UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

Determinants of Acceptance and Use of Routine HIS in Developing Countries: The Case of DHIS2 in Kenya

BY

JOSEPHINE WANGARI KARURI

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DECLARATION

I declare that this thesis is my original work except where due references are cited. It has not been presented for a degree in any other university. No part of this thesis may be reproduced without the prior permission of the author or the University of Nairobi

NAME OF STUDENT

Josephine Wangari Karuri: Signature:  Date: 15 August 2015

This thesis has been submitted for examination with our approval as the University Supervisors.

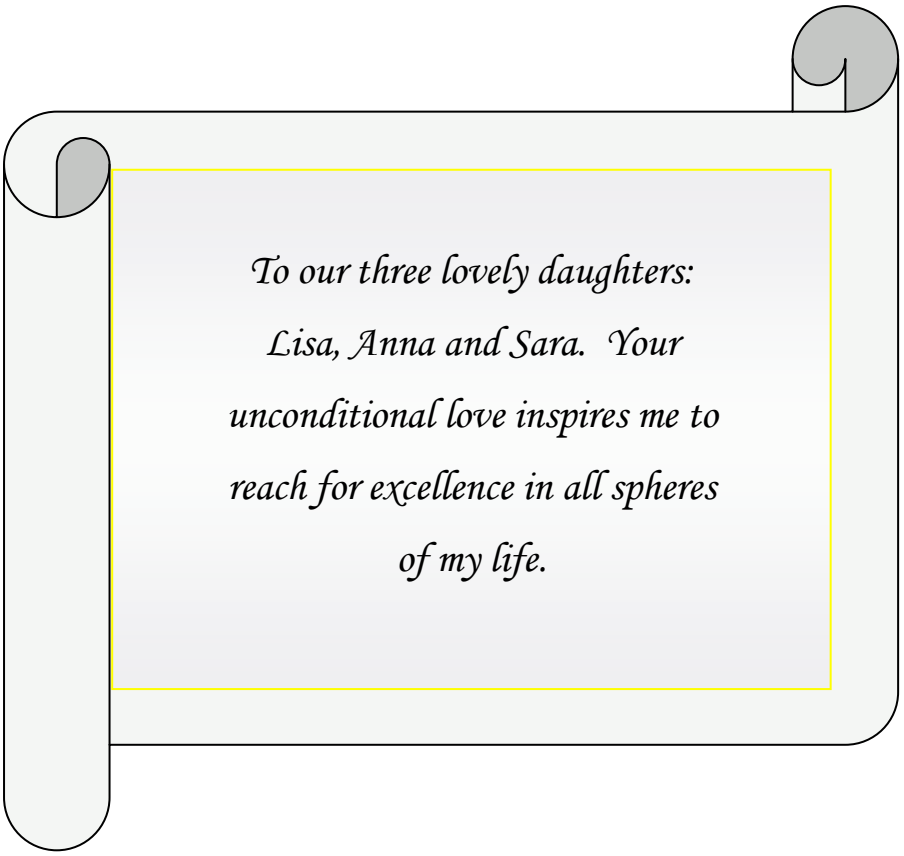
NAMES OF SUPERVISORS

Prof. Peter Waiganjo Wagacha: Signature  Date: 15 August 2015

Dr. Daniel Orwa Ochieng: Signature:  Date: 15 August 2015

University of Nairobi
School of Computing & Informatics
P. O. Box 30197 – 00100 GPO
Nairobi

DEDICATION


To our three lovely daughters:
Lisa, Anna and Sara. Your
unconditional love inspires me to
reach for excellence in all spheres
of my life.

ABSTRACT

The process of implementing ICT in the healthcare sector of developing countries has in the past been often fragmented and ill-managed, leading to weak systems that provide inaccurate, incomplete and untimely information. The increasing application of ICT to manage these countries' routine health information systems (HIS) is expected to improve efficiencies, leading to availability of quality health information for monitoring, evaluation and delivery of healthcare services and programs.

In 2010, Kenya initiated the process of adoption and implementation of a web-based system (DHIS2) as the national HIS that will facilitate management of routine health information for evidence-based decision making. For maximum benefits to be reaped from this implementation, DHIS2 needs to gain acceptance from all categories of targeted users. This study sought to develop a new technology acceptance model that can better explain the key determinants of acceptance and use of DHIS2 in Kenya. The findings from this case study can be extended to explain acceptance and use of health IT in other similar settings.

The overall objective of this research was "***to enhance knowledge and understanding of health I.T. adoption by building and validating a technology adoption model to study determinants of acceptance and use of national HIS in a developing country context'***. The specific objectives were to:

i. To develop a technology adoption model than can predict the complex relationships that affect adoption of routine HIS in a developing country's healthcare context

ii. Validate the model through Structural Equation Modeling (SEM) using empirical data collected from public health care workers in Kenya

iii. Generate the final model and evaluate the strength of the relationships between the exogenous and endogenous constructs, hence deduce the factors that most contribute to the HIS Adoption and Use process

iv. Cross-validate the extended model across different categories of healthcare workers via multi-group analysis.

The study was conducted primarily through the use of quantitative methods, but qualitative data was also collected in the pre-study through conducting Key Informant Interviews (KII) to provide the background and contextual information used in refining the conceptual model. An exploratory study design was subsequently used to determine the existence of relationships between the dependent and independent variables in the model. In the pilot phase of the study, focus group discussions and quantitative analysis of data collected from twenty two DHIS2 users was used to establish the survey instrument's understandability and Completion Time; test the instrument's content validity; and also establish the reliability of construct measurement through measures of composite reliability as well as internal consistency reliability (Cronbach's alpha). Findings from the pilot phase were used to further refine the survey instrument and the conceptual model.

In the main phase the study, a questionnaire was administered to health workers through a cross-sectional survey both at national and county / sub-county levels. The total number of valid questionnaires returned was 266 against a target of 250. This number represents slightly more than 20% of the approximately 1100 health workers who have been trained on DHIS2 in Kenya, and these were drawn from at least 10 of Kenya's 47 counties. The resulting quantitative data was used to empirically test the research model and the associated hypotheses. Data analysis for both the pilot and main survey phases was done in two parts: descriptive analysis of the data was performed using SPSS statistical analysis tool, for the purpose of obtaining the frequencies, means, standard deviation, skewness and kurtosis; with the latter two measures being used to test for distribution normality of each indicator's data. Subsequently Structural Equation Modeling (SEM), and specifically Partial Least Square path modeling (PLS), was used for analysis of the conceptual model and testing of the proposed hypotheses.

By the end of the study, a technology adoption model had been adapted, tested and validated to explain HIS adoption in a developing country context. The specific significance of this study is that it:

- Contributes to research on technology acceptance by extending UTAUT theoretical model
- Identifies the complex structural and contextual factors that contribute most significantly to adoption of public health IT in developing countries context
- Tests the validity of UTAUT in the unique context of public health IT in developing countries context
- Provides public health IT implementers and policy makers with a basis on which to identify factors that can be manipulated to enhance acceptance of such systems in developing countries

Key Words: **Technology Acceptance; DHIS2; UTAUT; Health Information Systems; Structural Equation Modeling;**

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And special thanks to my three lovely daughters, for their great patience and love, spiced with some gentle nudging to hasten the PhD completion process and resume 'normal' life. And to my dear husband, Dr. V. Mark Gacii, thank you for holding down the fort so willingly and so ably while I burnt the midnight oil.

Last but most important I thank the Lord Almighty, who gave me the conviction, the faith and the strength I needed to undertake this journey. To Him be all the Glory.

RESEARCH SUMMARY

The World Health Organization (WHO) defines Health Information System (HIS) as a system that integrates data collection, processing, reporting and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services. A national HIS is usually founded on routine data collection systems but complemented by information from other sources such as community surveys, clinical studies, health systems research, census, and other periodic or population-based surveys. The process of implementing national Health Information Systems (HIS) in developing countries has in the past been often paper-based, fragmented and ill-managed, leading to weak systems that provide inaccurate, incomplete and untimely information. The increasing application of ICT to manage developing countries' routine HIS is expected to improve efficiencies and effectiveness of such systems, leading to availability of quality health information for efficient monitoring, evaluation and delivery of healthcare services and programs in these countries. In 2010, Kenya initiated the process of adoption and implementation of a web-based system (DHIS2) as the national Health Information System that will facilitate management of routine health information for evidence-based decision making. For maximum benefits to be reaped from this implementation, DHIS2 needs to gain acceptance from all categories of targeted users.

Researchers agree that one major factor leading to failure of systems implementation is the inadequate understanding of the socio-technical aspects of information technology (IT), particularly how people and organizations adopt IT. Technology acceptance studies have been conducted widely and various models developed in an attempt to predict the critical determinants of technology acceptance, specifically from the users' perspective. One such model is the Unified Theory of Acceptance and Use of Technology (UTAUT) which reportedly was able to explain up to 69% of user intention to use technology under different settings. These settings did not however include the healthcare domain in a developing country context, with all the unique challenges of implementing ICT under such

settings. This study undertook a rigorous evaluation of an extended UTAUT model to establish the key factors and their complex relationships in determining the acceptance and use of DHIS2 in Kenya. The findings from this case study can be extending to explain acceptance and use of health IT in other similar settings, particularly in sub-Saharan Africa.

The overall objective of this research was "***to enhance knowledge and understanding of health I.T. adoption by building and validating a technology adoption model to study determinants of acceptance and use of national HIS in a developing country context"***.

The specific objectives were to:

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iii. Generate the final model and evaluate the strength of the relationships between the exogenous and endogenous constructs, hence deduce the factors that most contribute to the HIS Adoption and Use process

iv. Cross-validate the model across different categories of healthcare workers via multi-group analysis.

The study was conducted primarily through the use of quantitative methods, but qualitative data was also collected in the explorative pre-study through conducting Key Informant Interviews (KII) to provide the background and contextual information used in refining the conceptual model. An exploratory study design was subsequently used to determine the existence of relationships between the dependent and independent variables in the model.

In the pilot phase of the study, focus group discussions and quantitative analysis of data collected from twenty two DHIS2 users was used to establish the survey instrument's understandability and Completion Time; test the instrument's content validity; and also establish the reliability of construct measurement through measures of composite reliability as well as internal consistency reliability (Cronbach's alpha). The constructs' discriminate validity, which is defined the extent to which a given construct is different from other constructs, was also measured. Findings from the pilot phase were used to further refine the survey instrument and the conceptual model.

In the main phase the study, the finalized questionnaire was administered to health workers through a cross-sectional survey both at national and county / sub-county levels. The total number of valid questionnaires returned was 269 against an initial target of 250. This number represents slightly more than 20% of the approximately 1100 health workers who have been trained on DHIS2 in Kenya, and these were drawn from at least 10 of Kenya's 47 counties to ensure a good representation of the entire country. The survey also provided cross-sectional data on current usage, behavioural intention and acceptance of DHIS2, as well as on other factors surrounding utilization of ICT in public healthcare setting.

The resulting quantitative data was used to empirically test the research model and the associated hypotheses. Data analysis for both the pilot and main survey phases was done in two parts: descriptive analysis of the data was performed using SPSS statistical analysis tool, for the purpose of obtaining the frequencies, means, standard deviation, skewness and kurtosis; with the latter two measures being used to test for distribution normality for each indicator's data. Subsequently Structural Equation Modeling (SEM), and specifically Partial Least Square path modeling (PLS), was used for analysis of the conceptual model and testing of the proposed hypotheses. SEM was chosen because of its characteristic that allows researchers to perform path-analytics modeling of the complex relationships between multiple independent and dependent variables.

The results from the model testing showed that intention to use HIS was mostly influenced by degree to which an individual perceives that his or her peers, supervisors, an important others believe he or she should use the technology. Though to a lesser extent, this intention was also influenced by degree of ease of use associated with using the HIS (Effort Expectancy) and the belief that using the HIS would enable the health worker to attain gains in job performance (Performance expectancy). Another factor that contributed to the prediction of behavioural intention was Training Adequacy which was defined as the degree to which the health worker believed that he or she had received adequate training on use of the HIS. The predictive power of these four factors was found to account for approximately one third (30.9%) of the variance in behavioural intention. The perception that one has a choice to use or not use the HIS (Voluntariness of Use) was not found to significantly influence the behavioural intention. Though these results confirmed that the factors identified in UTAUT were also applicable in the context of this research, the fact that Social Influence was the most important factor was a contradiction to findings obtained when the model was tested in many developed countries' context.

Further model analysis revealed that the second level endogenous variable (Use Behaviour) was predicted by Behavioural Intention, Facilitating Conditions and Computer Anxiety. Together those three factors were able to explain 22.3% of the variance in use behaviour. One finding that was in contrast to previous findings when UTAUT was tested in developed countries was the fact that Facilitating conditions was the most influential factor for this endogenous construct, surpassing by far the influence of behavioural intention. As had been hypothesized, Technology Experience had a statistically significant negative effect on Computer Anxiety. When the moderating effects of Gender and Age were included, the predictive power of the model was increased up to 37.5% for intention to use, and 29.6% for use behaviour.

Multi-group analysis of the data was also done across three distinct heath workers categories segmented according to their assigned roles and functions. The identified groups were: (1) Data Management Group; (ii) Regional Health Management Team and (iii) National Level health officers. The generated model was thus tested for each of these groups to enable understanding of the factor relationships that are most important for each group. One key finding from this analysis was that the variance explained increased to approximately 40% in each of the models representing the 3 different health workers' categories. However a more detailed scrutiny of each group's structural model statistics revealed that the strength of the various distinct causal paths in each model were quite different. This is consistent with prior literature findings that the influence of individual factors on health workers depend on perception of autonomy by different cadres of health workers – for example regional managers are more autonomous in their decision making than the other categories of health workers, hence social influence will not be the most important factor in predicting their actions. This finding confirms that health workers are not a homogenous group across functions and cadres, and this must be taken into account when considering factors that affect their acceptance of particular health technologies.

By the end of the study, a technology adoption model had been adapted, tested and validated to explain HIS adoption in a developing country context. The specific significance of this study is that it:

- Contributes to research on technology acceptance by extending UTAUT theoretical model
- Identifies the complex structural and contextual factors that contribute most significantly to adoption of public health IT in developing countries' context
- Tests the validity of UTAUT in the unique context of public health IT in developing countries' context
- Provides public health IT implementers and policy makers with a basis on which to identify factors that can be manipulated to enhance acceptance of such systems in developing countries

Though the study successfully achieved all the laid out objectives, it did however experience a few limitations. One was that the target population which could be included in the study was limited to the number of people actually trained on DHIS2. Another was the fact that the data collection for this study was done using a cross-sectional approach which, though it has its advantages, does not have the benefit of examining the change in construct relationships across time. Purposive sampling, rather than simple random sampling was used was used as it was the only feasible option for accessing an adequate and representative sample across the three categories of health workers considered in this study.

In conclusion, there is still room for expanding knowledge in the subject area in further research. First, future research can apply a longitudinal study approach in order to test the how the predictive effect of different factors varies across time. Additionally, as much as practicable, the use of probability sampling in identifying the study respondents should be applied. Finally, there might be need to decompose some of the factors that were found to be most important in explaining intention and use behavior of HIS in developing countries, particularly **social influence** and **facilitating conditions** which were confirmed as very important determinants of technology acceptance and use in such settings. Additional factors that can be tested in future studies include the influence of: User Attitude, Peer Influence, Culture; Self efficacy; End-user Support; Infrastructural Adequacy and Managerial Support.

Key Words: **Technology Acceptance; DHIS2; UTAUT; Health Information Systems; Structural Equation Modeling;**

PUBLICATIONS

The following papers have been published during the course of undertaking this research. These contribute to enhancing knowledge on implementation of public health information systems in developing countries, and the development of an extended model for adoption of health IT in such setting. The District Health Information Software (DHIS2) was identified as a good case representative of such systems, having been implemented in 46 developing countries at the time of this study.

Papers

2014. Karuri J., Waiganjo P., and Orwa D. "*Determinants of Acceptance and Use of DHIS2: Survey Instrument Validation and Preliminary Findings using PLS-SEM*" Journal of Emerging Trends in Computing and Information Sciences (JETCIS), 2014;5(8):647-660

2014. Karuri J., Waiganjo P., and Orwa D. *"Implementing a web-based Routine Health Information System in Kenya: Factors Affecting Acceptance and Use".*International Journal of Science and Research (IJSR). 2014;3(9):1843-1851

2014. Karuri J., Waiganjo P., Orwa D., Manya A. "*DHIS2: The Tool to Improve Health Data Demand and Use in Kenya".* Journal of Health Informatics in Developing Countries (JHIDC). 2014;8(1):38–60.

Presentations

2014: Karuri J., Waiganjo P., and Orwa D. *'Scaling up use of the Kenya Health Information System: the Barrier and Enabling Factors'* conference presentation at the Africa Nazarene University 1st Annual International Conference held at the ANU, Ong'ata Rongai Campus. Dates: 29 – 30 May 2014

2013. Karuri, J., Waiganjo P., Manya A. "*Adoption of Health Information Systems by Health Workers in Developing Countries – Contextualizing UTAUT".* Paper presented at IST-Africa 2013 Conference & Exhibition Nairobi, Kenya, 29 - 31 May 2013

LIST OF ABBREVIATIONS

CCC	Comprehensive Care Centre
CDC	Centre for Disease Control and Prevention
COBPAR	Community-Based Program Activity Reporting
C-TAM-TPB	Combined Technology Acceptance Model Theory of Planned Behaviour
DANIDA	Danish International Development Agency
DFID	Department for International Development
DHIS2	District Health Information System version 2
DHMT	District Health Management Team
DHRIO	District Health Records and Information Officer
DHS	District Health System
DTPB	Decomposed Theory of Planned Behaviour
EE	Effort Expectancy
ERP	Enterprise Resource Planning
FBO	Faith Based Organization
FGD	Focus Group Discussion
FOSS	Free Open Source Software
FTP	File Transfer Protocol
GoK	Government of Kenya
HIS	Health Information Systems
HMIS	Health Management Information System
HMN	Health Metrics Network
HMT	Health Management Teams
HRH	Human Resources for Health
HISP	Health Information System Programme
HRIO	Health Records and Information Officer
HTML	Hypertext Mark-up Language
ICT	Information and Communications Technology
IDT	Innovation Diffusion Theory

IS	Information System
IT	Information Technology
KDHS	Kenya Demographic and Health Survey
KEPH	Kenya Essential Packages for Health
KePMS	Kenya Program Monitoring System (for PEPFAR supported activities)
KII	Key Informant Interview
KNBS	Kenya National Bureau of Statistics
LAN	Local Area Network
LMIS	Logistics Management Information System
M&E	Monitoring and Evaluation
MM	Motivation Model
MOH	Ministry of Health
MOMS	Ministry of Medical Services
MOPHS	Ministry of Public Heath and Sanitation
MPCU	Model for PC Utilization
NGO	Non-governmental Organization
NHIF	National Health Insurance Fund
PC	Personal Computer
PE	Performance Expectancy
PEOU	Perceived Ease of Use
PEPFAR	U.S. President's Emergency Plan for AIDS Relief
PLS	Partial Least Squares
PU	Perceived Usefulness
PHMT	Provincial Health Management Team
RHINO	Routine Health Information Network
RHIS	Routine Health Information System
SCT	Social Cognitive Theory
SEM	Structural Equation Modeling
SOUTAUT	Service Oriented Unified Theory of Acceptance and Use of Technology
TAM	Technology Acceptance Model

TOT	Training of trainers
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
UTAUT	Unified Theory of Acceptance and Use of Technology
WHO	World Health Organization

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Chapter 1: INTRODUCTION

1.1. Background and Motivation

A review of the literature reveals that more than 40% of information technology (IT) developments in various sectors including the health sector have failed or been abandoned (Heeks 2002; Littlejohns et al. 2003). A major factor cited as leading to this failure is the inadequate understanding of the socio-technical aspects of IT, particularly the understanding of how people and organizations adopt information technology. Littlejohns et al (2003) reported that the reasons for failure of a large computerized health information system project in South Africa were a lack of users' understanding of reasons for new system and the underestimation of the complexity of the healthcare system. Lorenzi and Riley (2003) (Lorenzi & Riley 2003) pointed out that human issues at both individual and organizational levels contribute to failures in information system (IS) implementation. They categorized reasons for information system failure as ineffective communication, underestimation of complexity, scope creep, organization problems, technology problems, and leadership issues. DeLone and McLean (2003) (Delone & McLean 2003) argued that information system usage is one of the six interdependent dimensions used to measure IS success. Overall, these studies have concluded that the socio-technical aspects of the IT, particularly people and organizations, are essential for the successful adoption of new information systems.

Despite the large failure rates of new IT projects, the last decade has seen access, adoption, and use of health care ICTs and e-health technologies increase rapidly, especially in developed countries. This growth can be attributed to the fact that the healthcare industry is an information-intensive industry, and hence it is expected to gain great benefits by adopting IT applications ranging from medical to administrative systems. This rapid growth of investment in Information Technology (IT) by healthcare organizations worldwide has made user acceptance an increasingly important technology and management issue. To predict and explain the

acceptance and use of a technology, it is necessary to understand why people use or do not use the targeted technology. The acceptance issue has been explored widely in previous research studies, however additional efforts are required to extend and/or validate existing research results, particularly those involving different technologies, user populations and / or organizational concepts (Hu et al. 1999; Aarts & Gorman 2007; Schaper & Pervan 2007).

1.2. HIS in Developing Countries

The World Health Organization (WHO) defines Health Information System (HIS) as a system that integrates data collection, processing, reporting and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services (WHO 2004). A national HIS brings together data from the routine data collection systems as well as information from other sources such as community surveys, clinical studies, health systems research, census, and other periodic or population-based surveys. HIS is also recognized as one the six building blocks of Health Systems Strengthening (HSS) and as such, strengthening a national HIS to generate reliable and accurate public health information is one key approach to support public health reform initiatives in developing countries (Health Metrics Network 2008). However the collection, collation, compilation, analysis and reporting of health data in most developing countries is faced with major problems resulting in incomplete, inaccurate and untimely data which is not useful for health management decision-making at any level. The poor quality data scenario is made worse by lack of adequate ICT knowledge among health workers, as well as under-investment in HIS in developing countries (Abouzahr & Boerma 2005; Kimaro 2006; Mphatswe et al. 2012; Oak 2007; Odhiambo-otieno 2005; Rumisha et al. 2007).

