	☐	☐
2.4	Have you any experience with any online health data analysis tool?	☐	☐

Section 3: User tasks and obligations

3.1	Indicate the name of your Information System(IS):		
3.2	What are some of the tasks you perform with this system i. …………………………………………………………………………………………… ii. …………………………………………………………………………………………… iii.		
3.3	Do the tasks follow any order?	Yes ☐	No ☐
3.4	If 3.3 is **Yes,** what is the tasks flow? *(Describe)*		
3.5	Is the Order flexible?	☐ Yes	☐ No
	Any interdependencies between the tasks	☐ Yes	☐ No
	What is the frequency of performing such tasks?		
3.6	Do users see any information when performing	☐ Yes	☐ No
3.7	Do you have any documents or tools used when performing tasks	☐ Yes	☐ No
	What are some of the tasks products and where do they go?		

Section 5: Data Reporting and Use

		Yes	No	Unsure
5.1	Do you have any data reporting/ analysis tool that performs fast analytics**? If No Go 5.3**	☐ Yes	☐ No	
5.2	If **YES**, does it perform the following? Check all options that apply			
	☐ Connect and visualize data in minutes	☐ Anyone can analyze data with intuitive	☐ Publish a dashboard with a few clicks	☐ Quickly share information
5.3	From the time the request for a report is received, how long does it take to generate a			
	☐ A day	☐ A week	☐ A month	☐ A year
	☐ Varies (explain)			

Section 6: Additional Information

		Yes	No	Unsure
7.1	Does your organization's IS already link to or share information with other information systems?	☐	☐	☐
7.2	In your opinion, what are the primary advantages or strengths of your organization's IS			
7.3	What are the primary limitations of your organization's IS?			
7.4	What changes would you recommend be made to the system?			
7.5	Please provide any information about the system that could help me to think about how the system could be strengthened.			

Thank You.

Thank you for completing this Questionnaire.

Please feel free to add any additional comments, information or observations on additional pages

APPENDIX III: FOCUS GROUP DISCUSSION GUIDE

These questions will guide the discussion

1. Are you able to analyze data
2. How do you do it
3. What challenges do face
4. How did you overcome these challenges
5. Did you understand the system
6. Does this system work to your expectation or wish to work
7. Do you think the system captures your needs
8. Are the needs and requirements represented well in the system
9. Are there any preferences to the system used
10. Where would you want to see changes proposed
11. Tell me more about these

APPENDIX IV: TEST PLAN

Test	Purpose of test	Test inputs and files used in the test	Test procedure	Expected outcome
Unit testing	To identify errors within individual modules e.g interface, data structure, control flow, error handling	Both artificial and live data, oversize and undersize items and incorrect format	Data entered via the interfaces and test each system module separately	To post data into database if conditions are met and to print the error message in case of errors
Integration testing	To identify interface mismatches and unanticipated interactions between modules and sub systems	(User ID and password). Both valid and invalid	Supply data items at the login screen	Authentication if the system is well integrated and an error message for invalid details
System testing	To validate that the system meets its functional and nonfunctional requirements	Incorrect data, zero or negative values, voluminous data, no data at all in the records and out of range	User to test the system	Print error messages in case of incorrect data items and post items to database
Acceptance testing	to reveal errors or omissions on the requirements specifications or unacceptable system performance	User applied data	Data to be checked against the previous results	Generate reports or show error message if it does not meet the requirements

APPENDIX V: WEB BASED ANALYSIS TOOL EVALUATION FORM

Researcher: Musenge Kenneth

Institution: Uganda Martyrs University Nkozi

Course: MSc of Information System

Contact: 0753-553015

We appreciate your help in evaluating this analysis tool. Please indicate your rating of the system in the categories below by ticking (√) the appropriate response, using choices of SD – **Strongly Disagree**, D – **Disagree**, A – **Agree** and SA – **Strongly Agree.** Please fill out all questions

Participant's Name (optional): ____

Table 1 : Client's Satisfaction

Client's Satisfaction	**SA**	**A**	**D**	**SD**
Web based analysis tool can be used without thinking				
Terminologies related to the task is not understandable				
The sequence of screens are confusing				
Performing tasks are not straight forward				
You can explore Web based analysis tool features using Trial and Error				

Table 2 : Learning effectiveness

Learning Effectiveness	**SA**	**A**	**D**	**SD**
Web based analysis tool is easy to use				
It is not easy to navigate Web based analysis tool				
Web based analysis tool is enjoyable to use				
Web based analysis tool is easy to learn after training				

Table 3: Perceived Benefits

Perceived Benefits	**SA**	**A**	**D**	**SD**
Web based analysis tool may make sharing my results and reports easier				
Web based analysis tool functions facilitates the ease with which my records can be shared				
It is easy to understand the features provided by Web based analysis tool				

APPENDIX VII: SDG 3 TARGETS

Suggested SDG 3 Indicators arranged by OWG Targets

Goal 3. Ensure healthy lives and promote well-being for all at all ages	
3.1 by 2030 reduce the global maternal mortality ratio to less than 70 per 100,000 live births	17. Maternal mortality ratio (MDG Indicator) and rate
	3.1. Percentage of births attended by skilled health personnel (MDG Indicator)
	3.2. Antenatal care coverage (at least one visit and at least four visits) (MDG Indicator)
	3.3. Post-natal care coverage (one visit) (MDG Indicator)
	3.4. Coverage of iron-folic acid supplements for pregnant women (%)
	3.29. Percentage of health facilities meeting service specific readiness requirements.
3.2 by 2030 end preventable deaths of newborns and under-5 children	11. Percentage of infants under 6 months who are exclusively breast fed
	18. Neonatal, infant, and under-5 mortality rates (modified MDG Indicator)
	19. Percent of children receiving full immunization (as recommended by national vaccination schedules)
	3.1. Percentage of births attended by skilled health personnel (MDG Indicator)
	3.2. Antenatal care coverage (at least one visit and at least four visits) (MDG Indicator)
	3.3. Post-natal care coverage (one visit) (MDG Indicator)
	3.5. Incidence rate of diarrheal disease in children under 5 years