In the last decade however demand for good quality health information from developing countries has continued to grow, partly due to the performance based resource allocation adopted by international donors (e.g. GFATM, USAID), which subsequently makes it a requirement to monitor and report on short term health

program outputs and outcomes. This demand has led to some initiatives to overcome the HIS challenges in these countries by reforming the existing fragmented and paper-based routine health information systems through computerization. However despite the acknowledged critical role of HIS in developing countries and increasing allocation of resources for their implementation, computerization of HIS in these countries has proved to be challenging. Even in situation where such computerization has occurred, there has been reported failure by the targeted health workers to use HIS generated data for the anticipated evidence-based decision making (Wilson 2000; Mengiste 2010; Lungo 2008).

Failure of health information systems comes along with corresponding wastage both in economic terms and also due to the unrealized objectives for improvement in delivery of health services and availability of health data for decision making. Under the resource-limited setting in which developing countries find themselves, it is important that the factors leading to this high failure rate be mitigated to avoid unnecessary depletion of the already minimal resources. Understanding the factors that influence healthcare workers' acceptance and utilization of ICTs in these setting is thus a very important objective. The ability to identify, predict and manage people's acceptance of technology will facilitate implementation efforts, as acceptance of ICT by users is necessary for its ultimate success. This study investigated the factors that affect implementation of a routine health information system, in particular the District Health Information System (DHIS2), from the perspective of enterprise user adoption.

1.3. Technology Adoption in the Health Sector – The Gap

Overall, technology acceptance research is a mature field in information systems research, with many models and theories having been developed and tested for ICT acceptance and use in different industries (Venkatesh et al. 2003). Some well-known examples of these models include: the Theory of Reasoned Action (TRA) by Fishbein&Ajzen (1975); the Technology Acceptance Model (TAM) by Davis, Bagozzi&Warshaw (1989) and the Theory of Planned Behaviour (TPB) by Ajzen(1991)

(Ajzen 1991; Fishbein M and Ajzen I 1975; Davis 1989). Venkatesh et al (2003) capitalized on similarities of key factors in eight existing technology acceptance models to develop "The Unified Theory of Acceptance and Use of Technology" (UTAUT). This model demonstrated up to 69 percent accuracy in predicting user acceptance of the new information technologies tested. UTAUT has since been applied in its original or adapted form to study IT adoption in different sectors, including in the healthcare sector (Chang et al. 2007; Schaper & Pervan 2007; Kijsanayotin et al. 2009).

Despite the large volume of work done to validate the UTAUT model, only a small proportion of it has been conducted in the healthcare context, and especially healthcare context of the developing countries. Developing countries face a wide variety of health related challenges, including perennial struggle with limited financial and human resources, particularly in the public sector. WHO and other stakeholders have repeatedly emphasized the important role that a functional HIS should play in generating the information necessary to support improved health care management at all levels of these countries' health system. This is in turn expected to eventually lead to improved quality of the health service provided to these countries' populations (Sauerborn, R. and Lippeveld 2000; WHO 2004). The newness of formal HIS in these countries can explain the very limited previous academic research conducted in this domain (Chau & Hu 2002). Undertaking studies that will explain how users adopt and use ICT in the health sector will play a major role in ensuring effective deployment of such systems. Thus the opportunity to modify and adopt some of the existing technology acceptance models for application in such settings exists and is necessary. This study set out to examine the applicability of UTAUT to DHIS2 as a new innovation in the Kenya setting, and in so doing measure the level of acceptance and use of this tool by health information administrators and healthcare managers at the different levels of public healthcare system in the country.

A summary of the identified knowledge gaps that informed the choice of this research area include:

1. The fact that despite many models and theories having been developed and tested to understand the issues surrounding ICT acceptance and utilization, very little research to validate these models has been conducted in the context of public healthcare.
2. The fact that where there is some published scientific evidence about acceptance and use of health technologies, these have concentrated on very limited types of technologies, especially Electronic Medical Records (EMR), and none in the area of routine health information systems. There is thus need to extend such research to other types of healthcare applications.
3. The fact that even the existing acceptance studies have mostly been undertaken in developed countries and thus they do not take into account the different contextual factors present in developing countries (Schaper & Pervan 2007). Thus the need to extend such research to the context of developing countries is evident.
4. In particular there is need to investigate the role played by factors that have been shown to be of high importance when introducing new ICT technologies in developing countries, and these include the targeted users' prior experience in use of ICT, and the associated Computer Anxiety; and additionally the importance of accompanying such technologies with Adequate Training (Blumhagen et al. 2010; Kimaro 2006; Vital Wave Consulting 2009). Most developing countries exhibit communal societies, so it is anticipated that that Social Influence by important others will play a critical rule in users' technology adoption decisions (Hofstede et al. 2010).

1.4. Problem Statement

Having recognized the critical role played by a functional HIS, in 2010 Kenya's HIS Division overhauled the existing disintegrated and inefficient system to replace it with the web-based District Health Information Software (DHIS2). DHIS2 system has the potential to transform Kenya from the era of unreliable and fragmented HIS

system to the more ideal situation of availability and use of quality health information for rational decision making (Karuri, Waiganjo, Orwa, et al. 2014; Manya et al. 2012). Against this background it is important that all measures be put in place to ensure that DHIS2 does not fail as was experienced with the previously implemented HIS systems in Kenya. Furthermore, for maximum benefits to be reaped from this implementation, it is important that the DHIS2 gains acceptance from all categories of the targeted users, and especially by all health workers in the country.

While implementation of DHIS2 in Kenya was a major leap in the right direction, there is compelling evidence to suggest that health professionals are reluctant to accept and utilize information and communication technologies (ICT), and concern is growing within health informatics research that this is contributing to the lag in adoption and utilization of ICT across the health sector (Schaper & Pervan 2007; Ekirapa et al. 2013). A validated technology adoption model to evaluate the complex interrelations between factors affecting user acceptance of DHIS2 is beneficial in informing policy makers as well as system designers and implementers on approaches that will contribute to more successful implementation and scale up of this and other related health information technologies both in Kenya and in other similar developing countries' contexts.

The Unified Theory of Acceptance and Use of Technology (UTAUT) has been applied in its original or adapted form to study IT adoption in various sectors and demonstrated up to 69 percent accuracy in predicting user acceptance of new information technology (Schaper & Pervan 2007; Kijsanayotin et al. 2009; Chang et al. 2007). However despite this abundance of work done to validate the UTAUT model, only a small proportion of it has been conducted in the healthcare context, and especially healthcare context of developing countries. Yet developing countries face unique challenges in implementing ICT in health, ranging from ICT infrastructure challenges, lack of the adequate ICT skills among health professionals, economic challenges, as well as other social and political issues. This therefore means there is

need to review existing adoption models and adapt them to include technology acceptance factors that are relevant to the developing countries healthcare context. Another fact to note is that the only research conducted in developing countries healthcare context has focused on the relatively simple and individually driven applications of ICT in health rather than on any specific organizational-level health technology which is of greater concern at management levels (Venkatesh et al. 2003).

The opportunity to modify and adopt this model for application in such settings therefore existed and was necessary. This study set out to examine the applicability of an extended UTAUT to DHIS2 system as a new innovation in the Kenyan setting, and in so doing measure the level of acceptance and use of this system by public health workers in the country. From a theoretical perspective, this research extended the model's theoretical validity and empirical applicability by examining UTAUT within the context of a national health information system in a developing country context.

1.5. Research Objectives

The primary objective of the study was to leverage UTAUT and other technology adoption models to evaluate the acceptance and use of the newly introduced system for collection of routine health information, the DHIS2, among health care professional in the public healthcare setting of Kenya.

The study sought to understand the unique contribution of the identified factors to the adoption of DHIS2 by the healthcare professionals who were sampled from different levels of the public healthcare system in Kenya. The groups of users involved in this study were the Health Information Managers [who are mostly the Health Record Information Officers (HRIOs)]; Regional Health Managers at county and sub county levels; and the national level Health Officers; all of whom had been trained or sensitized on the use of DHIS2. The reason for focusing on these three categories of users is because they represent the key stakeholders who will ensure

the success of the DHIS2 in the country, with the Information Managers having the responsibility to ensure all available information is loaded into the system correctly, while the other two categories represent the host of beneficiaries who are expected to use the information in DHIS2 for evidence based decision making.

The overall objective of this research was "*to enhance knowledge and understanding of health I.T. adoption by building and validating a technology adoption model to study determinants of acceptance and use of national HIS in a developing country context"*. The specific objectives were to:

i. To develop a technology adoption model than can predict the complex relationships that affect adoption of routine HIS in a developing country's healthcare context

ii. Validate the model through Structural Equation Modeling (SEM) using empirical data collected from public health care workers in Kenya

iii. Generate the final model and evaluate the strength of the relationships between the exogenous and endogenous constructs, hence deduce the factors that most contribute to the HIS Adoption and Use process

iv. Cross-validate the model across different categories of healthcare workers via multi-group analysis.

1.6. The Research Questions

To guide the process of addressing the outlined research objectives, the following research questions were formulated:

1. What unique factors predict user adoption of a Health Information System in the public health care setting of developing countries?
2. Can existing technology acceptance and use models be leveraged upon to study contribution of the identified factors to acceptance and use of HIS in this context?
3. Which of the identified factors are most influential in contributing to the acceptance and use of routine HIS in developing countries?

4. Is the proposed theoretical model valid across different categories of healthcare workers?

1.7. Context of the Study

The study was carried out in the context of implementing HIS in Kenya, which is an extension of other developing countries especially in Sub-Saharan Africa because of the unique challenges they share in implementing computerized HIS. The HIS investigated under the study is built on DHIS2. A review of the literature shows that there has been a rapid expansion in use of DHIS2 in developing countries, with this system playing a key role in helping governments and health organizations to manage their HIS operations much more effectively. Sub-section 1.7.1 explains the basis of categorizing countries as either developed or developing. Subsection 1.7.2 defines Health Informatics, which is the overall discipline on which this study is based. Subsection 1.7.3 briefly describes DHIS2 and sheds more light on the critical role this system is playing in implementation of HIS in developing countries. Subsection 1.7.4 explores the subjects of computerizing HIS in Kenya's public health sector and the role DHIS2 is playing in this process. Finally Subsection 1.7.5 explains the 'Adoption of HIS' terminology as used in the context of this study.

1.7.1 What is a Developing Country?

A search of the Literature reveals that there is no universally agreed upon definition of what a developing country is. But there is general agreement that developing countries are more disadvantaged than developed countries, and that their citizens usually have lower life expectancy, less education and less income (Sullivan & Sheffrin 2003). The World Bank classifies countries in four income groups according to their gross national income: namely lower income; lower middle income, upper middle income and high income countries (Vital Wave Consulting 2009). It then proceeds to classify all low and middle income countries as developing countries. On the other hand the International Monitory Fund (IMF) uses a more flexible classification system that considers per capita income level, export diversification and degree of integration into the global financial system (The International

Monetary Fund 2014). Based on this system, the IMF has come up with the map in figure 1.1 which indicates the development category of each country. It is obvious that most of the countries in Asia, Africa and South America are considered to belong to the developing countries category. Despite the identified importance of national HIS for evidence-based decisions, health information systems in many developing countries have been found to be weak, fragmented, mostly paper-based and often focused exclusively on disease-specific program areas (Health Metrics Network 2008) .

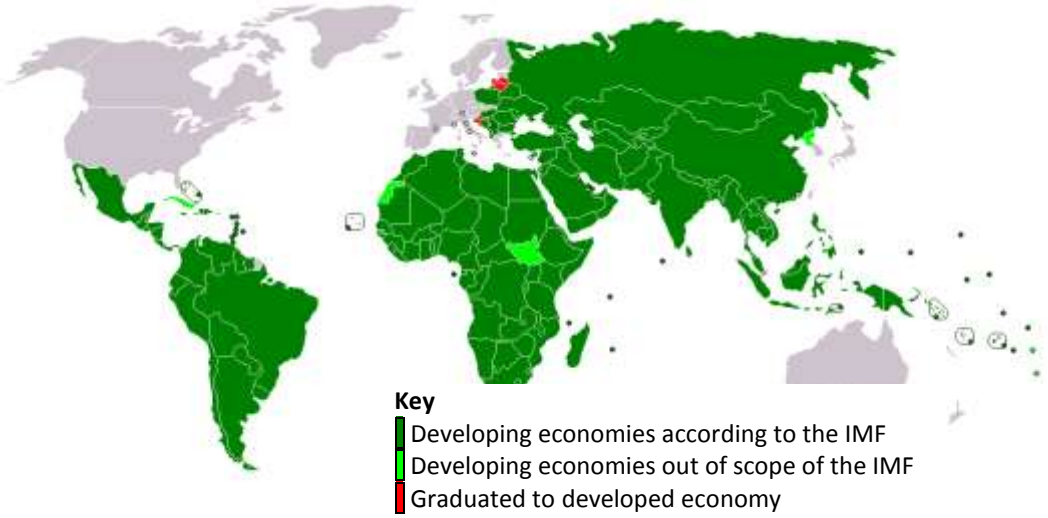


Figure 1.1: IMF Developing Countries Map
(Available at https://en.wikipedia.org/wiki/File:IMF_Developing_Counties_Map_2014.png)

1.7.2 What is Health Informatics

Health informatics or eHealth has been defined as the use of electronic information and communications technologies to provide and support health care wherever the participants are located. It is considered an evolving scientific discipline which deals with the resources, skills and tools required to store, retrieve, disseminate and use health related information to deliver healthcare and promote health. The discipline utilizes the methods and technologies of the information science that include computers, information and communication systems for providing best quality healthcare in the basic as well as in applied biomedical sciences (Eysenbach 2001; Wyatt & Liu 2002). Thus the DHIS2 is one example of a Health Informatics tool.

1.7.3 Critical Role of DHIS2 as the HIS in Developing Countries

The District Health Information System Software (DHIS) is a free and open source database and application for collecting, processing, and analyzing health information, and whose development and implementation was started in 1998 by the Health Information System Programme (HISP) based in South Africa. HISP is a research network which is organized by the University of Oslo and is devoted to the development of HIS in developing countries. It stems from the effort to build a HIS in post-apartheid South Africa in the mid 1990s, but has now spread and includes partners in many parts of Africa and Asia. DHIS is designed to support decentralized decision making and health service management by allowing health care workers to use their data to analyze their levels of service provision, predict service needs, and assess performance in meeting health service targets (Braa et al. 2004; Braa et al. 2010).

Currently DHIS2 is implemented at different levels in 46 developing countries around the world as illustrated in table 1.1

Table 1.1 Countries using DHIS2

DHIS as National HIS		Program Level or Partial national roll-out		Pilot stage or early phase in roll-out	
Bangladesh	Tanzania	Algeria	Nigeria	Afghanistan	Nepal
Burkina Faso	The Gambia	Bhutan	Sierra Leone	Benin	Niger
Ghana	Uganda	Colombia	Solomon	Cameroon	North Korea
India	Zambia	DRC	Islands	Congo	Samoa
Kenya	Zanzibar	Laos	South Africa	Brazzaville	Senegal
Liberia	Zimbabwe	Malawi	Sri Lanka	Cote d'Ivoire	South Sudan
Rwanda		Mozambique	Tajikistan	Guinea Bissau	Sudan
			Vietnam	Mexico	Timor Leste
				Myanmar	Togo
				Namibia	Vanuatu

The overall objective of DHIS2 implementation is to be able to generate, analyze and disseminate health information to facilitate effective policy formulation, management, planning, budgeting, implementation, monitoring and evaluation of health services and

program interventions in the health sector. DHIS2 is able to support collection and analysis of routine health services data, as well as non-routine data such as population estimates, facility workload and survey data. Currently this data is collected by means of a paper-based system of registers, tally sheets, and monthly data collation forms at each health facility. The collated monthly data is either entered directly into the web-based DHIS2 or sent to the district level where is entered on to the web-based DHIS2 software, then analyzed in the system. The web-based DHIS2 is intended to capture health facility service delivery data and allow analysis at that level, promoting data use at all levels for decision making.

DHIS2 is configured to allow the generation of reports, which can be either standard or customized to meet the user requirements; and to also carry out data quality analysis and provide a dashboard for monitoring and evaluation of health programs' indicators. The essential reports have already been built into the system and are immediately available for review at all levels i.e. by the health facility, district, province / county and national health departments. Data quality is addressed through mechanisms incorporated into the data collection process and functions within the DHIS software. Another advantage of the DHIS2 platform is its very modular web interface which allows for easy incorporation of various modules, enabling easier replication of the complex paper reporting formats that are unique to each country of implementation (Braa et al. 2010; Braa, Monteiro, et al. 2007).

1.7.4 Computerizing HIS in Kenya's Public Health Sector

Kenya's vision 2030 goal for the health sector is "to provide equitable and affordable quality health services to all Kenyans". One of the approaches identified as necessary for achievement of this vision is the devolution of management of health care to the communities, counties and sub-counties. At the same time, the vision recognizes that the integration of Science, Technology and Innovation (STI) in national processes is central to the success of the government's policy priorities and programmes. The First Medium Term Plan 2008-2012 of Vision 2030 identifies the need to strengthen the national health information systems to enable them provide adequate information for monitoring health goals and empowering individuals and

communities with timely and understandable information on health (Government of Kenya 2007; Government of Kenya 2008b).

Recognizing the critical role played by a functional HIS in provision of the timely, relevant and quality information required by the Health Ministry to manage their programs and activities and to achieve improved efficiencies in health services delivery at all levels, the Ministries of Health were instrumental in the conducting of several assessment of the Kenya HIS system over the last decade (between years 2000 and 2010). These assessments revealed that despite rising demand for health information, Kenya's HIS was weak and poorly integrated. In particular the routine health information was found to be deficient in quality, timeliness and depth of analysis, and hardly accessible to stakeholders for use in decision making (Blumhagen et al. 2010; Government of Kenya 2008a; Ministry of Health 2009a; Ministry of Health. Health Sector Programme Support - Phase 2 2009). The ultimate recommendation was that the existing HIS be overhauled and replaced with a comprehensive and integrated HIS system that responds to the needs of the myriad stakeholders operating in the Kenya health sector. After considering many options, the DHIS2 was selected and its implementation in Kenya commenced in year 2010 (Kenya Ministries of Health 2009).

1.7.5 Adoption of HIS

Traditional innovation adoption research based on Rogers Innovation Diffusion Theory (IDT) (Rogers 1995)is primarily concerned with examining how an innovation is accepted by the total population in the adoption process, without taking into consideration behavioural and perceptual characteristics of the individual consumer or user of that technology. Such studies focus on the identification of who would or would not adopt an innovation, without outlining how the decision to adopt is arrived at in the first place. In studying the acceptance and use of new technologies in the health care sector however, the term "*adoption"* has been extensively used in the literature to represent not necessarily the abstract state of the decision to "*adopt*" an information technology as used in the context of the IDT, but more

specifically to explain the extent to which individual users "*accept and use"* that technology from a social psychological perspective. This individual acceptance of the new technology is operationalized through the users' "*behavioural intention"* to use that technology as measured through different indicator variables; and Behavioural Intention is commonly used as a predictor of "*future use"* (Fishbein M and Ajzen I 1975; Taylor & Todd 1995; Davis 1989; Venkatesh & Davis 2000; Venkatesh et al. 2003). It is on this understanding of the link between behavioural intention and actual technology use that this study's model to explain HIS acceptance and use has been developed. As the study is conducted in the healthcare setting, the researchers chose to remain consistent with meaning of technology adoption as widely applied in this research area. DHIS2 represents the new HIS technology whose acceptance and use is being evaluated in a developing country context. Against this background the term '*HIS adoption*' is used interchangeably with the term '*HIS acceptance and use*' unless where specifically stated otherwise.

1.8. Contribution to knowledge

This study contributes to the body of knowledge that focuses on technology adoption by extending the UTAUT theory and validating it in a new context both in terms of technology (HIS) and low resources (developing countries). In addition to the theoretical contribution, it provides new knowledge that will make practical contribution to more effective development and implementation of public health IT in developing countries; as well as the associated formulation of health information policies and guidelines. Given the many shared characteristics between developing countries especially in sub-Saharan Africa, it is apparent that an extension of the Unified Model of Technology Acceptance and Use (UTAUT) to study HIS adoption in Kenya will be a good representation of the practicability and applicability of UTAUT to other developing countries' context as well.

The detailed contribution of the study can be classified into three categories, namely: Theoretical, Methodological and Practical /Managerial as discussed below.

1. Theoretical Contribution

a) Extension and modification of the Unified Theory of Acceptance and Use of Technology (UTAUT)(Venkatesh et al. 2003) to study technology acceptance in the context of healthcare in developing countries. Previously this model has mostly been applied for studies of user acceptance within developed countries context.

b) Additionally the well established baseline model, UTAUT, has been extended to study acceptance and use of a new technology artifact in a new organizational setting. To the researchers' knowledge, this is the first ever scholarly research study based on UTAUT model to study behaviour intention and actual use of a national level HIS in a public healthcare setting of any country

c) The researchers built the unique extended model by identifying and validating new factors (constructs) which impact on behavioral intentions and actual use of HIS: These new factors are: **Perceived Training Adequacy**, **Computer Anxiety** and users' prior **Technology Experience**. The contribution of **Voluntariness of Use**, which had also been proposed as a new factor, was also tested but not found to be significant. The new factors were combined with existing factors in UTAUT to produce a unique research model with eight constructs and two moderating variables.

d) Overall, this study has led to validation of UTAUT model for application in undertaking HIS studies in Kenya as well as in other developing countries, making the necessary recommendation of how it should be adapted to suit such a setting

2. Methodology Contributions

The study outlines the importance of going through logical steps in undertaking credible research in the area of technology acceptance and use, regardless of the study artifact and organizational context. A summary of key

recommendations based on the methodology used in this study is given below:

a) The researchers should start by doing a thorough contextual investigation from existing literature. This help them to identify factors that have already been tested and the findings obtained, and so clearly identifying the gap to be addressed by the research. When testing a particular technology artifact like the DHIS2, the researcher also needs to conduct a desk review to fully understand the contextual setting of the study environment.
b) Second, the researchers need to undertake exploratory qualitative study early on in technology acceptance and use research. This provides them with important feedback from subject level experts on the factors they consider as critical for the success of the technology artifact under study. Based on this the researchers are able to relate stakeholders view on barriers and enablers of the technology adoption to measures and constructs in their research model.
c) Another important methodology step is the pilot study. Through this phase the researcher is able to a priori confirm the survey tool's completeness and understandability, and obtain focused feedback on how to improve the tool and thus enhance the chance of obtaining higher rates of valid survey responses. Also important is the ability to use the pilot data to test the proposed research model's reliability and validity and act on the results to improve the model accordingly.
d) This research sets an example of how to design an exploratory study for evaluating the causal relationships between different factors contained in a complex study model. For this kind of study second generation statistical techniques such as the partial least squares structural equation modeling (PLS-SEM) used in this study are much more suitable than first generation techniques such as multiple regression, ANOVA or t-tests. The study clearly and in a simplified manner details how PLS-SEM was applied

for estimating the theoretical model. Future researchers can benefit from following the detailed methodology.

e) This study also clearly outlines the situation where it may be more advantageous to use PLS-SEM as opposed to covariance-based SEM. This is especially so when dealing with complex causal models with a lot of constructs and indicators, yet having to work with a limited data set. PLS-SEM also has the advantage of having the capacity to work with non-normally distributed data and in exploratory research setting such as was the case in this study.

3. Practical / Managerial Contribution

a) By understanding the factors considered to be critical by users in determining their level of acceptance and use of HIS, management and implementation teams can plan for more effective HIS systems deployment approaches, including advising system developers on the context specific customization they need to make on their softwares to make them more acceptable to the intended users

b) Social influence emerged as the most pertinent factor that influences intention to use the HIS. This fully resonates with the findings from the explorative phase of the research where respondents identified a close link between social influence and the behaviour change necessary for health workers to accept and use DHIS2. Managers should ensure that there is a senior-level "champion" or leader to spearhead the use of new HIS systems, with the bottom line being that health workers will in most cases adapt their behaviour in accordance to what they perceive to be the expectations of their superiors. Peer influence can be enhanced through joint performance review meetings.

c) The other factors of performance expectancy and effort expectancy were also found to be important as identified in UTAUT, so implementation of the system should take these into account by ensuring the system design is user friendly and that the end-users are involved in its customization to

assure that indeed there will be value-add from using the system. The new factor of Training Adequacy was found to contribute to overall user acceptance of the system, as such it would be beneficial for managers to carefully plan for this aspect of system deployment, and to use formal and informal assessment methods to conduct regular evaluations of training adequacy aspects from the user perspective.

d) It also emerged that availability of adequate facilitating conditions was the most important factor for ensuring actual use of the HIS system. Managers can provide this facilitation through provision of adequate ICT infrastructure such as access to computers and the internet, provision of responsive technical support and other knowledge resources.

e) Computer anxiety level was found to be an important factor that negatively affects users' actual use of HIS, and this was in turn predicted by the level of technology experience that these users had been previously exposed to. There is thus need for managers to proactively work to minimize this anxiety by ensuring that health workers are exposed to ICT training from early stages of their careers, and if possible mainstream such training to become a part of the health workers formal pre-service curriculum.

1.9. Structure of the Thesis

This thesis consists of a total of six chapters. Chapter one introduces the issues related to the topic under investigation i.e. acceptance and use of health information systems in the public healthcare context of a developing country. The chapter provides the theoretical background and the study motivation. Subsequently it defines the research problem, research objectives and corresponding research questions, as well as the context in which this study was undertaken. Finally it provides this outline of the overall structure of the thesis.

Chapter two focuses on a review of literature that relates to the context of the study. It discusses in detail various technology adoption theories which have been used in the past to explain user acceptance of technology in general. It then zeros in on use of UTAUT theory specifically in healthcare context, and provides a summary of key findings from studies done in this context. Based on existing literature, the chapter also discusses implementation of routine HIS in developing countries, and the critical role DHIS continues to play in this area in Kenya and beyond.

The understanding of the study background presented in chapter one, as well as of relevant adoption factors which were identified in the literature review described in chapter two serve as important inputs for Chapter 3. These inputs were further crystallized by findings of a qualitative pre-study conducted to provide contextual understanding of the factors considered as barriers or enablers of HIS adoption in Kenya, as described in chapter 3. The chapter concludes by drawing on all this background information to lay out the research's conceptual model, and the twelve associated hypotheses to be tested and analyzed.

Chapter four presents the study methodology which leads up to testing of the proposed research hypotheses. It starts by discussing the research paradigms and strategy, as well as providing justification for the choice of methodology for each phase of the study. It further discusses development and pretesting of the data collection instrument used in the main phase of the study, including its measurement items and scale. Also included is an elaborate description of the data analysis methods used, including justification for the choice of the statistical techniques utilized, and a presentation of the tests for reliability and validity of the latent constructs included in the research model. Finally the chapter explains the ethical considerations taken into account while undertaking this research.

Chapter five reports the results of data analysis undertaken in the pilot test and the main phase of the study using different data analysis tools. It reports the results the descriptive analysis of the quantitative data using PASW (SPSS) Software version 18.

Then it goes on to elaborate on all of the steps conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) technique, and the findings obtained in each step. This chapter also reports the outcome of the model constructs reliability and validity tests, and the subsequent evaluation of the 12 proposed research hypotheses to determine whether or not they are supported by the empirical evidence.

Chapter 6 presents a more detailed discussion of the study results, linking them to the overall study objectives and research questions. This discussion is enriched by considering findings from the literature reviewed and from the qualitative pre-study. The chapter discusses implications of the research results from theoretical, practical systems implementation, and managerial perspectives. Finally the chapter concludes by discussing limitations of the study and making recommendations for future research.

The ***Appendices*** contains samples of the ethical and other approval that were required to allow conducting of research in the Kenya healthcare sector. The Study Guide used in conducting the Key Informant Interviews for the explorative qualitative study is also included. Also contained in this section is the final questionnaire that was used in the cross-sectional survey that provided empirical data for this study. This was accompanied by an Informed Consent form that all survey participants had to sign to indicate voluntary participation in the study. Also included in this section is a summary of the results of the Pilot study conducted as part of this research, primarily to confirm the validity and reliability of the tool, constructs and measures used in this study. Finally the section includes a detailed but overall evaluation of the study and its contribution, guided by recommendations by Whetten (Whetten 1989).

Chapter 2: LITERATURE REVIEW

2.1. Introduction

Research on users' acceptance and use of ICT has intensified over the past few decades because of the increasing use of computers and information technology in all work domains. Researchers in this area seek to understand the factors that influence people to accept and use these ICT systems, and in particular which among those factors are deemed as most important. Acquiring such understanding adds value to different categories of stakeholders including the system designers, organization management and even higher level policy makers. Consequently concentration of research in this area has generated many competing technology acceptance models originating from different theoretical disciplines such as psychology, sociology and information systems, each with different sets of determinants for acceptance or usage of ICTs. The operationalization of user acceptance is perspective-dependent and from social psychology perspective, intention-based models are used to predict usage. These models focus on the determinants of behavioral intention, serving as a surrogate for technology usage or technology acceptance, all looked at from the perspective of the targeted system users.

2.2. Formulation of the UTAUT Model

There is constant effort by researchers to improve the predictive power of existing technology acceptance models. Venkatesh et al developed the Unified Theory of Acceptance and Use of Technology (UTAUT) by incorporating factors from eight prominent technology acceptance models based on their effectiveness in predicting anticipated and actual system use behaviour. The 8 models were:

a) The Theory of Reasoned Action (TRA) (Fishbein M and Ajzen I 1975)
b) Davis' Technology Acceptance Model (TAM) and its extended version (TAM2)(Davis 1989; Venkatesh & Davis 2000)
c) The Motivation Model (MM) (Davis et al. 1992)

d) The Theory of Planned Behaviour (TPB) (Ajzen 1991)
e) The Combined TAM and TPB (Taylor & Todd 1995)
f) The Model of PC Utilization (MPCU) (Triandis 1977; Thompson et al. 1991)
g) Roger's Innovation Diffusion Theory (IDT) (Rogers 1995)
h) Social Cognitive Theory (Bandura 1986; Compeau & Higgins 1995; Compeau et al. 1999)

The UTAUT model was validated by comparing its effectiveness against that of the eight theoretical models for four different IT systems in four different industries, including two voluntary and two mandatory systems. None of these industries however was in the health sector. The model's effectiveness was also examined at three different time periods, namely: after training, one month after implementation, and three months after implementation. Venkatesh et al (2003) found that none of the tested models could explain more than 50% of the variance in user intentions to use a new technology whereas the combined model was able to explain 69% of intention to use IT (technology acceptance). The model was further cross-validated by applying it to evaluate systems in two additional organizations and demonstrated good predictive ability. When considering the direct effects only, UTAUT was able to explain much less of the variance at 27% of intention to use and 37% of use behaviour only. An extended UTAUT model (UTAUT2) has since been developed by Venkatesh et al (2012) to specifically to focus on consumer acceptance and use of Information Technology by adding 3 constructs, namely: hedonic motivation, price value, and habit. As such UTAUT2 is not applicable the current study (Venkatesh et al. 2012).

2.3. Contributions of the Eight Technology Acceptance Models

Prior to settling on the UTAUT model as the basis for this study, the researchers undertook a thorough review of the contributing theories to identify their constituent factors and assess their suitability for inclusion in the research model. This was necessary because though UTAUT was formulated by integrating factors selected from these eight models, some of the individual factors that were left out

may be suitable for inclusion in our research model given the unique context being studied. Undertaking the review was also a way for the researchers to confirm that UTAUT was indeed the optimal model to serve as the foundational model for the study. In summary this section demonstrates the evolution of influencing factors for predicting acceptance and use of technology in the eight prominent models that contributed to formulation of UTAUT. It then further explores application of UTAUT in studying technology adoption in healthcare and in other settings.

2.3.1 Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) is one of the most well established theories intended to predict and explain human behaviour. TRA posits that the behavioural intention to perform a particular behaviour is determined by a personal factor and a social factor (Fishbein M and Ajzen I 1975).The personal factor is represented by attitude, and the underlying assumption that the attitude stems from beliefs and evaluations, and determines an individual's positive or negative feeling toward performing the target behaviour. The social factor is represented by subjective norm. Fishbein and Ajzen (1975) refer to the beliefs that constitute subjective norm as normative beliefs, defined as 'the person's perception that most people who are important to him think he should or should not perform the behaviour in question". This model is generic and not specific to any particular behaviour, thus it has served as the foundation for explaining and predicting human behaviour in any context.

Being a general behaviour theory, researchers identified a limitation in this theory when applied in a particular contextual setting (Davis 1989; Ajzen 1991).The theory was also criticised for being unsuitable to predict behaviour in situations where the individual has low levels of volitional control. The biggest contribution by this theory is the Behavioural Intention (BI) construct which is used for predicting actual technology use behaviour. BI is also used in the theories that were developed later based on TRA, namely TPB, TAM and UTAUT. In the test by Venkatesh et al (2003) this theory was only able explain between 19% and 20% of the variance in intention to use technology.

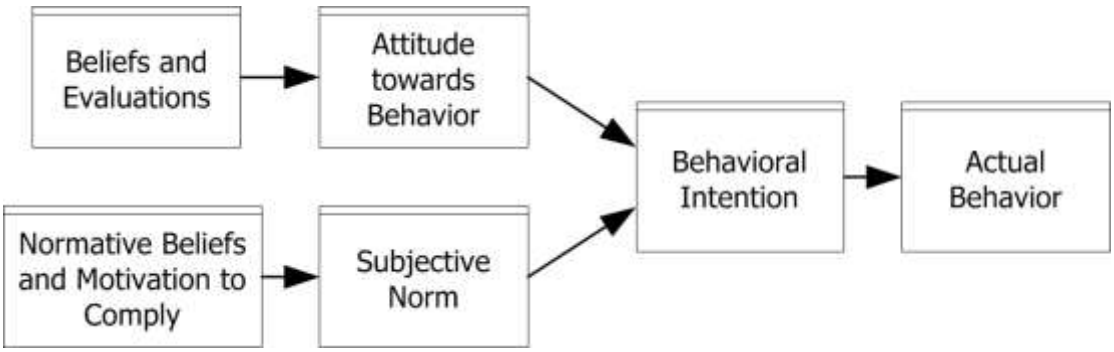


Figure 2.1 Theory of Reasoned Action

2.3.2 Technology Acceptance Model (TAM)

TAM was designed by Davis in 1989 to predict information technology acceptance and usage, and it used the Theory of Reasoned Action (TRA) by Fishbein and Ajzen (1975) as its theoretical base. Davis emphasized users' behavioural intention to use a technology to be affected by how useful they perceive it to be and how easy they perceive that that technology is to use. TAM has since become the most widely applied models for explaining individuals' acceptance of information systems. It has been widely tested, refined, extended, and combined with other theories and models in a variety of study contexts and disciplines, thus it is apparent that TAM has been a major contributor to most of the models developed after it. The basic TAM consists of two constructs of "perceived usefulness (PU)" defined as *the degree to which a person believes that using a particular system would enhance his/her job performance,* and "perceived ease of use (PEOU)" which is defined as *the degree to which a person believes that using a particular system would be free of effort*(Davis 1989).

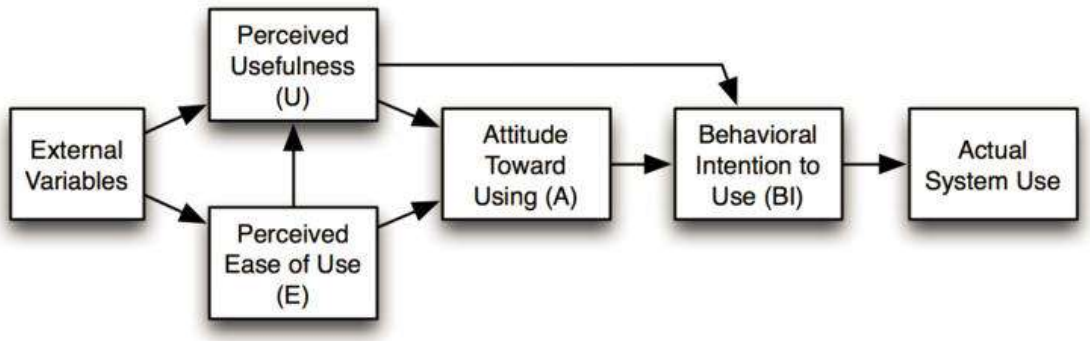


Figure 2.2TheTechnology Acceptance Model (TAM)

TAM theorizes that the effects of external factors like the system characteristics and exposure on intention to use are determined by perceived usefulness and perceived ease of use. The theory assumes that once a person decides to do something, he/she does so freely without limits. However, in real life situations, there are usually some constraints such as skills, resources, time, and environmental and organizational factors that control that capacity. These additional factors can be particularly relevant to technology acceptance and use in developing countries where facilitating conditions could be a major limiting factor.

TAM has been tested and adopted by many different researchers in Information Systems. Kouibain and Abass (2006) for example modified TAM and extended it to assess the "acceptance" and "voluntary use" of camera mobile phone technology in Kuwait (Kouibain & Abbas 2006). In the developing countries context, Anandarajan et al (2000) used TAM to study technology acceptance in the banking industry in Nigeria but they observed that, like many other theories of acceptance of information technology, TAM was designed and mostly tested in the developed world(Anandarajan et al. 2000). Several studies carried out in the developing countries context using the TAM model found that perceived usefulness did not motivate technology acceptance as much as social influence (Kripanont 2007; Kaba et al. 2008).

2.3.3 Technology Acceptance Model 2 (TAM2)

To explain perceived usefulness and usage intentions in terms of social influence and to show how familiarity with a technology increased its use over time, TAM was theoretically extended by Venkatesh and Davis (2000) to develop TAM2. TAM2 was formed by integrating antecedents to perceived usefulness, including social influence variables (subjective norm and image) that had been reported missing in the original TAM. It also integrated cognitive instrumental processes variables (job relevance, output quality, and result demonstrability). It was assumed that understanding factors that determine the system's perceived usefulness would in turn provide

measures which would increase adoption and use of a system. The model also includes moderating influences of experience and voluntariness. To test TAM2, the investigators used longitudinal data collection methods from four different institutions. The study found that social influence and job relevance constructs significantly influenced users acceptance of a new system. The resulting TAM2 model and its constructs is depicted in figure 2.3.

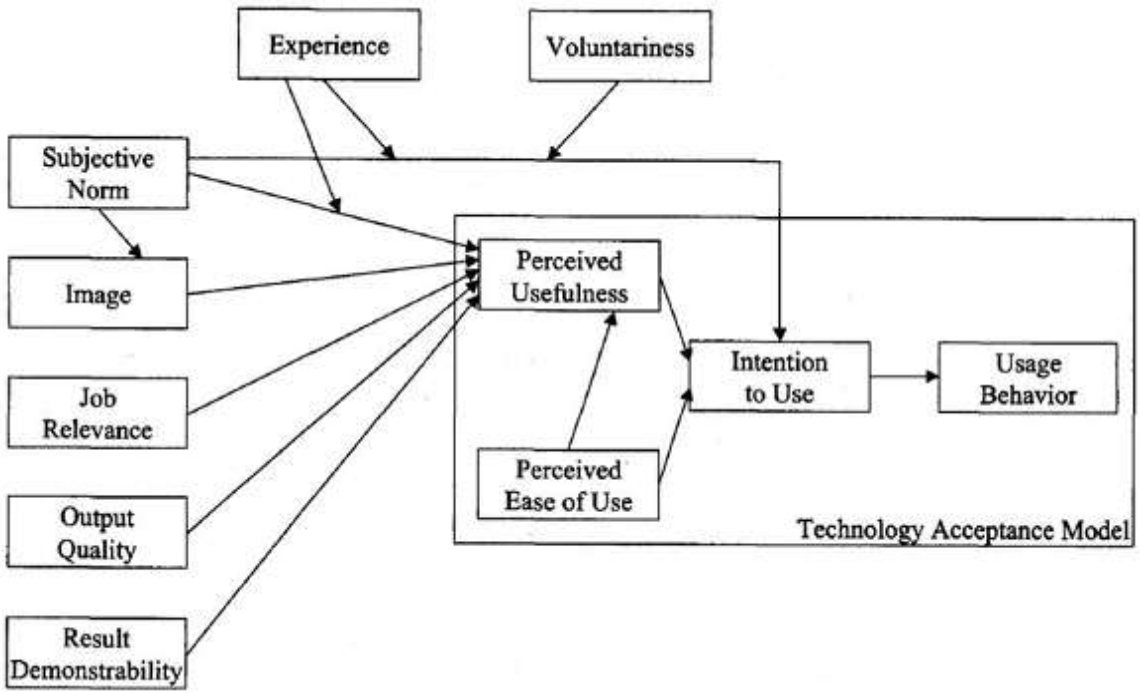


Figure 2.3TAM2 - Extension of TAM

In a nutshell, TAM's major strengths are that it provides factors which lead to IS acceptance, and provides room for extensions and elaborations better than other competing models. Observed shortcomings by users of TAM are that it does not predict barriers that hinder technology adoption, and that its simplicity has led to its over-use at the expense of designing other more suitable models (Taylor & Todd 2001; Bagozzi 1992).

2.3.4 Motivational Model (MM)

The motivation theory comprises two main constructs: *extrinsic motivation* and *intrinsic motivation*. Extrinsic motivation is defined as the perception that users will

want to perform an activity "because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions. Intrinsic motivation is defined as the perception that users will want to perform an activity "for no apparent reinforcement other than the process of performing the activity per se" (Davis et al. 1992).The general motivation theory has been supported by a significant body of psychology researchers as an explanation for behaviour. Davis et al. (1992) (Davis et al. 1992) applied the motivational theory to derive a model to explain what motivates employees to use computers in their work.

2.3.5 Theory of Planned Behaviour (TPB)

Due to the limitations found in TRA, Ajzen and Fishbein (1985) proposed the theory of planned behaviour by adding the construct of *perceived behavioural control* to TRA. This was intended to improve the model's capacity to explain an individual's behaviour in specific situations. TPB has been used and validated by many studies in prediction of individual intentions and behaviour of technology adoption (Harisson & Mykytyn 1997; Mathieson 1991). Taylor and Todd (1995) however criticized TPB and TRA because of their assumption that individuals are already motivated to perform certain behaviour, an assumption that might not always hold. Venkatesh et al (2003) showed that this theory explains between 21% and 37% of the variance in intention to use technology.

The Decomposed Theory of Planned Behaviour (DTPB) is a related theory that was formed by 'decomposing' the three constructs in TPB into more factors. Constructs of DTPB include perceived usefulness, complexity, compatibility, subjective norms, self-efficacy and facilitating conditions. Taylor and Todd (1995) examined the appropriateness of TRA, TPB and DTPB as models to predict consumer behaviour and found that the decomposed version was better at explaining the behaviour (Taylor & Todd 1995).