Goal 3. Ensure healthy lives and promote well-being for all at all ages	
	3.10. Percentage of children under 5 with fever who are treated with appropriate anti-malarial drugs (MDG Indicator).
3.3 by 2030 end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases	19. Percent of children receiving full immunization (as recommended by national vaccination schedules)
	20. HIV incidence, treatment rate, and mortality (modified MDG Indicator)
	21. Incidence, prevalence, and death rates associated with all forms of TB (MDG Indicator)
	22. Incidence and death rates associated with malaria (MDG Indicator)
	26. [Consultations with a licensed provider in a health facility or in the community per person, per year] – to be developed
	27. [Percentage of population without effective financial protection or health care, per year] – to be developed
	3.5. Incidence rate of diarrheal disease in children under 5 years
	3.6. Percentage of 1 year-old children immunized against measles (MDG Indicator)
	3.7. Percent HIV+ pregnant women receiving PMTCT
	3.8. Condom use at last high-risk sex (MDG Indicator)
	3.9. Percentage of tuberculosis cases detected and cured under directly observed treatment short course (MDG Indicator)
	3.10. Percentage of children under 5 with fever who are treated with appropriate anti-malarial drugs (MDG Indicator).
	3.11. Percentage of people in malaria-endemic areas sleeping under insecticide-treated bed nets (modified MDG Indicator).

Goal 3. Ensure healthy lives and promote well-being for all at all ages	
	3.12. Percentage of confirmed malaria cases that receive first-line antimalarial therapy according to national policy.
	3.13. Percentage of suspected malaria cases that receive a parasitological test.
	3.14. Percentage of pregnant women receiving malaria IPT (in endemic areas)
	3.15. Neglected Tropical Disease (NTD) cure rate
	3.16. Incidence and death rate associated with hepatitis
	3.34. Percentage of women and men aged 15-49 who report discriminatory attitudes towards people living with HIV
3.4 by 2030 reduce by one-third pre-mature mortality from non-communicable diseases (NCDs) through prevention and treatment, and promote mental health and wellbeing	23. Probability of dying between exact ages 30 and 70 from any of cardiovascular disease, cancer, diabetes, chronic respiratory disease, [or suicide]
	24. Percent of population overweight and obese, including children under 5
	26. [Consultations with a licensed provider in a health facility or in the community per person, per year] – to be developed
	28. Proportion of persons with a severe mental disorder (psychosis, bipolar affective disorder, or moderate-severe depression) who are using services
	30. Current use of any tobacco product (age-standardized rate)
	3.17 Percentage of women with cervical cancer screening
	3.18. Percentage with hypertension diagnosed & receiving treatment
	3.21. Waiting time for elective surgery
	3.22. Prevalence of insufficient physical activity

Goal 3. Ensure healthy lives and promote well-being for all at all ages	
	3.23. Fraction of calories from added saturated fats and sugars
	3.24. Age-standardized mean population intake of salt (sodium chloride) per day in grams in persons aged 18+ years
	3.25. Prevalence of persons (aged 18+ years) consuming less than five total servings (400 grams) of fruit and vegetables per day
	3.26. Percentage change in per capita [red] meat consumption relative to a 2015 baseline
	3.27. Age-standardized (to world population age distribution) prevalence of diabetes (preferably based on HbA1c), hypertension, cardiovascular disease, and chronic respiratory disease.
3.5 strengthen prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol	30. Current use of any tobacco product (age-standardized rate)
	3.19. Harmful use of alcohol
3.6. by 2030 halve global deaths from road traffic accidents	25. Road traffic deaths per 100,000 population
3.7 by 2030 ensure universal access to sexual and reproductive health care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programs	7. Total fertility rate
	29. Contraceptive prevalence rate (MDG Indicator)
	44. Met demand for family planning (modified MDG Indicator)
	5.4. Adolescent birth rate (MDG Indicator)
	5.5. Percentage of young people receiving comprehensive sexuality education
	19. Percent of children receiving full immunization (as recommended by national

Goal 3. Ensure healthy lives and promote well-being for all at all ages	
3.8 achieve universal health coverage (UHC), including financial risk protection, access to quality essential health care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all	vaccination schedules)
	26. [Consultations with a licensed provider in a health facility or in the community per person, per year] – to be developed
	27. [Percentage of population without effective financial protection or health care, per year] – to be developed
	3.20. Healthy life expectancy at birth
	3.21. Waiting time for elective surgery
	3.29. Percentage of health facilities meeting service specific readiness requirements.
	3.30. Percentage of population with access to affordable essential drugs and commodities on a sustainable basis
	3.31. Percentage of new health care facilities built in compliance with building codes and standards
	3.33. Ratio of health professionals to population (MDs, nurse midwives, nurses, community health workers, EmOC caregivers)
	3.28. [Mortality from indoor air pollution] – to be developed
	12.3. [Indicator on chemical pollution] – to be developed