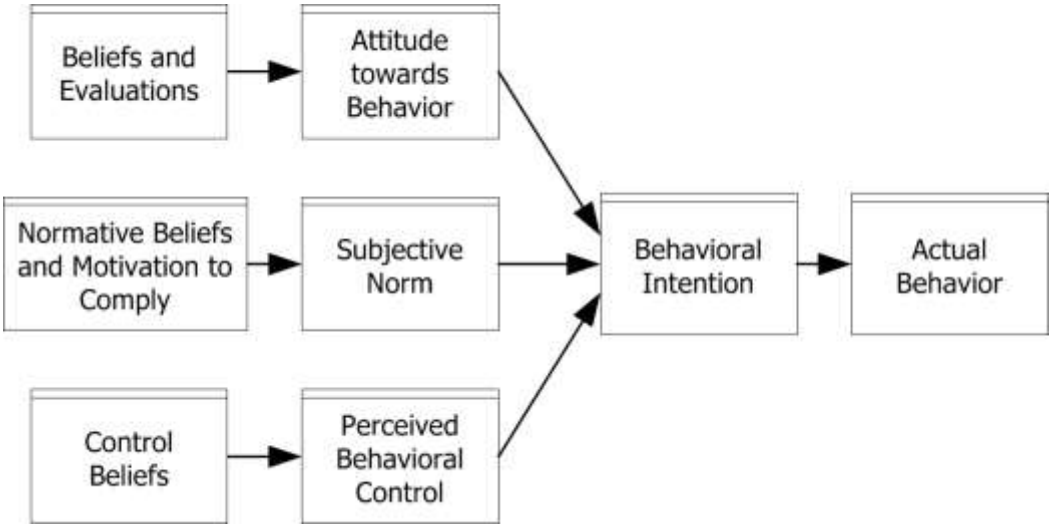


Figure 2.4Theory of Planned Behavior

2.3.6 Combined TAM and TPB (C-TAM-TPB)

Thompson et al. (1991) and Taylor and Todd (1995) observed that the original TAM did not include social influence and control factors on behaviour, but found that these excluded factors had a significant influence on ICT usage. The two factors are major determinants of behaviour in the Theory of Planned Behaviour (Ajzen, 1991). Taylor and Todd then added two more determinants of acceptance of a technology, "subjective norm" and "perceived behavioural control" and called their model "Combined Technology Acceptance Model – Theory of Planned Behaviour, (C-TAM-TPB)". The C-TAM-TPB, which is illustrated in Figure 2.5, can be used for the prediction of future usage behaviour for those with or without experience with the technology being studied. In the Venkatesh et al (2003) study, this model explained up to 39% of intention to use technology.

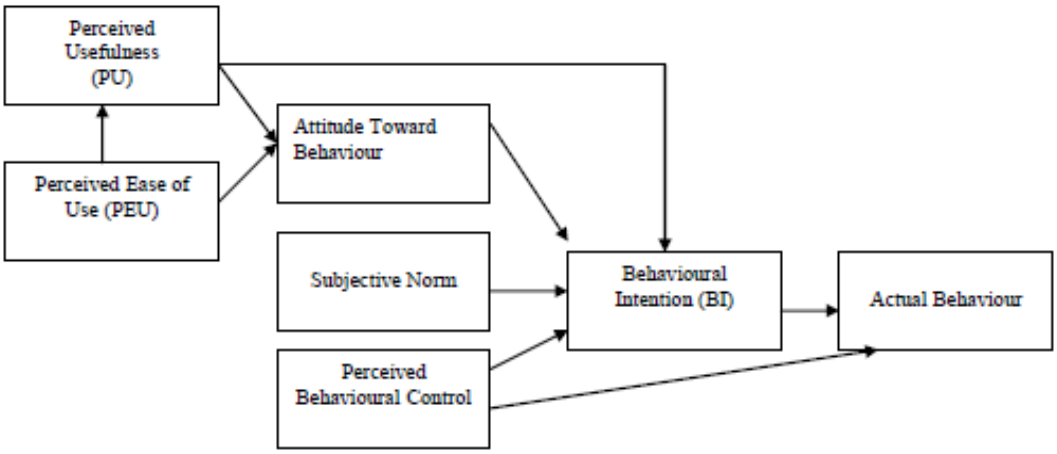


Figure 2.5TheCombined TAM and TPB (C-TAM-TPB)

2.3.7 Model of PC Utilization (MPCU)

Thompson et al (1991) designed the Model of PC Utilization (MPCU), which was largely derived from Triandis (1977) theory of human behaviour. MPCU was developed for the particular context of predicting the usage of personal computers (PC). The core constructs in MPCU model are: affect towards use, complexity, facilitating conditions, job-fit, long-term consequences and social factor.

2.3.8 Innovation Diffusion Theory (IDT)

The Innovation Diffusion Theory is derived from sociology and is heavily used in many disciplines to study adoption behaviour. Designed by Rogers (1995), the theory presumes five characteristics which are posited to influence the innovation diffusion: compatibility, complexity, observability, relative advantage and trialability. The main difference between the IDT as proposed by Rogers and other IT user acceptance models is that Rogers measures the attitude of an individual towards an innovation itself and not the attitude towards **using** that innovation (Moore and Benbasat, 1996). IDT theory tries to explain the innovation decision process, factors which determine the rate of adoption and categories of adopters. The theory helps to predict the likely rate of adoption of an innovation. The theory has however been criticized for not providing evidence on how attitude evolves into acceptance and rejection decisions, and how innovation characteristics fit into this process (Chen et al. 2002; Karahanna et al. 1999).

Moore and Benbasat (1991) adapted IDT determinants and developed seven constructs for individual technology acceptance. The constructs are: compatibility, ease of use, image, relative advantage, results demonstrability, visibility, and voluntariness of use (Moore & Benbasat 1991). Despite its low prediction levels that range between 37% and 39% in the Venkatesh et al (2003) study, IDT has been extended to sociology, public health, communication, geography, education, and many other disciplines, thereby surpassing several other models in that context.

2.3.9 Social Cognitive Theory (SCT)

The social cognitive theory was developed by Bandura (1986) to study human behaviour. It was then extended by Compeau et al. (1999) and used to study computer utilization, but the model is designed in such a way that it can be used to study acceptance and use of information technology in general. It includes constructs of affect, anxiety, outcome expectations-performance, outcome expectations-personal and self-efficacy. Self efficacy was defined as the "judgment of one's ability to use a technology (e.g. a computer) to accomplish a particular job or task", whereas affect is "an individual's liking for a particular behaviour".

Table 2.1 is included in this section to provide a summary of key attributes of each model and how applicable the model is to the current study.

Table 2.1 Key Attributes of Models that contributed to UTAUT

Model	**Contributions to the Current Study**	**Limitations to use in Current Study**
Theory of Reasoned Action (TRA)	Its biggest contribution is the Behavioral Intention (BI) construct which is used for predicting actual technology use behaviour (UB). The BI – UB relationship forms the basis of most theories that study technology acceptance at an individual level, which is the case in the current study	Two limitations identified in this theory are: - The study is too generalist to be used in a specific contextual setting - The theory only applies to behaviour that is consciously thought out beforehand – Irrational decisions, habitual actions , etc, cannot be explained by this theory
Technology Acceptance Model (TAM)	The Model looks at important aspects of technology acceptance in terms of benefits of using the	The two factors of use benefits and ease of use are not adequate to explain HIS acceptance in this study's

	technology and ease of use. These are considered some of the key factors when evaluating the use of HIS in developing countries	context. Other factors such as HR skills, infrastructural resources, and other organizational factors also needed to be considered in developing the study model
Motivational Model (MM)	This is a fundamental theory that is useful in this study because motivation does provide an explanation for behaviour.	The theory requires adaptation to a specific context to understand precisely which factors constitute extrinsic and which constitute the intrinsic motivation. Thus it is not possible to apply MM as it is in the current study.
Theory of Planned Behaviour (TPB)	This theory is based on TRA and is equally useful in providing the BI – UB link in technology acceptance by individuals.	Just like TRA, TPB makes the assumption that individuals are already motivated to perform certain behaviour and this would most likely not hold true for most of this study's participants. There is also need to further 'decompose' the added construct of Perceived Behavioral Control
Combined TAM and TPB (C-TAM-TPB)	Combining predictor factors of TPB with perceived usefulness in TAM makes this a better hybrid model	All the factors in this model except Attitude Toward behaviour have been included in the current study. There was however need to include other context specific factors such as Training Adequacy and Computer Anxiety which are not included in C-TAM-TPB
Model of PC Utilization (MPCU)	Though MPCU was developed for a specific context to predict usage of personal computers, its constructs are also amenable for use in other contexts. The MPCU factors included in this study are: complexity, facilitating conditions, and social factor	Three of the model's constructs are not directly applicable to the current study. These are affect towards use, job-fit and long-term consequences. Thus MPCU could not be used directly as foundation for the current study.
Innovation Diffusion Theory (IDT)	Some of the constructs derived from IDT by Moore&Benbesat to explain individual technology acceptance were applicable to the current study. These are: ease of use, image(related to Social Influence), relative advantage (Related to Performance Expectancy), and voluntariness of use	IDT focuses more on measuring the attitude of an individual towards an innovation itself and not the attitude towards using that innovation. In this case though the attributes of the innovation are still very important, the innovation / technology was not the primary focus of this study.
Social Cognitive Theory (SCT)	Some of the constructs in SCT are key factor in this study i.e. computer anxiety and outcome	The model is limiting in terms of the small range of factors involved. Because of the study context, it is

	expectations-performance. It is recommended that future study included evaluation of the self-efficacy factor	important to test the influence of other very relevant factors including facilitating conditions and social influence

2.4. The Unified Theory of Acceptance and use of Technology Model (UTAUT)

After examining the eight extant models of technology acceptance and use, Venkatesh et al. (2003) judiciously selected a subset of 32 constructs to form the UTAUT model. Their intention was to improve the predictive power of the behavioural intention to use technology, which ranged from 19% to 39% among the individual 8 models. With the integration of the eight models into UTAUT, the predictive power of the hybrid model increased to 69% (when including all the proposed indicator variables and moderators) which is way above the value for each model separately. The UTAUT model is depicted in the figure 2.4.

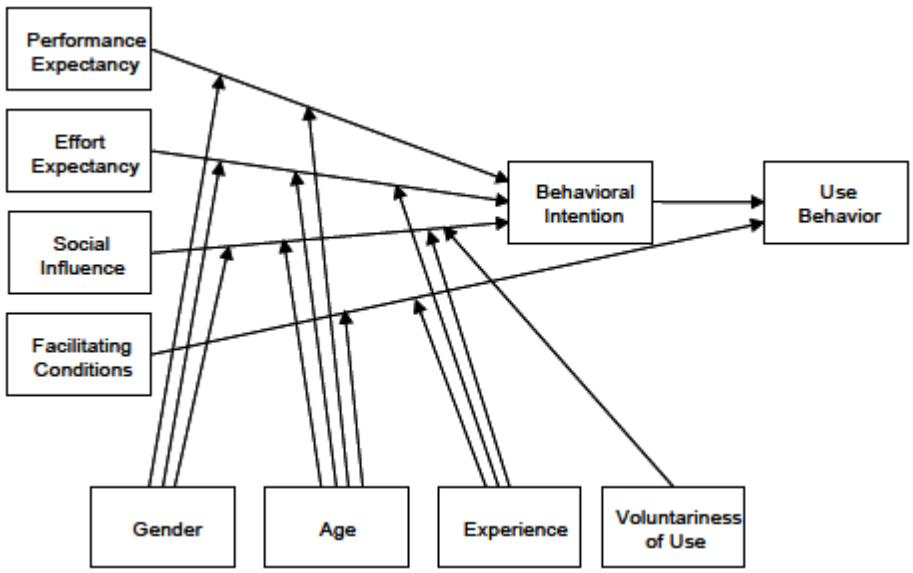


Figure 2.6: The UTAUT Model (Venkatesh et al. 2003).

Thus the UTAUT model came up with four constructs which it proposed to be the direct determinants of behavioural intention and subsequent use of technology. These four core determinants are:

(1) *Performance expectancy*, defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance"

(2) *Effort expectancy*, defined as "the degree of ease associated with the use of the system";

(3) *Social influence*, defined as "the degree to which an individual perceives that important others believe he or she should use the new system"

(4) *Facilitating conditions*, defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system"

Gender, age, experience, and voluntariness of use are specified as moderators. Venkatesh et al (2003) emphasize that most of the key relationships in the unified model are moderated. For example, age and gender are demonstrated to moderate all of the key relationships. They further suggested that social influences are more likely to be important to older workers, particularly women, and during early stages of adoption, and in mandatory usage settings.

The unified model was able to synthesize previously presented models and demonstrate good predictive validity. Due to its proven success in predicting user acceptance, this research adapted UTAUT to serve as the foundational basis for development of a theoretical model to study adoption of a routine health information system (DHIS2) at public health facilities in Kenya and by extension in other developing countries.

2.5. Previous Applications of the UTAUT Model

UTAUT has been applied in several ICT acceptance studies since it was designed in 2003. Louho et al. (2006) used UTAUT as their conceptual model to study the factors that affect use of hybrid media applications (Louho et al. 2006). Moran (2006) expanded the UTAUT model by introducing the determinants of "self efficacy" and "anxiety" and used this expanded model to study College Students acceptance of Tablet Personal Computers. Results from this study showed a high correlation

between attitude toward technology use and anxiety (Moran 2006). Anderson and Schwager (2006) examined the application of UTAUT to wireless LAN technology in smaller enterprises in the USA (Anderson 1997). Tibenderana et al (2010) adapted UTAUT to, among other changes, add "relevance" and "awareness" constructs and come up with a Service Oriented Unified Theory of Acceptance and Use of Technology (SOUTAUT) model which was able to explain 57% of variance towards acceptance and use of e-library services (Tibenderana et al. 2010).

In a study based on UTAUT model, Oye et al (2011) studied teachers' behavioral intention on the acceptance and use of the technology at the university of Jos Plateau state, Nigeria. They found that although the use of ICT was mandatory, the level of adoption among the university academic staff was still low (Oye et al. 2011). Among the four UTAUT constructs, they found performance expectancy to be the most influential factor for the acceptance and use of ICT by the respondents. In their conclusion they recommended that all employed teachers in Federal, State and Private universities should undertake mandatory training and retraining on ICT programmes.

Oshlyansky et al. (2007) applied UTAUT to study technology acceptance in nine different cultures and found that the social influence construct was strongly influenced by gender, age and experience within developing country cultures (Oshlyansky et al. 2007). Another culture based study was conducted by Yang and Lee (2006) in an effort to find out whether there is a difference in acceptance of ICT between countries. They adopted UTAUT and the Innovation Diffusion theory to study the factors that affect adoption of different models of cellular phones in Korea and USA. Results of this study showed that, unlike their US counterparts, the major factors influencing the Korea adopters were performance expectancy and social influence whereas effort expectancy was less important (Yang & Lee 2006).

2.6. Applications of UTAUT model in Health Informatics Studies

Though the use of technology in the health sector has increased rapidly in recent years, especially in developed countries, the number of technology acceptance studies conducted in this sector on acceptance and use of ICT is quite limited (Schaper & Pervan 2007). Yet user acceptance of technology remains one of the barriers to ICT use in healthcare. In this respect only a few studies are available in literature which cite the application of UTAUT model to study acceptance of technology in the health sector, and the situation is dire when one considers availability of such research in developing countries' context. A systematic literature review on eHealth adoption conducted between October and November 2011 found that, of the 93 studies that were critically reviewed: 77% were conducted in North America, 10% in Europe and 8% Asia. This means less than 5% were conducted in the rest of the world, including Africa (Li et al. 2013).Overall only a few studies in literature were found to have applied UTAUT to study technology acceptance in the health sector both in developing and developed countries and these are described below.

Kijsanayotin et al. (2009) investigated the factors that influenced health IT adoption in Thailand's Community Health Centres. Their key finding was that intention to use health IT is a function of the perception that health IT is useful, that it is easy to use, that important others believe he or she should use it, and of voluntariness of use. IT use is influenced by past IT experience, Intention to Use, and availability of facilitating conditions. Performance expectancy demonstrated the highest predictive influence on behavioural intention while past IT experience and facilitating conditions were more prominent for use behaviour. Though this study was conducted in a developing country context, the researchers cautioned that it only looked at health IT In general, rather than at a specific technology artifact as done in the current study.

Nuq (2010) used a model adapted from UTAUT in a study aimed at identifying and measuring the motivational factors that would expedite the introduction and

widespread use of eHealth services in developing countries (Nuq 2010). The study drew on responses from a sample of 549 medical professionals from ten developing countries. It provided evidence that performance expectancy, government policy, social influence with moderating effects of medical education, and medical knowledge positively impact on behavioural intention.

Schaper and Pervan (2007) developed a conceptual model based on the UTAUT and used it to study acceptance of technology among occupational therapists in Australia. They included some additional constructs to the UTAUT model such as Compatibility, Computer Anxiety and Self Efficacy. The key results of this study were that effort expectancy and compatibility do have an influence on usage intention. There was however an absence of effect from social influence, performance expectancy, and attitude towards computers.

The study by Chang et al. (2007) examining physicians' expectations of computer applications in Taiwan supported the important effect of Performance and Effort Expectancy on Usage Intention, and the subsequent impact on actual use. However this study found that there was minimal support for the impact of social influence on use intention and actual utilization (Chang et al. 2007). The study was done in a developed country.

Thus even though UTAUT has been tested in several industry settings and found to be appropriate for explaining high levels of technology acceptance factors, it is obvious that it has not been applied enough in the healthcare sector. This study will serve to reduce this research gap by applying UTAUT not only in the health sector, but also in a developing country's setting. To benefit from previous research on technology acceptance in health which may have identified important factors for consideration, it was necessary to look beyond the UTAUT model. The next section provides a summary of findings from key studies using a variety of theories but focusing on the healthcare sector only.

2.7. Overall User Acceptance Studies in Health Care Sector

When considering application of all the key technology acceptance theories, evaluation of the impact, effect and acceptance of health-care technology has continued to increase over the recent years. This is a welcome development because of the increasingly important role that technology has continued to take in the management and delivery of services in the health sector. Literature review however reveals that compared with other industries and sectors, user acceptance studies in the health sector are still quite limited, and more so when considering application in developing countries context (Schaper & Pervan 2007). There is thus need to learn from the outcomes of those studies conducted, and then consider how the existing models can be adapted or extended to study acceptance specific technology artifacts in the context of health care in developing countries' context. This is the gap that this study seeks to minimize by focusing on the case of HIS acceptance and use in Kenya. A summary of some of the published technology acceptance research in the healthcare context, some of which influenced development of the conceptual model for this study, is provided in table 2.2.

Table 2.2 Examples of User Acceptance Studies in Healthcare Sector

	Research Study	**Brief Description**	**Research Theory Used**	**Country Setting**	**Key Findings and Relevance to this Study**
1	Kifleet al(2008) (Kifle 2006)	Proposed a new model with three predictor constructs that were expected to influence telemedicine outcomes on the national level in the Sub-Saharan Africa. These are: – ICT policies, ICT Infrastructure, and the capabilities of the health sector institutions.	New Model	Developing	The importance of ICT infrastructure was examined and validated. Also concluded that having a good infrastructure is important in telemedicine transfer and showed the link between ICT infrastructure capabilities and government attitude and policies.
2	Kijsanayotin et al (2009) (Kijsanayotin et al.	Investigated the factors that influenced health IT adoption in Thailand's Community Health Centres	Modified UTAUT model	Developing	Intention to use health IT is a function of the perception that health IT is useful, that it is easy to use, that important others

	2009)				believe he or she should use it, and of voluntariness of use. IT use is influenced by Past IT experience, Intention to Use, and availability of facilitating conditions.
3	Huang and Shih (2010)(Huang et al. 2010)	Combined TRA with a TAM to determine which factors influence physician adaptation of EMR within rural areas of Taiwan, and particularly the role of external factors, such as professional autonomy, training, and computer self-efficacy	TRA and TAM	Developed	Found that EMR use is positively related to levels of training and computer self-efficacy, but not significantly influenced by feelings towards professional autonomy
4	Sharifian et al (2014)(Sharifian et al. 2014)	Investigated the factors affecting hospital information systems nurse-user acceptance of HISs in the Shiraz University of Medical Sciences teaching hospitals in Taiwan	UTAUT	Developed	Nurses' acceptance of HISs was mostly influenced by performance expectancy; but was also influenced by effort expectancy, social influence, and facilitating conditions.
5	Chang et al (2007)(Chang et al. 2007)	Examined physicians' acceptance of pharmacokinetics clinical decision support systems in Taiwan	UTAUT	Developed	Performance Expectancy and Effort Expectancy significantly influence Intention to use, but social influence did not. Facilitating conditions not found to be important
6	Chismar and Wiley-Patton (2002)(Chismar & Wiley-patton 2003)	Used the extended Technology Acceptance Model (TAM2) to study physician's intention to adoption internet health applications such as e-billing in USA	TAM2	Developed	Perceived usefulness and output quality had a significant effect on behavioral intention, while perceived ease of use and the social processes of subjective norm and image did not.
7	Schaper and Pervan (2007) (Schaper & Pervan	Outlined a project to ICT acceptance and utilization by Australian occupational therapists.	Extended UTAUT Model and framework for technology	Developed	Added unique constructs to original UTAUT model, such as: Compatibility, computer anxiety, and self-efficacy; as well as several new moderators

	2007)		acceptance (Chau and Hu)		
8	Chau and Hu (2002) (Chau & Hu 2002)	Empirically examined telemedicine technology acceptance by physicians was developed working in public tertiary hospitals in Hong Kong.	New Model based on TAM, TPB	Developed	Perceived usefulness was the most significant determinant of doctor's acceptance of telemedicine, however perceived ease of use and Peer Influence were not considered to have an effect on acceptance.
9	Lee et al (2008)(Lee et al. 2008)	Study of nurses' evaluation of a nursing information system in a hospital in Taiwan, done at two stages	1st Generation Multi-variate Analysis	Developing	Age and pressure to use the system were critical factors found in the study. Older nurses with limited computer skills took more time to adopt the nursing information system.
10	Wills et al (2008)(Wills et al. 2008)	Evaluated nurses and physician assistants' acceptance of EMRs in the state of South Dakota (USA)	UTAUT	Developed	Social Influence had slightly higher impact than EE and PE on behavioural intention; while BI had more influence than FC on use behaviour
11	Im I et al.(2011)(IM et al. 2011)	Examined the relationships of the constructs in the UTAUT model to determine how they are affected by culture.	UTAUT	Developed (different levels)	UTAUT model supports the data used very well. The effects of EE on BI and the effects of BI on UB were greater in the U.S. than Korea sample
12	Duyck et al. 2010 (Duyck et al. 2010)	Investigated Physicians (radiologists) and radiology technologists acceptance of Future picture archiving and communications system (PACS) at Ghent University Hospital, Belgium	TAM	Developed	Performance expectancy and facilitating conditions were found salient for predicting intention while social influence and effort expectancy were not
13	Royle et. al (2000)(Royle et al. 2000)	Evaluated acceptance and satisfaction with a clinical information system at a medical teaching unit of a tertiary hospital in Canada	1stGeneration Multi-variate Analysis	Developed	Peer Influence, Mentorship, Organizational Support and Collaboration found to be most effective strategies for promoting system use
14	Jayasuriya	Identified the factors that	TAM	Developed	Perceived usefulness was

	(1998)(Jayasuriya 1998)	determine computer acceptance among occupational groups in community health. Study was done in Australia.			the only significant predictor of computer use while level of education and prior computer use were not significant predictors of intention to use.
15	Wu et al(Wu et al. 2007)	Investigated acceptance of a mobile healthcare system among different categories of healthcare professionals in Taiwan	TAM & IDT	Developed	Compatibility, perceived usefulness and perceived ease of use are positively associated with behaviour Intention, but effect of technical support and training effects on the perceived usefulness not supported

Note: The most important factors as determined from these studies are highlighted.

2.8. Health Information Systems (HIS) and the Developing Countries Context

The main purpose of a HIS is to produce relevant and quality information which can be used to support evidence-based decision making by various actors at all levels of the health system(Health Metrics Network 2008). Over the last decade or so, the role of HIS has been seen as increasingly important to improve the health sector in developing countries (Chaulagai et al. 2005). This is because reliable and accurate public health information is essential for monitoring health and for evaluating and improving the delivery of health-care services and program, particularly in these countries.

The importance of strengthening a country's routine health information systems (RHIS) has been well recognized by various international organizations [WHO, UNDP, etc], aid agencies [DFID, USAID, DANIDA, etc] and national governments as one approach to support the public health reform initiatives in developing countries. Recognizing the importance of strengthening the previously fragmented and unstructured health information systems for better healthcare delivery and management, there has been tremendous initiatives in these countries to reform the existing paper-based routine health information systems through computerization (Lungo 2008; Mengiste 2010).

There is an ever increasing demand for health information to inform policy making in order to determine priorities, resource allocation and monitoring of the impact of health programs. Routine health information systems have the potential to play a major role in facilitating integration between individual health and public health interventions (WHO 2004). Since both individual health care services and public health functions are carried out within the health services system, the routine health information system is the main source of data for both types of interventions. While performing their daily health care activities, care providers within the health unit record data for the patients as well as on health unit management indicators. Routine health unit-based data can subsequently be aggregated to generate information on services provided to the population, for disease surveillance, and for other public health functions. Yet most experts agree that routine health information systems in most developing countries are woefully inadequate to provide the necessary information for supporting individual care and public health activities. In fact, poor use of information for evidence-based decision making is identified as probably one of the main causes of the current lack of linkages between individual care and public health systems in many developing countries (Lungo 2003).

The collection, collation, compilation, analysis and reporting of health data in HIS of most developing countries is riddled with major problems. The biggest challenge cited in literature is that the data received are often not helpful for health management decision-making because they are incomplete, inaccurate, untimely, obsolete and unrelated to priority tasks and functions of local health personnel (Lungo 2003; Kimaro 2006). Based on findings from a situation analysis that was done in Tanzania, it was observed that at the facility and district levels, reporting systems are weak, both in terms of completeness and timeliness (Rumisha et al. 2007). This situation is most likely exacerbated by gaps in health knowledge and information communication in developing countries.

HISs in many developing countries have evolved in a rather chaotic and fragmented manner, with multiple and overlapping demands from both the vertical programs and the national health administrative departments and ministries. This has in part been due to donor pressure demanding diverse reports from the various programs that they support in these countries. The vertical programs usually maintain their own '*vertical'* reporting information systems, existing alongside the national health information system. Over time this results in a multitude of uncoordinated and disintegrated data collection system and ultimately in a national HIS that is predominantly unreliable, irrelevant, ineffective and inadequate in providing the much needed data for decision making (Routine Health Information Network 2003; WHO 2006).

In an attempt to reverse this worrying trend and to ensure availability and accessibility of comprehensive health information at all levels and for all stakeholders, most of developing countries are now pursuing strategies aimed at integrating their fragmented systems. While some countries have managed to standardize and integrate some of the vertical programs into the national HIS, ensuring continuous use and reliance on the integrated system by the vertical programs' for many others is still a big challenge (Galimoto 2007).

2.9. Computerizing Routine Health Information Systems

Traditionally, data collection in developing countries has relied primarily on paper-based routine health information systems; however there is growing recognition that these systems can be replaced with flexible computerized ICTs. The benefits expected from introduction of these computer based systems include significant cost reductions as well as timely delivery of health care services in these countries (Braa et al. 2004; Braa, Monteiro, et al. 2007; Braa, Hanseth, et al. 2007). Other improvements in this area will include rationalizing the amount and types of data that is collected, improving formats and procedures for data recording and reporting. Another benefit expected from computerizing the data capture processes is that this allows data to be analyzed at the point of data collection as well as at the

subsequent levels. In this way managers and decision makers at higher levels of the data flow hierarchy will also be able to view disaggregated data from the lower levels of the system

Substantial challenges are however faced in the process of introducing ICT based initiatives to transform the routine health systems in developing countries. These, mostly context sensitive challenges, include inadequate financial and infrastructural resources such as computers, internet connectivity, and even electricity; limited human resource capacity to handle the new systems and technologies; fragmented and uncoordinated organizational structures; and the multitude of heterogeneous stakeholders with different data demands (Heeks 2002; Chilundo & Aanestad 2004; Kimaro & Twaakyondo 2005). This means that it is important to consider the contextual differences in studying acceptance of computerized information systems in developing countries.

Overall, the performance of a HIS system has been linked to different categories of determinants which include:

a) Technical determinants such as data quality, system design, or adequate use of information technology.
b) Organizational and environmental determinants that relate to the information culture within the country context, the structure of the HIS, the roles and responsibilities of the different actors and the available resources for HIS
c) Behavioural determinants such as the knowledge and skills, attitudes, values, and motivation of those involved in the production, collection, collation, analysis, and dissemination of information. There are ongoing efforts to try and mitigate the constraints related to this determinant by introducing a 'data culture' in most developing countries through:
    - Establishing standard procedures for use of data and information at the level at which it is collected,
    - Training staff in data analysis and interpretation, and

- Incorporating data/information use into routine activities such as supervision and planning.

A key solution that developing countries are implementing in their efforts to strengthen their national HISs is decentralization of the Health decision making processes to the peripheral levels of district or other regional levels. This involves getting these levels to play a bigger role in the development and implementation of the national HIS, as well as the subsequent use of the HIS information for informed decision making (Braa & Hedberg 2002; Odhiambo-otieno 2005; Kimaro 2006; Lungo 2008).

2.10. Evolution of the National Health Information System in Kenya

There are over 6000 government, faith-based, NGO and private registered health facilities distributed all over Kenya. The Health Management Information System for collecting, processing and reporting on the routine data collected at these health facilities is the principal responsibility of one directorate within the Ministry of Health (MoH), which currently is the Division of Health Informatics and M&E. At the peripheral level, health facility data officers are responsible for routine data collection and monthly submission of summary reports to the districts (also referred to as sub-county). The District Health Records Information Officer (DHRIO) is then in charge of verifying the facility data and transmitting it upwards to the national level. At the community level, the Community Health Workers and the community health extension workers are responsible for collection of community based data and transmitting the same to the health facilities (Government of Kenya 2008a).

Kenya designed its first national health information system (HIS) in the early 1970s and subsequently completed the successful piloting of this HIS in 3 districts in 1976 (Odhiambo-otieno 2005; Ministry of Health 2009a). In 1983, the Government of Kenya (GoK) decentralized the Ministry of Health's (MoH) decision-making process to the districts in response to the national policy on District focus for Rural Development. This led to the establishment of Health Information Systems offices in

all districts, whereby all Heath data from all health facilities in the district would be processed. This was also in line with World Health Organization (WHO) resolution calling on all WHO member states to strengthen District Health Systems (DHS)(WHO/SHS/Geneva 1989).

It was envisaged that this decentralization would provide the DHS managers with access to accurate, reliable and up-to-date information relevant for management at their levels. However, despite the establishment of this decentralized national routine HIS, a number of parallel and mostly donor driven district health information system started to mushroom all over the country citing the following challenges with the national system:

(a) That health facilities collected information haphazardly and irregularly

(b) The information collected was incomplete and unreliable with limited analysis and use at the point of collection;

(c) Too much data was collected thus rendering analysis impossible.

A study of some of these parallel systems found that they were characterized by a lack of integration, and were disjointed with no effective central co-ordination or other mechanisms for information flow to allow sharing of information among stakeholders who need it (Odhiambo-otieno 2005). Over the years several tools and systems have been introduced in the Ministries of Health to try and address the identified gaps in management of the national routine health information. One of them, the "Kwale Model", was a District-based health information system implemented at the Coast province and it is considered a phenomenal success in some studies. The "Kwale model" was however never scaled up as envisaged, and is no longer in use even at the Coast province where it was piloted.

The first National Health Sector Strategic Plan (1999 – 2004) articulated the ministry's strategy to strengthen its co-ordination function with the private sector and non-governmental organizations in health care delivery, and recognized that proper design and implementation of integrated health information systems was

critical. However, it was also during this period that the country experienced major defragmentation of HIS with various development partners introducing many systems outside of the national HIS, including LMIS, KEPMS, CORPAR, CDC, iHRIS, nursing HR, Hospital ERPs, among others (Ministry of Health. Health Sector Programme Support - Phase 2 2009).

Kenya's Ministry of Health was cognizant of the inadequacy of the existing health information systems and were thus instrumental in the conducting of several assessment of the Kenya HIS system over the last six decade or so (Ministry of Health 2009a; Government of Kenya 2008a; Luoma et al. 2010). These assessments identified very similar challenges within the Kenya HIS and these include:

- Gross underreporting under the existing HIS as well as lack of elaborate feedback at all levels
- Inadequate capacities of HMIS staff in terms of professional knowledge, skills, and even numbers.
- Too many data collecting and reporting tools (forms and registers) and lack of integration at the various levels – HMIS Needs Assessment conducted in 2003 identified 45 different reporting tools at the peripheral level
- Too many indicators defined to monitor the sector and inadequate data collection and reporting tools at the data collection points
- Lack of guidelines and policy to make reports mandatory from the various sources.
- Inadequate supportive supervision to districts and provinces.
- Lack of capacity in computer skills and data analysis among staff both at the peripheral and national levels
- Data from the private health facilities not incorporated in the national HIS, largely because the private sector did not see the need to submit reports to the national HIS.

The assessments also came up with an array of recommendations to enhance the HIS system, some of which include:

- that mandatory reporting from private providers and NGO facilities be instituted and elaborated through provision of HIS policy guidelines;
- that the overall capacity for data collection, analysis and reporting at the health facility, district and national levels be strengthened;
- that a census of health providers be conducted to enable the national HMIS system take into account the full range of health information stakeholders in the country and including proper documentation of contributions by the various governmental and non-governmental players.
- That elaborate integrated and harmonized data collection tools be developed; as well as user friendly data capture systems with adequate linkages to the central data processing unit.
- That a comprehensive HIS strategic plan is developed to support the HIS and facilitate buy in and support by all stakeholders.

It is important to recognize that the challenges identified in these assessments are not unique to Kenya alone; rather they are similar to those reported in other studies conducted in developing countries, particularly in Sub-Saharan Africa (Heeks 2002; Lungo 2008; Kimaro & Nhampossa 2007). Recognizing the crucial role that a functional and integrated national HIS would play in availing timely data for evidence-based planning and decision making, the government in collaboration with stakeholder formulated the HIS Policy and HMIS strategic plan 2009 – 2014 to guide the interventions to make this goal achievable. It was envisaged that a strengthened HIS would have sufficient capacity to serve all health stakeholders' information needs (Ministry of Health 2008; Ministry of Health 2009b).

2.11. FTP System for Collection of Routine Data in Kenya

In 2008 the country introduced the use of the File Transfer Protocol (FTP) to transfer data from the district level to the National level. During the initiation of the FTP, a major revision of reporting forms and registers was carried out during 2007/2008. Data from these reporting tools were captured on a monthly basis by health facilities and submitted to the district level. The district would then aggregate all its facilities'

data in MS Excel spreadsheets before onward transmission to the national level through the File Transfer Protocol. If the excel data from the district was transmitted successfully through the FTP system, then the spreadsheet data would be automatically added to a master excel sheet maintained at the national level. Where the district was not able to FTP the data, they had the option of sending the Excel Spreadsheet as an email attachment, in which case there was need for manual intervention before the data could be added to the master excel sheet. The national level received only district aggregates which could not be disaggregated to show facility specific details, thus making it impossible to perform analysis of comparative performance across facilities. Furthermore, it was very difficult to manage the data and to get an overview of the data when spread over about 180 sheets, each sheet representing a district. The continuous splitting up of districts to create new districts did not make the data management any easier (Luoma et al. 2010; Blumhagen et al. 2010).

The process described above came to be known as the FTP system and was the official national HIS system from Kenya from 2008 till 2011. Other challenges identified with the FTP system were:

- The data collected did not include community based data
- By the time it reached the national level for analysis, the data was already aggregated across all facilities in a district, hence it was not possible to drill down and see data from a particular health facility
- The data flow bypassed the province levels and hence provinces did not have easy access to the relevant data for their health-related decision making
- There was always a major time lag between when data was reported and when it was received at the national level, analyzed and made available to stakeholders for their evidence-based decision making, this made the data less useful.
- This system of data transmission and analysis did not have inbuilt error checking and data validation mechanisms, hence the level of reported data accuracy was also suspect.

- In terms of infrastructure, the districts relied mostly on wireless modems which many a times experience low bandwidth availability.
- Sometimes the data files were infected with viruses from the source computers – such files would be rejected by the server at the national level and hence this data was not updated in the master file.

In addition to the challenges listed above, the FTP system did not solve the problem of multiple parallel HIS systems and the erosion of trust that stakeholders were experiencing with regard to the national HIS. A 2009 Critical review of all softwares in use in the Kenya health sector revealed that there were over 70 databases and none was 'talking' to each other (Ministry of Health. Health Sector Programme Support - Phase 2 2009). The FTP system was thus successful in transmitting routine service data from lower levels to the central level but however lacked adequate features to facilitate analysis and use of information for decision making, or even to assure the quality of data within the system.

2.12. From FTP to DHIS2

Over the last few years, Kenya's Ministry of Health has been engaged in a rigorous process of restructuring the national HIS to address the cited challenges. This process has so far resulted in the development and adoption of a national health information policy document as well as the detailed Strategic Plan for Health Information Systems (2009 – 2014) (Ministry of Health 2008, Ministry of Medical Services & Ministry of Public Health and Sanitation 2009b) Both documents recognize the crucial role played by availability of routine health information for critical decision making in national health care management and the associated resources allocation. In particular the policy articulates the need for progressive decentralization of HIS and also for efforts to be made to promote information use at the point of data collection, which in most cases is the health facility. The Policy recognizes that the application of information technology in the health sector is of paramount importance to align the multiple stakeholders towards a common reporting mechanism and objective. It thus seeks to implement a robust system for

the use of information technology to capture, store and exchange health information in an environment supported by systems that will bring administrative simplification and improve patient care services by providing a continuum of care.

Recognizing the inadequacies of the FTP system and the as yet unmet need to strengthen management of routine health data and information at all levels of service delivery in the Kenya Health system, the division on HIS embarked on a process to acquire a web-based database that would facilitate the processing of facility level data at all levels. In addition to the requirement to generate aggregate reports for use at regional and national levels, the system's standard output had to include dashboards generated for use at health facilities to assist them in planning, and initiating the urgent interventions required in management of facility services. The system was also expected to be simple, scalable, user friendly and capable of capturing both community and health facility level data, hence providing the foundation for an integrated national health information system (Ministry of Health 2009a).

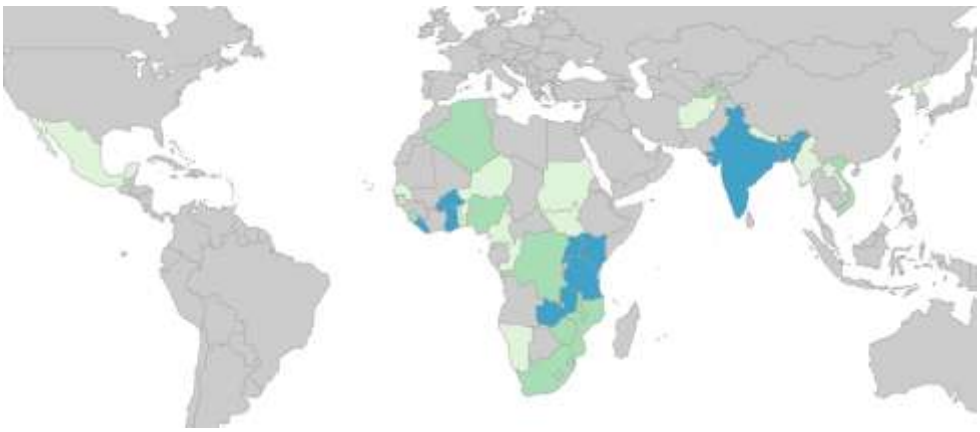
After considering many options, the District Health Information Software (DHIS2) was found to meet the stated software requirements. The District Health Information System Software (DHIS) is a free and open source database application for collecting, processing, and analyzing health information for health administration purposes whose development and implementation was started in 1998 by the Health Information System Programme (HISP) based in South Africa. Development of DHIS2 is coordinated by the University of Oslo, and the system has since been implemented in many other developing countries in Africa and Asia. The DHIS was developed to collect aggregated routine data from all public health facilities in a country. It is intended to support decentralized decision making and health service management. DHIS allows health care workers to analyze their levels of service provision, predict service needs, and assess performance in meeting health service targets. The implementation of DHIS2 is highly supported at the national policy level.

2.13. About HISP and DHIS

HISP is a research network devoted for the development of HIS in developing countries, organized by the University of Oslo. It stems from the effort to build a HIS in post-apartheid South Africa in the mid 1990s, but has now spread and includes partners in many parts of Africa and Asia. HISP has two main areas of focus. The first is research into HIS in developing countries, including running PhD and masters programmes. The second objective for HISP is to lead the development of the DHIS. The HISP focuses on action research and user participation, especially local participation to customize the health information software with the aim to developing local knowledge and skills in computers, design, data handling and use (Braa et al. 2004).

The initial version of the DHIS software was based on MS Office (Access) and Visual Basic technologies, with the key focus of making the software flexible enough for appropriate customization and quick adaptation to typical routine health information systems' needs in different regions. The rationale for designing such a flexible system was to support decentralization of health management and to empower the lower levels (especially the districts) of the health system, by giving them the possibility to customize an information system to fit their needs, as opposed to the more traditional centralized systems. The DHIS software (version 1.x) was developed initially in South Africa, where it became the national standard. Its success there led to it being piloted and/or adopted in several other developing countries, including Mozambique, India and Malawi (Braa et al. 2004). However, DHIS version 1 was based on Microsoft Access technology, and in 2004 a decision was made to build a new DHIS version from scratch using free and open source frameworks (Øverland 2010). Development of the current version of the software, the DHIS2, started in year 2004 and is coordinated by University of Oslo in Norway. This current version is web-based, fully open source, based on Java technology and allowing for distributed development.

Thus though originally the DHIS was developed for three health districts in Cape Town, it has since spread via the HISP network to nearly half of sub-Saharan Africa, where its use covers a population of 300-400 million people, and also to a number of countries in Asia. The initial scope of the system was management of routine monthly Primary Health Centre data; however it has systematically been expanded to cover nearly all aspects of routine health data and information management. DHIS's relative success in South Africa and the fact that the software is highly customizable to suit the local country's context has led to rapid adoption of this system to support HIS in several countries in developing countries, particularly in sub-Saharan Africa. The fact that the current version of the software, DHIS2, is based on Free and Open Source Software (FOSS) gives the countries an opportunity to get the software free of charge and to make use of local expertise to customize it according to local needs (Braa&Hedberg, 2002). Software customization includes mimicking manual health data collection tools to look similar on the software data entry forms, accommodating most routine data elements, and in some cases translating the software into the local language. Figure 2.7 illustrates the geographic distribution of all the 46 countries that have implemented DHIS to date, also showing the status of this implementation.



Legend:

DHIS as National HIS

Program or Partial National Rollout

Pilot or Early Roll-out Phase

Figure 2.7 Countries that are currently implementing DHIS

Source: https://www.dhis2.org/inaction

The DHIS2 Data is collected routinely on all services provided by a facility, as well as periodically on infrastructure and human resources, as part of health facility surveys. This data is collected by means of a paper-based system of registers, tally sheets, and monthly data collation forms. The collated monthly data is either entered directly into the web-based DHIS2 or sent to the district level where is entered on to the web-based DHIS2 software, then analyzed in the system. The requisite reports have already been built into the system and are immediately available for review at all levels i.e. by the health facility, district, county and national health levels. Data quality is addressed through mechanisms incorporated into the data collection process and functions within the DHIS software.

One advantage of the DHIS2 platform is the fact that it has a very modular web interface which allows for easy incorporation of various modules, enabling easier replication of the complex paper reporting formats that are unique to each country of implementation (Braa, Hanseth, et al. 2007). In the Kenya context, introduction of DHIS2 project had to take into consideration the following two important areas of the previous FTP- Excel system:

i) DHIS2 had to be built on the same data sets and paper reporting forms that were used by the FTP-Excel system and the same procedures for routine registration, collection and reporting from the facilities to the district.
ii) The previous FTP-Excel system required both computer and Internet literacy at the district and hospital levels. Many users were also familiar with web-based application through the Master Facility List system and many were trained on it. This was expected to make it easier to implement DHIS2.

2.14. Implementation and rollout of DHIS2 in Kenya

The following account of the implementation and rollout process was obtained from various DHIS2 activity reports, workshop presentations and informal discussions with members of the division of HIS.

Phase I: System Adaptation and Customization

The first activity in the DHIS project was the formation of a national DHIS core team to drive the process from within the Ministry of Health. Technical assistance from HISP at the University of Oslo was included in the process and capacity building was carried out through training and learning by doing. The first priority of the team was to customize the system for Kenyan use and pilot the customized system in one province in the country. The first version of the new system was based on all the routine reporting forms as they appeared in FTP system. It was anticipated that once the system was running, additional health programs and reporting forms would gradually be included.

Team building and training was carried out during the first phase through collaborative development of the first DHIS prototype system. The DHIS team in the HIS unit at the MoH worked together with the University of Oslo consultants in customizing the system starting by setting up the organizational hierarchy. In doing this, the team paid attention to the new constitution that abolished provinces and created counties as new organizational units. Other important activities included defining data elements, data sets, validation rules, indicators, report tables, standard reports, the dashboard, charts, forms for data entry and setting up of the Geographical Information System (GIS) module.

Through learning by doing, the aim was, throughout the project, to build local capacity so that they could master maintenance and future development of the system, such as for example including and integrating new data sets and user groups. This was largely achievable because DHIS is a generic tool with a flexible user interface that allows the user to design the contents of the information system and include new requirements without the need for software programming.

Phase II: pilot in Coast Province

After having tested the prototype in Machakos, Nyamira and Kisumu East districts, Coast province was selected for the larger scaling piloting of DHIS2. The pilot was

rolled out to all districts and health facilities of Coast province in February 2011. The implementation in Coast province started with one week residential training of selected health workers from the province. The health workers were trained on the general aspects of DHIS, data entry, data quality and generation of reports.

Immediately after the training, the trainers visited all the districts in the province with the aim of giving hands-on support, help with computers, software and Internet and solving any local district problems. During the follow up visit, other members of the District Health Management Team who had not been trained were also informed of the new system. Six weeks after the installation of DHIS at the Coast province, all districts were visited by the DHIS core team and the Technical assistants during supportive supervision. The main aim was to review the progress of the project and solve any arising issues. Subsequently a two day review meeting comprising all the health managers at coast province was held. The meeting was used to deliberate on way forward in resolving the identified challenges, as well as the overall lessons learnt during this piloting phase. The meeting ended with a go ahead for the national rollout.

Phase III: Roll out of DHIS Countrywide

During the roll out of DHIS countrywide, a series of activities were executed.

i) **Training of trainers (TOT)**

The rollout process started with a one week Training of Trainers (ToTs) in April 2011. The most skilled HIS workers were selected for training as ToTs so that they could subsequently form a pool of trainers during the rollout. They supported implementation of DHIS 2 in their own provinces and offered support to neighbouring provinces. Overall 115 TOTs were trained.

iii) **National training: Classroom training and on-site support visits**

Nationwide training on DHIS2 was conducted province by province targeting the district health records information officers, Hospital health records information

officers and the district health management team members. The main objective of the training was to equip District and provincial healthcare managers with knowledge, attitudes and skills needed to effectively manage health information using DHIS2. Topics covered during the training included; introduction to the DHIS project, getting started, reporting /analysis tools in DHIS (Standard reports, data sets, report tables, completeness, static reports) and how to use DHIS for data reviews, analysis and planning.

More than 800 health workers from 216 districts were trained in this phase. Following the findings of the supportive supervision conducted two weeks after the training, it became very clear that the on-site support visits were important in getting the users started in use of DHIS2 as they helped to address the many smaller practical problems that needed to be sorted. These included support for internet connectivity via modems; correct usage of the DHIS2 browser interface; and building of user confidence in managing DHIS2 when alone in the office. Support visits then became an important part of the rollout methodology and were instrumental for the participatory development of new functionalities and problem solving in the DHIS.

2.15. DHIS2 Infrastructure

DHIS2 in Kenya was installed on a central server using the “cloud” based computing infrastructure. The DHIS infrastructure was such that users were expected to access the system via the internet both for data entry and information use purposes. This is in contrast to the FTP system whereby data entry at source was expected to be purely manual. Figure 2.8 illustrates this difference.

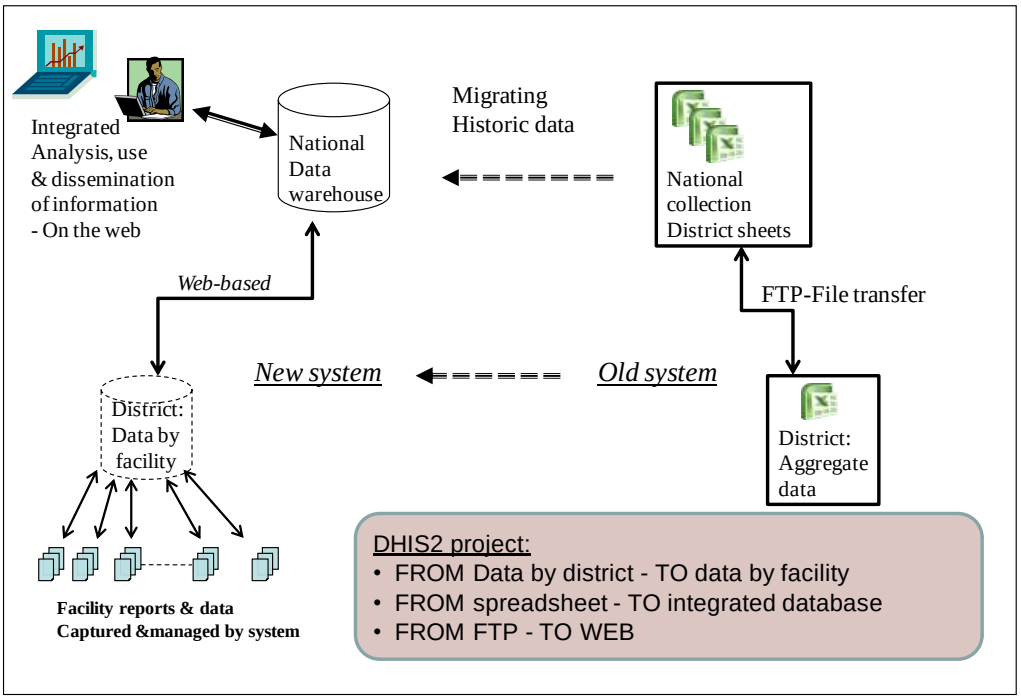


Figure 2.8 Transition from FTP to DHIS2. Source: Division of HIS

Public health facilities in Kenya suffer from the usual infrastructural problems experienced in other developing countries such as inadequate access to computers, internet connectivity, and telephone and electricity services. Recognizing this factor, the implementers of the system planned it such that most of the health facilities would still generate paper-based monthly reports which they would then send to their respective districts for keying into the web-based DHIS2. Practically all the districts have access to computers and internet [via mobile provider based modems]. The higher level health facilities [district, provincial and referral hospitals] do however have access to computers and internet and hence were expected to key in their data directly on the DHIS2 system.

The use of internet modems was found to work well during the piloting phase, and this led to the decision to go for a central server solution for the DHIS2 implementation in Kenya, rather than deploying offline standalone instances in districts around the country. The Ministry of Health server could however not be used, as the connectivity was too poor in the building and the server setup not

reliable, which is why the implementer resorted to use of an external server in the "cloud computing" infrastructure.

The status at the time of the study was that different categories of users across Kenya and beyond could be able to access the system online through modems and LANS, and the FTP system had been officially closed. The implementation of HTML 5 standard, allowed for offline data entry, thus improving the robustness of Internet connectivity in rural parts of Kenya - Users could capture data offline by using the memory in the browser and "flushing" the data (i.e. transfer to the server) when online. DHIS2 also allowed for use of mobile application for reporting and viewing of reports; as well as allowing more modules to be gradually built in (such as for human resources management, Finance, Patient level etc) and integrated as per user needs

2.16. Preliminary experience from the Deployment of DHIS

Though the system had not been used for a lengthy enough period of time to enable it to be conclusively judged successful or not at the time of this study, preliminary experiences indicated the fact that DHIS2 provided simple analysis and was encouraging data use for decision making right from the lowest level. The inbuilt data quality checks improved overall data quality and use of the cloud-based Central Server ensures that changes made in the system were available immediately to all users. Unlike the previous FTP system which experienced frequent down times, use of the cloud-based servers ensured that, for the most part, DHIS2 was available on a 24/7 basis. Additionally there was improved dissemination of public health information via the public login option, and strengthened ability to monitor the incidence of public health threats and respond in timely manner. It was expected that the system would improve efficiency of administrative systems in health care facilities.

Despite these advantages, deployment of DHIS2 was however faced with some substantial challenges, mostly having to do with inadequate resources of different types which include:

- Connectivity: The strength of Internet connectivity varies widely in Kenya. Some regions also have less access to electricity and mobile telephony. It was thus difficult to implement data entry by health facilities prior to enhancement of the infrastructure at these levels.
- Capacity: User capacity to use DHIS2 effectively was also a challenge because of the limited availability of skilled ICT work force in the health sector.
- Stakeholders Needs: When these needs are not deemed to be met, there is the risk of introducing redundant tools and subsequently overloading the system unnecessarily. Thus standardized tools needed to be developed and updated regularly to take into account the reporting needs of the various stakeholders.
- Capital: The project was heavily donor funded, and thus there was a lurking need to find ways to blend private and public resources in ways that would make it sustainable in the longer term.

The above challenges which are concerned with resources are relatively easy to understand and hence to also develop and implement focused strategies aimed at mitigating them. A more serious challenge that was identified with regard to use of DHIS2 in Kenya was the fact that despite introduction of this promising system, there was still evidence of very low levels of data demand and use by the targeted users in Kenya (Ekirapa et al. 2013). As has been pointed out in various HIS assessment framework, evaluation of a HIS implementation should be multidimensional and include a behavioural aspects of implementing the health system. Thus there was need to undertake the current study which sought to understand the factors affecting acceptance and use of DHIS2 by the different categories of targeted users in Kenya. The findings from this study were expected to provide empirical evidence that can guide HIS managers and implementers in Kenya and other similar settings to achieve higher success levels in implementing this and other similar systems.

2.17. Evaluating the Factors that Affect Acceptance and Use of DHIS2 in Kenya

It is evident that developing countries are increasingly making an effort to introduce computerized routine health information systems at a national level (rather than parallel, program-based health information systems), with the point of entry for such system being the public health facilities in the country. The introduction of these systems into settings where they did not exist before obviously has to be accompanied by a cultural change, and a way of ensuring readiness of the targeted users to embrace the system. A successful cultural shift enables the system to be viewed as an integral component of the society that is locally owned and controlled. When the efforts to transfer ownership and control to local partners fail, the demise of a system may follow. To successfully accomplish the cultural shift and local adoption, it is important that local stakeholders be involved in the development, implementation, use and management the system.

As discussed earlier, DHIS2 has the capacity to present key advantages to the Kenyan health sector on the path to integration and elimination of parallel reporting systems; as well as availing of information for decision making at all levels of the health system. It is however important that the relevant capacity building, infrastructure and staffing levels be evaluated and availed for the system to work well. There is also need for further exploration of the behavioral determinants of use of DHIS2 such as the knowledge and skills, attitudes, values, and motivation of those involved in the production, collection, collation, analysis, and dissemination of information as implementation of a good system does not guarantee its adoption and use (Lafond & Field 2003). This exploration of behavioral determinants of acceptance of DHIS2 in Kenya was the main focus of this study. A conceptual model for evaluating these factors is described in the next chapter.

Chapter 3: RESEARCH MODEL DEVELOPMENT

3.1 Introduction

A conceptual model helps the researcher to formulate testable relationships which can improve the understanding of the determinants of the situation being studied (Sekaran 2003). In this study, the conceptual model is also referred to as a theoretical or study model, and the three terms are used interchangeably. The current study aimed at designing a model that can contribute to the prediction of health workers' behaviour with regard to the use of a Routine Health information system, and in so doing identify the critical factors that HIS managers and other stakeholders need to focus on in order to achieve more effective deployment of the system under study. By identifying critical HIS acceptance and use determinants from the targeted users' perspective, it then becomes possible to manipulate these factors in such a way that the system's use behaviour is influenced toward the intended outcomes. The study focused on implementation of DHIS2 in Kenya which, though being a specific technology artifact, is representative of HIS deployment in public health sector of developing countries which operate in similarly challenging implementation environment. Through a comprehensive literature review, UTAUT was identified as the most comprehensive and predictive among the available technology acceptance models, and thus the conceptual model for the current study is adapted from UTAUT model.

It is worth re-emphasizing the fact that while several studies have been identified in literature that used UTAUT to evaluate acceptance of health related technology among public health workers, only one of those studies was conceived for a developing country context (Kijsanayotin et al. 2009). And even that one only evaluated acceptance of general heath IT rather than that of an organizational level system that is of higher economic importance to entire countries or regions. Therefore, it is important to assess the applicability of UTAUT to developing

countries and hence the need to perform an exploratory qualitative study to identify the most appropriate constructs for this environment. By applying the UTAUT model to evaluate acceptance of a public health IT system in developing countries, this model is extended to a new application, a new professional domain (healthcare) and a new geographic zone (Africa). This extension of the model contributes important to knowledge to multiple stakeholders

3.2 The Stages of the Study Model Development

This research was thus conceived to develop a research model adapted from UTAUT model that could explain factors that influence user acceptance of a health information system (DHIS2) in developing countries' context. The model development and validation was done in two main stages as described in the sections that follow.

Stage 1: Review of Context-Relevant Literature

In developing the study contextual model, the researcher used information acquired through literature review to gain more understanding both of technology acceptance theories as well as of the of the context in which computerization of health information systems is happening in the low-resources developing countries, of which Kenya is part. The findings from this stage have been discussed at length in Chapter 2.

Stage 2: Qualitative Pre-Study

In order to customize the research model and to ensure that it covers all of the important elements of public health IT adoption in developing countries, it was necessary to undertake an exploratory qualitative study and this was done between August and November 2013. Exploratory studies are usually conducted prior to undertaking quantitative methods in order to better understand the concepts of interest and hence contribute to development of good research theories (McDaniel & Gates 2002). As described in Karuri et al (2014), the specific objectives of this phase were:

- To gain an understanding, from the perspective of key stakeholders, of factors considered as critical to the successful scale up and use of DHIS2 in Kenya
- To breakdown the role played by these factors, either as barriers or enablers of this scale-up process.
- To understand the perceived opportunities and threats that this system faces in view of the ongoing implementation of the devolved system of government in the country (Karuri, Waiganjo & Orwa 2014).
- To make recommendations on how barriers and threats can be addressed to hasten acceptance and scale-up the use of DHIS2 in Kenya.

Subsequent analysis and synthesis of the findings was then done to identify the factors needed to develop an UTAUT-based research model that covers all of the important elements of adopting routine HIS in developing countries. The following sections describe the approach and key findings from this phase.

3.3 The Exploratory Qualitative Study

The descriptive qualitative study was done through conducting key informant interviews (KIIs) with a wide range of stakeholders in the implementation of DHIS2. These ranged from the External implementing Consultants, Local implementing Coordinators, National Priority Health Programs Managers, Senior Health Records Information Officers, NGO Implementing Partners, Local University developers supporting the systems and WHO Program Officers. A total of 25 interviews were conducted and these were audio recorded with the informants' consent. The informants selected had all interacted widely with the DHIS2 system implemented in Kenya, either in the capacity of developers, implementation coordinators, system reviewers, system users, or a combination of these roles.

A topic guide with open ended questions was used to guide the discussions and collect information around key themes which included: perceived role of DHIS2 in shaping Kenya's health care sector; the key processes that have guided

implementation of DHIS2 and the main challenges encountered; the barriers and enablers of adoption of DHIS2; and recommendations on the way forward in order to reap maximum benefits from this system. The Interviews were organized around the study guide questions but conducted using the unstructured, in-depth and active interview approach (Fontana & Frey 1994). Subsequently a general thematic data analysis was undertaken to identify all discussions on the pre-specified themes and sub-themes, as well other themes raised by the interviewees.

Each interview was treated as an individual case, and the transcribed data was analyzed with the NVivo computer-assisted qualitative data analysis software (CAQDAS). NVivo assisted in the qualitative analysis process by enabling easier data management, storage of the interview transcripts, and help in coding the text. Finally the researchers identified patterns across categorized data and used them to draw conclusions and recommendations on factors that need to be addressed in order to enhance user acceptance and use of DHIS2 in the country.

3.4 Key Findings from Qualitative Study

All interviewees recognized the great opportunity that DHIS2 presented for Kenya to streamline its national health information. One key system characteristic that was appreciated was the fact that the system is operated in open-access mode, enabling unrestricted access to DHIS2 reports via the public login option. This was deemed to greatly ease dissemination and access to public health information. Also recognized was that the DHIS2 system enabled undertaking of simple, customized data analysis, which should encourage data use right from the lowest levels. This potential would be enhanced further as more and more health facilities got connected to the system for direct reporting.

While considering these opportunities that DHIS2 presented, one major theme that emerged from the analysis of the KIIs was the need to recognize the barriers and enabling factors that existed in scaling up implementation and use of DHIS2. Since the initial objective of deploying the system nationwide had been completed, the next

couple of challenges remained to push the use of this system to higher levels such that it became more accessible to all healthcare workers and that they in turn actually used its data for evidence-based decision making. This section discusses some of the key factors identified from this phase as the perceived barriers and enabling factors, and the informants' perspective of their potential impact on the scale up of DHIS2.

(i) Age and Gender

With a few exceptions, the general consensus among the informants was that age played an important role in the way health workers were adopting and using DHIS2 in Kenya. The main perception was that the younger health worker were more comfortable with the use of technology based tools and resources such as DHIS2, especially when the people concerned have had no formative training on computers and technology issues. The informants were also of the opinion that most members of the District Health Management Teams (DHMTs) were relatively older and as such are not comfortable with use of the new technology and systems like DHIS2. Most people however did not perceive gender as being a key factor that influences the use of DHIS2. This is despite the fact that the majority of the respondents (85%) were male.

(ii) Attitude, Information Ownership, and Behaviour Change

The common thread linking this theme was identified as attitude. It emerged that despite the presence of other challenges such as unreliable infrastructure and inadequate training, most of the informants considered the user attitude to be main determinant of whether the DHIS2 system would be successful or not. And this was deemed to start right from the top with most of the health managers having the false notion that use of DHIS2 data was the reserve of Health Records Information Officers (HRIOs) or program M&E officers. Being a country where health workers tend to follow their managers unquestioningly, management attitude toward DHIS2 greatly influenced the attitude of the sub-ordinates thus leading to sub-optimal use of the system. In addition most users saw the implementation of a new system, not as an opportunity to benefit their work productivity and efficiencies, but rather as an opportunity to get maximum personal benefit during the project implementation by

getting new computers, modems, training and other benefits. Implementation of DHIS2 should have presented an opportune moment to address some of these negative attitudes and to institute the requisite behaviour change.

(iii) Local Capacity for Technical Support and Training

Many of the informants interviewed did not have the confidence that the country possessed the required technical capacity to support the system locally without having to resort to escalating issues to parties external to the Ministry of Health. This was especially important when considering the quick implementation of the system in the country, and on a very large scale, meaning there had not been adequate time to critically test the system to ensure error free and optimal functionality. In addition as the end-users, especially the health programs continued using the DHIS2 data to monitor various priority disease trends; they were naturally coming up with requests for system enhancement, additional functionality, elimination of certain software glitches or inclusion of more sophisticated data validation rules. It emerged that many such users were getting disillusioned by the slow rate of responding to such support requests. Though a lot of health workers were trained on use of DHIS2 nationwide, some of informants were of the opinion that the quality of this training could be improved.

(iv) Championship, Leadership and Management

The general consensus under this sub-theme was that for the DHIS2 scale up to be a success, health managers, right from the point of data generation to the highest national office needed to have total buy-in on the system and to recognize the potential it had to transform healthcare delivery in Kenya. It was not enough to demand that other people use the system. Rather the system champions, who naturally would be managers at the different levels, needed to show by example that they valued the system by first of all taking time to understand the role DHIS2 was intended to play, and then actually logging on to the system to scrutinize data for themselves. Several informants gave examples of situations they had come across

within the health sector where the champions and leaders had propelled their projects to excel much more than other projects in similar settings.

(v) Computer Proficiency and Anxiety

Since the launch of its e-government strategy, the Kenyan government has been at the forefront of advocating for computerization of public services for more efficient service delivery. The Kenya National e-Health Strategy (2011 – 2017) brought the focus of this computerization to the health sector (Ministry of Medical Services and Ministry of Public Health and Sanitation 2011). But as results of this study confirmed, many healthcare workers suffered from computer anxiety and would have preferred to have nothing to do with use of related technologies such as the DHIS2. According to the information obtained in the exploratory phase of the research, this anxiety could be attributed to several causes, the first one being the fact that many health workers considered themselves as 'Born Before Computers' having been educated in an era where everything was done manually and there was no mention of computers in their formal studies. Another reason given was that some health workers feared that use of computers would bring with it efficiencies that would lead to exposure of the loopholes they had been taking advantage of to get unfair gains at the work place. Other less ominous reasons identified were simply resistance to change and the need for some training and sensitization on these skills before they took the plunge.

(vi) Social Influence and Behaviour Change

The theme of social influence and behaviour change was found to be closely interlinked with the other theme on the need for a Champion and Leadership on data ownership and use. The bottom line was that health workers would in most cases adapt their behaviour in accordance to what they perceived to be the expectations of their immediate supervisors. At the same time peer influence on health worker behaviour was significant, and hence the need to provide more opportunities for sub-regional sharing of experiences in data reporting and use for decision making.

(vii) Ease of Access and Use of DHIS2 Data

The informants were in agreement that DHIS2 was generally easy to use for those who are familiar with it, and especially for data entry since the system mimicked the actual paper collection forms. There was however concern that for first time users, the system could be quite daunting because the user interface was not intuitive and could be confusing. Some criticized the then existing need to undertake some of the data analysis outside of the system such as using Excel Pivot tables. It seemed a short orientation on how to navigate through the system easily would go along way if presented to all the targeted users.

(viii) Funding, Infrastructure and Other Resource Requirements

Getting the use of DHIS2 at optimal levels, especially at health facilities, was very closely linked to availability of funding to support various resources including computing and internet infrastructure, data collection tool, adequate staffing levels and training. The informants were wary of the country's seemingly over-reliance on donor funding in support of these resources.

(ix) Health Worker Orientation & Training

All the informants interviewed had a lot to say about the need for adequate training of health workers if at all they are ever going to use DHIS2 as envisaged. And it was very important that this training be packaged properly depending on the cadre of users who were targeted. The question of just how long the training should be was found to be complex, with some asserting that the one week standard training period was less than adequate, especially considering that most of them would not have had much interactions with computers beforehand. The need to rethink the protocol to follow when training the managers was also touched on, primarily because such personnel would neither appreciate being trained by their juniors nor sitting in the same class as their juniors. All were in agreement that when the workers were well trained and sensitized on the benefits of using the system, then this contributed directly to how well they used the system both for their routine

work as well as in generation of information products that could aid in relevant decision making.

(x) Assurance of the Information Security

The informants expressed concern about whether Kenya had put in adequate measures to ensure security of the data collected and processed through DHIS2. In particular informants were concerned by the fact that this data was available through open access to any interested party from any part of the world as soon as it had been entered at the district and health facility levels. This despite the reality that some of the data keyed in was erroneous and had not been validated by the data owners. Some interviewees however informed the researchers that the ministry was in the process of setting up a web-portal that would only contain the validated version of DHIS2 data. In the meantime it was noted that some researchers were already using the available data and misrepresenting the Kenya health situation at international conferences.

(xi) Institutional Capacity and Staffing Levels

One of the challenges that continued to plague the health care sector in Kenya was the issue of high workload and low workforce, especially in the lower level health facilities. This compounded the challenge of trying to scale up use of DHIS2 in the country because some rural health facilities had one clinical staff who was expected to attend to several clinical roles in addition to finding time to collect and collate the health information. The situation was not much better at the higher health facilities where the resident HRIO was expected to support roles which were seen as more important than data management, such as patient registration. These challenges were even more complicated by the fact that the managers in charge of these health facilities were in most cases not fully aware of the role of DHIS2 and how it could assist them in their day to day work. Infrastructural challenges in many Health Facilities (HFs) meant that even the most proactive ones were unable to access DHIS2 directly for data entry and information use.

(xii) Performance Enhancement and Value Addition

Those who had had a chance to interact with DHIS2 agreed that the system added real value to the country's health data management scene, especially when compared with previous HIS systems. The range of values identified included the ease of access to the health information and the timeliness with which that information was available. It also had to do with the ease of report generation especially for the standard charts and reports that were already inbuilt in the system. The added fact that the system was for the most part friendly and easy to use was like an added bonus. Despite the fact that the system was initially only targeted to report on routine service delivery data from the HFs, DHIS2 had since been used innovatively to report on malaria commodities. This had led to such improved reporting rates that quantification of malaria medicines could now be done based on the consumption data reported through DHIS2.

(xiii) Sensitization and Advocacy at Management Level

The key selling point for DHIS2 was not just the fact that it was capable of collating and aggregating reports from all service delivery points in a speedy manner, but more so the fact that health care workers at all levels could be able to access and use this information for appropriate decision making. Yet according to the explorative research's informants, very few healthcare managers were sensitized on this aspect of DHIS2, with most viewing it as a tool for the HRIOs and the program M&E officers. The situation had become more dire with the establishment of the county governments. If the governors and County Health Executives were not sensitized on the role of DHIS2, there was fear that they would view it as a tool for the central government and not embrace it as expected. Given their administrative roles, training and sensitization for the management teams needs to be handled with care to ensure observation of all protocols.

A sample of some free form comments that were obtained from this phase of the study is given below:

"The culture of information use needs to be developed… inculcated over time starting from the very top. And what I've heard from informal circles, I don't know how true it is, is that the president demands that people provide evidence for the decisions that they make. So he's requiring that of his managers of that level, so am hoping or expecting that it trickles down all the way so that you have evidence for the decision that you make…" - Int018

"..behaviour changes as the leadership, if the leadership is not demanding use of information, forget about the rest. So it starts from the top… and we are seeing it in many other arenas, I mean now as a governor, how do you operate? In any institution in any environment, the leader shows the way." - Int013

"Younger generation are very positive because they are I.T. compliant, but the older generation are challenged because they take too long to learn" - Int019

"We also get challenges with the people providing support… [There is need for] highly qualified people who are able to fix up that system. …. who are able to support that system at that high technical level. But one of the biggest bottle necks we have is the capacity of IT support within MOH to manage this system… There should be a cadre that is highly qualified at that level. The challenge for the Ministry is to motivate such highly qualified people to work for the ministry" - Int018

"*I think at national level we did not train people, it was a one-two hour presentation of this is DHIS, you can view data here, and you can do maps. Most of the training was done understandably at the facility and for direct users, but then at national level we should have had a more tailored presentation, training and sensitization on exactly what you would expect them to do in DHIS." - Int001*

"..so if we are able to have adequate staffing, if we are able to have adequate financial commitment to install the internet to these facilities, if we are able to have adequate financial commitment to procure the computer hardware and software, I think that

would be the way to go, so that we can be able to improve the quality of the data that we collect, hence we can improve on the quality of the information we can get for decision making." - Int016

"I think it's just a matter of engaging the leadership and telling them we have a system like this and you are the people who are supposed to be using your own data so please make sure all the reports are uploaded, people are analyzing their data and using their data. You just need to sensitize them." - Int013

3.5 Linking the Exploratory Findings to Research Model

A closer scrutiny of the factors identified in this phase confirmed that many could be directly linked to the constructs already existing in UTAUT model. This increased the researcher's confidence that UTAUT is indeed still relevant for application in the developing countries' context. However there were some factors and items identified which seem to be unique and only relevant to the developing countries context, hence requiring an extension of UTAUT before application in such settings. All these factors identified from this exploratory study as being most pertinent in influencing acceptance and scale up of use of DHIS2 in Kenya are summarized in table 3.1. The factor names and definitions are adapted from UTAUT and other technology adoption literature.

Table 3.1Factors identified in Exploratory research on DHIS2 Acceptance in Kenya

Pertinent Factors	Role in Acceptance and Scale up of DHIS2 in Kenya	Included in UTAUT
Computer Anxiety – defined as the degree to which anxious or emotional reactions are evoked when using computer technology	Intensity of this anxiety was found to be influenced by age as well as the level of prior computer experience among the intended users. Thus exposing targeted users to practical sessions on general computer use before introducing DHIS2 could serve as a mitigating factor.	NO

Technology Experience – defined as the duration of past use of computer and internet; and the current frequency of using both.	A common thread that ran through the interviews was that many of the targeted DHIS2 users had not had adequate interaction with the computer and internet technologies necessary to use this system with ease. It was suggested that this status of one's prior technology experience would contribute to their level of computer anxiety and subsequently to the intensity of use of DHIS2	NO
Performance Expectancy – defined as degree to which an individual believes that using DHIS2 will enable him or her to attain gains in job performance	For them to accept DHIS2, targeted users need to be sensitized on value-add they may expect from using the system. Some value-add items identified include: ▪ Facilitation of decision making based on service delivery data in the system e.g. a health facility could review its workload as reported in DHIS2 to inform its decision on hiring of additional health workers; ▪ Enabling facilities, sub-counties and counties to make decisions on need for commodities based on prior consumption and patient load as recorded in the system	YES.
Effort Expectancy - defined as the degree of ease of use associated with the use of DHIS2	DHIS2 is easy to use and this should encourage easier adoption of the system. There is however need to ease the web navigation process especially for new users	YES
Social Influence – defined as the degree to which an individual perceives that his or her peers, supervisors, and important others believe he or she should use DHIS2	Social influence was found to play a key role in user acceptance of DHIS2, manifesting itself in the form of: ▪ Culture among health workers that causes them to follow their leaders almost blindly ▪ Practice of passing on information orally instead of recording it ▪ Habit of delaying performance of activities till the very last minute e.g. preparation of monthly report ▪ Emphasis on the need to have a champion(s) that health care workers can look up to in	YES

	using the system	
Training Adequacy – defined as the degree to which an individual believes that the training he or she received is enough to enable him or her use DHIS2 effectively.	Perceived adequacy of Training was cited as a key determinant of acceptance of the DHIS2. Without the training there may be little motivation to adopt the system. Some aspects of adequate training as identified in this study include: ▪ The need for the trainers to be selected appropriately as not everyone can make a good trainer ▪ Adequate duration of training	NO
Organizational Facilitating Conditions – defined as the degree to which an individual believes an organizational or technical infrastructure exist to support use of DHIS2	Facilitation that can support faster adoption and scale up of DHIS2 use includes: ▪ Provision of appropriate computing infrastructure and internet access ▪ Conclusively addressing the issue of high workload and low workforce in most health facilities	YES
Voluntariness of Use – defined as the degree to which an individual perceives that he or she has a choice to use the HIS	▪ This was identified as an important factor with some recommending that the system should be made mandatory for all in order to enhance its usage ▪ Many were however of the opinion that perception is key and health workers would be more willing to adopt the system if they perceived that they were doing it of their own volition	NO*
Age and Gender (moderating variable)	Age and Gender were identified as factors with capacity to moderate how the targeted DHIS2 users interacted with the system.	YES

Note: Voluntariness of use is included in UTAUT as a moderating variable, but the exploratory study suggested that it was a key factor affecting intention to use DHIS2

At the time of conducting this research study, DHIS2 had been in use in Kenya for about 3 years. Most of the targeted users had interacted with the system over similar time durations, so length of experience in using DHIS2 was not considered a relevant moderating variable.

3.6 Study Model Development and Hypotheses Formulation

The main objective when conducting this exploratory qualitative phase of the study was to examine if it is possible to categorize the factors identified by the key informants with those identified from technology acceptance and use literature, and particularly within the constructs defined by the UTAUT model. The end result was that the qualitative study supported all of the constructs in the original UTAUT model as summarized in the previous section. Additionally it contributed to the identification of new constructs to be included in the research model, namely: **Training Adequacy**; **Voluntariness of Use** (as an exogenous construct), **Computer Anxiety** and **Technology Experience**. Similar to UTAUT, the exploratory study also identified Age and Gender as moderating variables. However the other two UTAUT moderators were not considered applicable in the study context. Building on the above-mentioned exploratory research and the literature review, a newly conceived conceptual research model to answer the research questions was created. The model is based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model and is discussed in the section below.

As discussed in the preceding sections, conceptualization of the research model followed a detailed approach where information acquired through literature review was jointly synthesize with an understanding of the context within which computerization of health information systems is happening in Kenya, as well as insights from a qualitative pre-study done on acceptance and use of DHIS2 in Kenya (Karuri, Waiganjo & Orwa 2014). This led to an extension of the UTAUT model to include Training Adequacy and Voluntariness of use as direct determinants of Behavioural Intention, and Computer Anxiety as a direct determinant of Use Behaviour. In addition Technology Experience was also included and postulated to

predict the individual's computer anxiety. Only two moderators were included in the model, namely gender and age. The resulting research model that was generated is illustrated in figure 3.1.

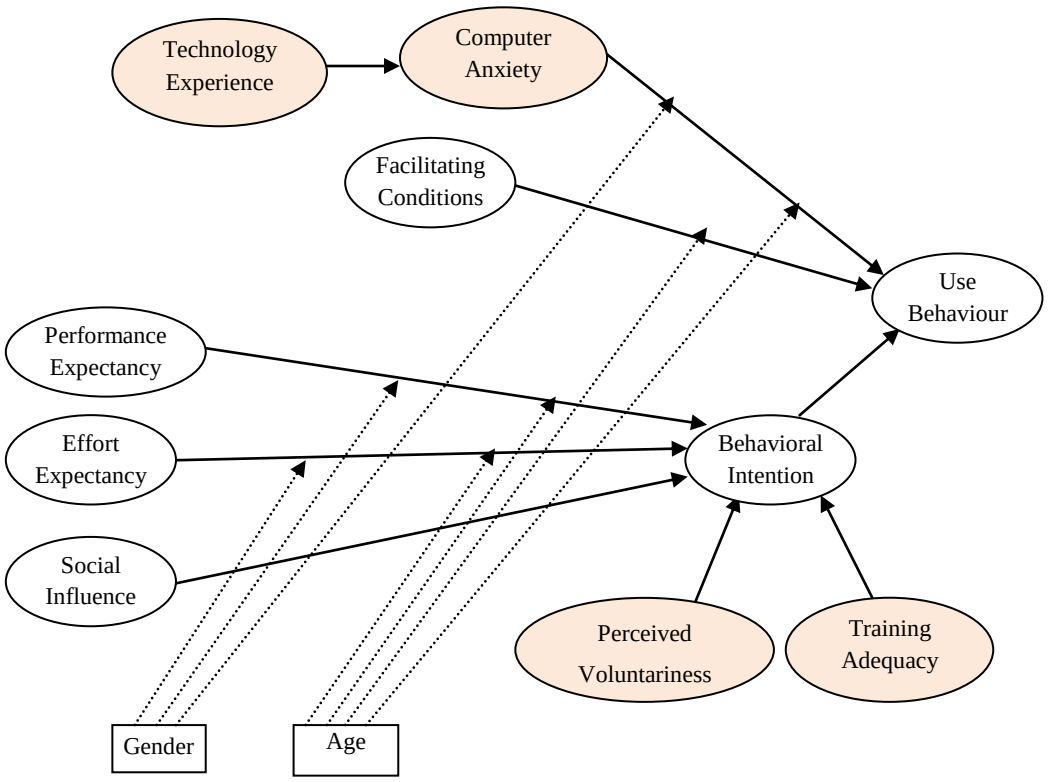


Figure 3.1 The Research Conceptual Model for user acceptance of DHIS2 (Adapted from Venkatesh et al)

3.7 The Research Hypotheses

There is evidence from both cognitive and behavioural sciences of the importance of perception in an individual's evaluation of technology and their subsequent decision to accept it. Perceptions, rather than objective technology attributes, have been found to be more relevant to technology acceptance decision making and are the focus of the investigation in this study (Moore & Benbasat 1991). The following discussion explains the basis on which the hypotheses were selected.

3.7.1 Determinants of Behavioural Intention

Performance Expectancy

Performance expectancy (PE) is defined as the degree to which an individual believes that using ICT will help him or her to attain gains in job performance (Venkatesh et al. 2003). In previous acceptance studies, the performance expectancy construct is consistently a strong predictor of intention (Davis et al. 1992; Taylor & Todd 1995; Venkatesh & Davis 2000) The significance of performance expectancy to health professionals has been demonstrated in most of the studies that have examined technology acceptance in health (Chau & Hu 2002; Chismar & Wiley-patton 2003). Thus we proposed:

> ***H1:*** *Performance expectancy will positively affect the health worker's intention to use DHIS2*

Effort Expectancy

Effort expectancy (EE) is defined as the degree of ease associated with the use of a system and was found to be a significant predictor of intention in the UTAUT model. The influence of effort expectancy on behavioural intention is expected to be particularly significant when the technology being introduced is quite new and different from what the users are accustomed to, as is the case with DHIS2. A lot of previous studies have confirmed this to be the case (Agarwal & Prasad 1999; Davis 1989; Moore & Benbasat 1991; Schaper & Pervan 2007; Thompson et al. 1991; Venkatesh et al. 2003), however there are a few that had contrary findings (Chau & Hu 2002; Chismar & Wiley-patton 2003). This study supports UTAUT and postulated that effort expectancy would play a significant role on user acceptance of DHIS2.

> ***H2:*** *Effort expectancy will positively influence the health worker's intention to use DHIS2*

Social Influence

Social influence (SI) is defined as the degree to which an individual perceives that important others believe he or she should use a certain technology. The impact of this construct on behaviour is through compliance, internalization and identification (Venkatesh & Davis 2000). Through internalization and identification an individual's

belief structure is altered, whereas compliance causes an individual to alter his or her intention based on social influence (Venkatesh et al. 2003). The direct effect of social influence on behavioural intention has been shown in many technology acceptance studies, but some studies conducted in the health sector found this factor insignificant in the intention decisions of physicians to use Internet-based health applications (Chau & Hu 2002; Chismar & Wiley-patton 2003). This study did not, however, target the independent physicians who were the subject of studies that found social influence insignificant. In addition, the study setup was in a developing country context where the cultural values of collectivism and high power-distance are expected to be quite dominant (Hofstede et al. 2010), hence the influence of peers and supervisors is expected to be higher. Van Biljon and Kotzé (2008) identified social influence as one of the important determining factor influencing mobile phone adoption and use in South Africa (Biljon & Kotzé 2008). Findings from the pre-study conducted in this research also suggested that the targeted health workers are very much influenced by what they perceive to be the wishes of their supervisors and whether or not DHIS2 champions exist at their work place. It is thus plausible that social norms and pressures may be significant in determining the technology acceptance decisions of health care workers in a developing country setting such as Kenya. Additionally the effect of social influence in this context is applicable to all, regardless of gender, so we hypothesized that:

> ***H3:*** *Social influence will positively affect the health worker's intention to use DHIS2*

Training Adequacy

Training adequacy (TA) is defined as the degree to which an individual believes that the training he or she received is adequate to enable him or her use DHIS2 effectively, and this was identified as a key factor that influences the targeted users' intention to use DHIS2. Training is expected to increase the individual's belief in their capacity to undertake a certain function, as well as to increase his or her actual ability to use the system. Adequacy of training will thus help users to become more comfortable while using a technology artifact, and thus impact positively on their behavioural intention (Aggelidis & Chatzoglou 2009). Because DHIS2 is very different

from the traditional HIS systems in terms of technology and platform of use, it is anticipated that the more the users' perceive the training received to be adequate, the higher will be their intention to use DHIS2. Thus this study postulated that

H4: *Perceived training adequacy will have a significant positive influence on health worker's intention to use DHIS2.*

Voluntariness of Use

Voluntariness is defined as the degree to which an individual perceives that he or she has a choice to use or not use health IT, and it is an important concept that also influences the intention to use information technology. Perceived voluntariness was treated as a moderating dichotomous variable (voluntary/compulsory) in the original UTAUT model. However voluntariness was considered a key factor in our pre-study (Karuri, Waiganjo & Orwa 2014), with the majority of the informants being categorical on the need for there to be some form of policy and legislation to enforce health information reporting in the country, both from the public and the private health sectors. As has been suggested in other technology acceptance studies, we expected that the more the perceived voluntariness, the more users would have a positive attitude toward DHIS2, and hence the more their intention to use the system (Moore & Benbasat 1991; Karahanna et al. 1999; Agarwal & Prasad 1999). Thus we hypothesized that:

H5: *Voluntariness of use will have a positive influence on behavioural intention.*

3.7.2 Determinants of System Usage

The main assumptions underlying UTAUT also form the base of this study's research model. In UTAUT Actual Use is proposed as the final dependent variable representing the measurement of technology acceptance, and the theory posits that it has two direct determinants which are Intention to Use and Facilitating Conditions. This study however proposed an addition direct determinant of actual use which is Computer Anxiety. This section explains the choice of determinants for use behaviour in the study model.

Behavioural Intention

The intention-behaviour relationship is presumed in many technology acceptance studies, consistent with the UTAUT study's finding that behavioural intention has a significant positive influence on usage (Ajzen 1991; Mathieson 1991; Taylor & Todd 1995; Venkatesh & Davis 2000). It was thus hypothesized that:

> ***H6:*** *Behavioural intention will have a significant positive influence on health worker's use of DHIS2.*

Facilitating Condition

Organizational facilitating condition is defined as the degree to which an individual believes that organizational and technical infrastructure exists to support use of the system (Venkatesh et al. 2003). This incorporates objective factors in the implementation context such as management support and the provision of IT technical support. Support for the investigation of organizational facilitating conditions can be found in the health informatics literature (Anderson 1997; Kijsanayotin et al. 2009) among other studies. Several of these studies found that facilitating conditions significantly predicted technology use but did not predict intention to use IT where both PE and EE constructs are present in the model.

In the developing country setting, the availability of the prerequisite organizational and technical infrastructure to support use of a newly introduced technology is not guaranteed. The degree to which these facilitating conditions are present will influence the intensity with which a new technology can be used. Thus we postulated that:

> ***H7:*** *Organizational facilitating conditions will positively affect the use of DHIS2*

Computer Anxiety

Empirical evidence from UTAUT suggests that both computer self-efficacy and computer anxiety do not exert a significant influence on behavioural intention, due to the effect being captured by the existence of effort expectancy (Venkatesh et al. 2003). However, evidence from literature as well as the results obtained from this

research's pre-study suggests that computer anxiety may be more salient in Kenya and other developing countries' context because of the prevalent challenges of lagging behind in computerizing of health systems in these countries. The level of anxiety is dependent on degree to which the targeted user has previously been exposed to the use of computers and the internet. The following hypotheses were thus proposed:

H8: *Computer Anxiety will have a negative influence on health worker's use of DHIS2*

H9: *Technology Experience will have a negative influence on Computer Anxiety*

3.7.3 The Moderators

A moderator variable is one that has some strong effect on an independent variable and dependent variable relationship. The presence of the moderator variable effects some changes in the original relationship between the independent and dependent variables. Gender, age, experience and voluntariness of use were identified as moderators in the UTAUT model. For our model voluntariness of use and technology experience were operationalized as direct determinants of behavioural intention and actual use behaviour, respectively, leaving only gender and age as the relationships moderator. The following hypotheses summarize some of the expected contribution of the moderating effects:

H10: *The influence of performance expectancy on behavioural intention will be moderated by gender and age, such that the effect will be stronger for men and particularly for younger men.*

H11: *The effect of effort expectancy on behavioural intention will be moderated by gender and age, such that the effect will be stronger for women and particularly for younger women*

H12: *The effect of computer anxiety on use behaviour will be moderated by gender and age, such that the effect will be stronger for women, particularly older women.*

Chapter 4: RESEARCH METHODOLOGY

4.1. Introduction

This chapter describes the methodology that was used to achieve the research aims and objectives. The overall objective of this study was to evaluate and extend the body of knowledge and understanding regarding user acceptance of health information technology in public health sector of developing countries. To meet the stated objective, a conceptual model and related hypotheses were developed founded on the UTAUT model but extended based an exhaustive review of the published literature concerning the user acceptance and use of technology in general, and particularly in the health sector of developing countries.

One of the most widely used systems for management of health information at national or entire country's regions in developing countries is the DHIS2. For this reason, the case of implementation and user acceptance of DHIS2 in Kenya was used to represent implementation of high impact public health IT in developing counties. This study was mostly conducted through the use of quantitative methods, but qualitative data was collected to provide context specific background information with regard to implementation of DHIS2 in Kenya. The main data was collected through a cross-sectional survey. A comprehensive survey instrument was developed with questions corresponding to all the items used to measure the different constructs contained in the study's conceptual model. This chapter elaborates on the process used in developing and validating the survey instrument, selecting an appropriate sample, undertaking the data collection and the various stages of statistical data analyses.

The research methodology and design for this study were chosen in order to achieve the set objectives outline in chapter 1. The rationale for each choice is explained and discussed in terms of research process, conceptual framework, study designs,

development of the main instrument, piloting the instrument, study population, sample and data collection and analysis

4.2. The Study's Philosophical Perspectives

One definition of research is the formal, systematic application of scientific method to the study of problems. Research designs are categorized broadly as either qualitative or quantitative. Quantitative methods rely heavily on positivism, and the objective of quantitative research is to develop and employ mathematical models, theories or hypotheses related to the phenomena being studied. The process of measurement is central to quantitative research because it provides the important connection between empirical observation and mathematical expression of quantitative relationships. According to Kaplan et al (1996), quantitative research is most useful when a theory is already established and when individual relationships need to be quantified and validated. On the other hand qualitative research is based on based on interpretivism, and employs analyses and interpretations of observations for the purpose of discovering underlying meaning and patterns of relationships (Kaplan & Duchon 1988; Gay et al. 2006; Fitzgerald & Howeroft 1998).

A hypothesis is defined as an explanation of the occurrence of certain behaviour, phenomena, or events. In most cases quantitative research design involves developing hypothesis based on observation, deducing the implication of the hypothesis, testing the implications, and confirming or disconfirming the hypotheses (Sekaran 1992; Gay et al. 2006).

4.2.1 Cross-sectional Surveys

There are two types of surveys used when evaluating acceptance and use of technology, namely: longitudinal surveys and cross-sectional survey. Since the DHIS2 which was being investigated was in its early stages of introduction, the best survey method was deemed to be cross-sectional. By using cross-sectional survey, the study would be able to predict future usage. The survey was designed in such a way as to enable collection of a data sample that was representative of the overall usage of

DHIS2 among the target population. In IS/IT evaluation studies, cross-sectional survey methods are not new because they have been used by several researchers (Chau & Hu 2002; Venkatesh & Davis 2000; Kijsanayotin et al. 2009).

The cross-sectional survey design was to gather quantitative data to assess the relationships between the study variables. A cross-sectional study involves data collection that covers a one-off time period. Data collection of individual observations can occur at one point in time or may be over a period of days, weeks or months. According to Mugenda (2008), this sort of survey helps to establish whether significant associations among variables exist (Mugenda 2008). The additional value of this type of survey is that it allows one to generate testable hypotheses. Additionally, this survey method has been found to offer more accurate means of evaluating information about the sample and enables the researcher to draw conclusions and more easily generalize the findings from a sample to the population. Survey methods are quicker, more economical and efficient, and easier to administer to a large sample (Sekaran 2003).

Cross-sectional designs have three distinctive features:

i) There is no time dimension, only differences between groups are measured rather than changes over time;
ii) There is reliance on existing differences rather than change following any intervention and there is no allowance for differences to emerge over time;
iii) Grouping individuals in the sample is based on existing differences or according to a category or the independent variable to which they happened to belong rather than random allocation.

Longitudinal studies are feasible when there is need to describe the pattern and direction of change and stability, which was not the focus of the current study (De Vaus 2001). Rather the objective of this study was to understand usage behaviour as a dependent variable that would predict the actual usage of the DHIS2 in the coming years, and addresses any factors that might impede the acceptance of this system to

health workers in the public health sector. **Behavioural intention** is associated with **self-predicted future usage** of a new technology and both factors were the subject of investigation in this study.

4.3. The Overall Research Approach

Several factors were considered in choosing the proposed research approach and methods for this study. The study aimed to design a viable predictive model of behavioural intentions of users of technology services. The study was based on the well established UTAUT model with addition of 4 new constructs for context specific application. These characteristics required the means of a structured, well-defined framework and definite measurements that could establish relationships between variables, and from which inferences could be made from the study sample to a larger population. Most of these qualities can be addressed by quantitative research methods (Kaplan & Duchon 1988).

The ultimate focus of the study was to test hypotheses related to the proposed conceptual framework model, which included the hypothesized relationships adapted from previously established technology acceptance relationships. Thus the conceptual drive of the study was deductive in nature. The study followed a confirmatory strategy of research that required empirical analysis as a way of proving or disproving previously assumed hypotheses related to user acceptance of health IT.

Nevertheless, although this study was mainly quantitative in design, it also used qualitative methods during the preliminary stages. Literature review and key informant interviews were used to conduct in-depth assessment of the readiness for innovative routine health IT in Kenya and other developing countries, in order to determine the overall readiness of adoption and use DHIS2 by health workers in the country. These qualitative methods also contributed a lot in the initial refinement of the primary survey tool / questionnaire. The combination of quantitative and

qualitative techniques in research provides for a richer contextual base upon which research results can be interpreted and validated.

4.4. The Study Design

Though this research was conducted primarily through the use of quantitative methods, the qualitative data collected provided background and context information with regard to the DHIS2 implementation in Kenya. Overall, the research design included 5 main phases as summarized here:

- Phase one focused an extensive review of the existing literature on acceptance of technology, zeroing in on the studies conducted in healthcare domain. The literature review was instrumental in identifying the possible factors that need to be examined with regard to acceptance and use of ICT in the healthcare setting of developing countries. These factors were considered and used in developing the initial version of the contextual study model adapted from the UTAUT model, as well as the hypotheses associated with these factors.

- Phase two involved preliminary data gathering through conducting of Key Informant Interviews (KII) with various DHIS2 stakeholders in order to get background contextual information on this system's implementation in Kenya. The context specific information was instrumental to development of a refined version of the conceptual model, and the initial version of the survey instrument. The details of how this phase was conducted plus its outcome are given in Chapter 3.

- Phase three was the pilot study which was designed and conducted primarily to verify the appropriateness of the items selected to provide measures for the latent variables of the study's conceptual model. The findings from this phase were used in the final refinement of the survey instrument before the main data collection phase.

- Phase 4 was the main data collection phase during which quantitative data was collected using the cross-sectional survey approach. The survey sample was carefully selected to be representative of DHIS2 users in Kenya.
- The final phase, phase 5, was concerned with quantitative analysis of the survey data and contextualizing the research findings. In this phase, the researchers employed a two-step approach using the structural equation modeling (SEM) analysis with SmartPLS software (Ringle et al. 2005). The first step was evaluation of the Conceptual Model's measurement model to examine the validity and reliability of latent constructs indicators. The second step was the detailed evaluation of the structural model procedure and the subsequent examination of support for the proposed research hypotheses.

All these 5 phases of the study are illustrated in figure 4.1 and described in more details in different sections of this chapter.

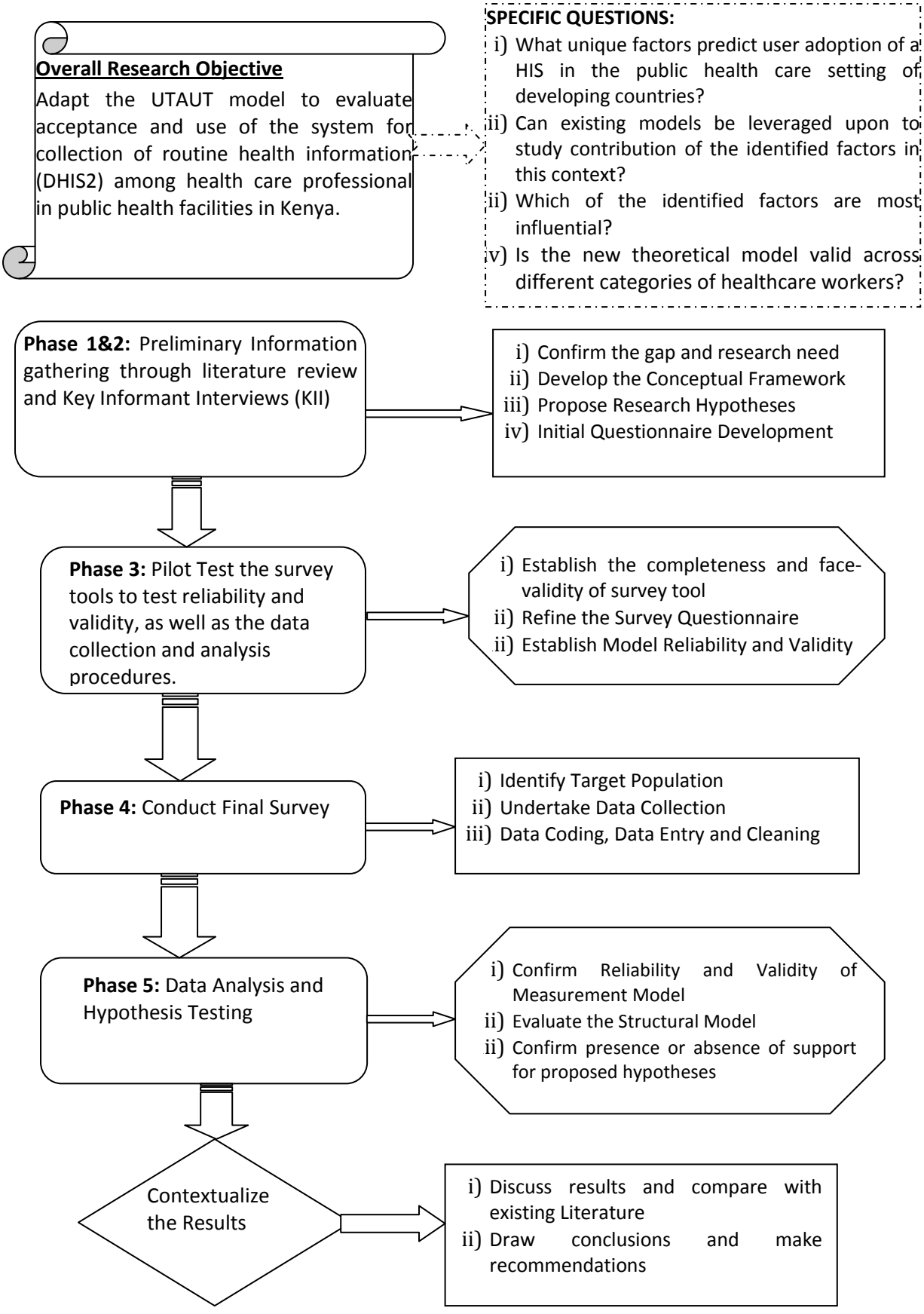


Figure 4.1 Summary of the Research Design

4.5. Development of the Survey Instrument

A review of the literature identifies some advantages of using a mostly structured and self-administered questionnaire as the main data collection tool, as was the case for this study, include the following:

a) The tool easily provides for the quantifiable information required for structural equation modelling as was required in this study.

b) A structured questionnaire is the most efficient and effective data collection tool especially when the study had defined variables to measure. Sekaran (2003) agrees that field studies often use questionnaires to measure variables of interest.

c) A questionnaire can be administered to a large number of individual respondents simultaneously; is less expensive, less time consuming and does not require a lot of skills, compared to conducting interviews(Mugenda 2008).

4.5.1 Questionnaire Design Steps

The survey instrument in this study was a printed questionnaire; designed taking into account the recommendations contained in the literature concerning presentation and formatting that enhances readability and understandability. This means that the researcher made a conscious effort to keep the questions simple, easy to read, and unambiguous thereby minimizing the chance of misunderstand or misinterpretation of the questions by the respondents. This was in order to prompt higher survey response rates and hence meet the intended survey objectives (Kitchenham & Pfleeger 2002).

As recommended in the cited literature touching on this subject, the following steps were followed during the questionnaire design phase:

i) First and most important, the study objectives were formulated and discussed with research experts to ensure their clarity, and that their capacity to fully address the identified research questions. .

ii) A thorough review of existing literature on technology acceptance was done to guide the design of the study conceptual model, along with selection of the appropriate model constructs and indicators. The researchers also gained knowledge on how questions for measuring these indicators have been formulated in the past, including choice of appropriate phrasing.

iii) An adequate number of measurement items were selected to ensure that the meaning of each construct was fully captured as conceptualized.

iv) Expert opinion and feedback was sought throughout this phase from stakeholders involved in design, implementation and use of DHIS2 in Kenya, as well as from academic researchers who have undertaken user acceptance studies in the past.

v) A qualitative pre-study was undertaken to confirm appropriateness of the constructs included in the research model. This provided insight into selection of the corresponding measurement items and subsequently the design of the questionnaire.

vi) Finally a pilot study was done to assess the psychometric properties of the indicator measures obtained through the use of the questionnaire. Additionally focus group discussion with the pilot teams pinpointed specific items in the questionnaire that required to be modified.

4.5.2 Final Instrument Layout

The final survey questionnaire consisted of 5 pages, the first of which was a covering letter explaining the purpose of the survey and inviting targeting participants to complete the survey. The letter assured survey participants of the confidentiality of the data gathered and informed them that their participation in the survey was completely voluntary. A copy of the questionnaire is included in **Appendix 6**.

The subsequent 4 pages of the questionnaire consisted of 3 distinct categories of questions as described below:

- Category One (corresponding to Sections A, B and C on the questionnaire): This first part included 47 questions which correspond to the 47 manifest

variables used in the analysis of the conceptual model. All indicator measures except those associated with two constructs used a 7- point Likert type scale ranging from strongly agree to strongly disagree. The exceptions were measures for Technology Experience and Use Behaviour which used a different measurement scheme as defined by the researchers.

- Category two corresponded to Sections D and E on the questionnaire. This part of the instrument consisted of 5 questions evaluating the respondents' access to computer and technology resources and their use of DHIS2, and 5 questions on age, gender, education level, profession and workstation. The purpose of this category of questions was to provide contextual information that might be useful in understanding the findings from the Structural Equation Modelling.

- Category Three: This corresponds to the final section of the questionnaire which consisted of three open-ended questions asking respondents to indicate their opinion on the usefulness and/or challenges faced in using DHIS2, and any other comments they would wish to make on the subject. The objective of the open-ended questions was to identify and compare the factors stated by the respondents, with the constructs defined in the proposed theoretical model. This informed some of the discussions and recommendations arrived at in this study. Inclusion of this small section of open-ended questions enriched the study by enabling the combination of both quantitative and qualitative methods to provide a firmer contextual basis for interpretation and validation of the results. Additionally, adding open-ended questions in a qualitative study design can lead to the discovery of factors not considered during development of study's theoretical model, hence leading to recommendations for inclusion in future studies (Kaplan 2001; Ammenwerth et al. 2003; Kaplan & Duchon 1988).

4.6. Constructs Operationalization and Measurement Scale Development

The constructs or latent variables used in developing the study model are actually abstractions that cannot be observed directly (Gay et al. 2006). Hence the variables had to be operationalized to render them measurable by looking at all possible behavioural properties which make up each construct. These were then translated into observable and measurable elements in order to develop a standard measure for the concept. The measurable elements are also referred to as manifest variables or indicators.

Most of the questions for collecting the manifest variables data were adapted from the tool developed by Venkatesh et al. (2003), but edited to match the context of routine health information system, which is the technology that was being investigated in this study. Additionally, since the UTAUT model was extended to include additional constructs, there was need to include new questions in the questionnaire to provide data for the new manifest variables.

Operational definitions for some of the study's core constructs derived from UTAUT were already specified by Venkatesh et al. (2003). These constructs have since been used by several other scholars who include Moran (2006), Anderson &Schwager, (2004); Kripanont (2007). Each of the variables was measured using one or more statements, referred to as indicators in this study.

The measurement scales used in the study were mostly ordinal and a few nominal ones. The Likert scale, which is an ordinal scale, was used for most of the questions that served as measurement indicators for the conceptual model's constructs. The Likert Scale was developed by Rensis Likert in 1932 and it requires participants to make a decision on their level of agreement with the given statement. The most commonly used adaptations of this scale are the 5-point and the 7 point Likert scales. This study employed the seven-point rating scale as it has been used very frequently in technology acceptance and IS literature; including in the UTAUT study

(Davis 1989; Kijsanayotin & Speedie 2006; Venkatesh et al. 2003; Venkatesh & Davis 2000). The nominal scale was used for questions that required the survey participants' to select certain categorical options e.g. for demographic characteristics such as gender and other demographic questions.

Table 4.1 represents model constructs and definitions, their corresponding measurement items as used in this study; and the literature references that informed their operationalization. A note of the measurement scale used for each construct's items is given at the bottom of the table. Most of the indicators were operationalized based on definitions by Venkatesh et al, but adapted to fit the local setting. Technology Experience was however operationalized as prior experience in use of computer and internet, including the current frequency of using the two.

Table 4.1 The Study Model's Constructs Measurement Statements

Indicator Code	Measurement Statements	Literature References	Measurement scale
Performance Expectancy (PE): – the degree to which an individual believes that using DHIS2 will enable him or her to attain gains in job performance			
PE1:	Using DHIS2 will enable me to accomplish tasks more quickly	Davis (1989); Venkatesh et al (2003); Chismar& Wiley(2002); Chau & Hu (2002); Anderson &Schwager (2004); Compeau& Higgins (1999); Chang et al (2007)	7 Point Likert Scale[a]
PE2:	Using DHIS2 will allow me to accomplish more work than would otherwise be possible		
PE3	DHIS2 will enable me to make work related decisions based on better evidence		
PE4:	If I use DHIS2, I will increase my chances of getting a promotion.		
PE5:	Overall, I would find DHIS2 useful in my job.		
Effort Expectancy (EE): the degree of ease of use associated with the use of DHIS2			
EE1:	My interaction with DHIS2 is or would be clear and understandable.	Venkatesh& Davis (2000); Davis &Venkatesh et al (2003); Duyck et al (2008)	7 Point Likert Scale
EE2:	It would be easy for me to become skilful at using DHIS2.		
EE3	Learning to operate DHIS2 is easy for me		
EE4	Overall, I would find DHIS2 easy to use		
Computer Anxiety (ANX): the degree to which anxious or emotional reactions are evoked by the need to use computer technology			
ANX1	I feel nervous about using computer systems	Compeau et al (1999); Duyck et al (2008);	7 Point Likert Scale
ANX2	It scares me to think I could cause loss of data in		

	the system by hitting the wrong key	Venkatesh et al (2003); Davis (1992); Venkatesh (2000)	
ANX3	I would hesitate to use DHIS2 for fear of making mistakes I cannot correct		
ANX4r.	The challenge of learning about computers is exciting.		
ANX5	DHIS2 is somewhat intimidating to me		
ANX6r	I look forward to using a computer.		
ANX7r	I am able to keep up with important technological advances in computers.		
ANX8	I feel nervous when using internet-based applications		
Social Influence (SI): the degree to which an individual perceives that his or her peers, supervisors, and important others believe he or she should use DHIS2			
SI1:	People who are important to me think that I should use DHIS2	Venkatesh et al (2007); Kripanont (2007); Chang et al (2007); Venkatesh& Davis (2000); Schaper&Pervan (2007)	7 Point Likert Scale
SI2:	My colleagues think that I should use DHIS2.		
SI3:	The senior management has been supportive in the use of DHIS2 at my duty station		
SI4:	In general, use of DHIS2 has been supported and encouraged at my duty station		
Facilitating Conditions (FC): the degree to which an individual believes an organizational or technical infrastructure exist to support use of DHIS2			
FC1:	I have the resources (e.g. reporting forms, computer, antivirus, etc) necessary to use DHIS2	Kripanont (2007); Venkatesh et al (2003; Schaper&Pervan (2007); Anderson &Schwager (2004); Duyck et al (2008); Chang et al (2007); Chau & Hu (2002)	7 Point Likert Scale
FC2:	Access to the Internet is available any time I want to use DHIS2		
FC3:	I have the knowledge necessary to use DHIS2.		
FC4:	DHIS2 is compatible with other systems that I use at my work.		
FC5:	DHIS2 experts are available for assistance with DHIS2 difficulties		
FC6:	I have knowledge sources (e.g. books, documents, consultants) to support my use of DHIS2		
FC7:	I think that using DHIS2 fits well with the way I like to work		
Training Adequacy (TA): the degree to which an individual believes that the training he or she received is enough to enable him or her use DHIS2 effectively			
TA1:	The training received on DHIS2 is very helpful in my use of the system	Wu et al (2008); Jayasuriya (1998); Aggelidis and Chatzoglou (2009)	7 Point Likert Scale
TA2:	I have training reference documents that I can consult in my use of DHIS2		
TA3:	I feel the training received is adequate for my efficient use of DHIS2		
TA4r:	I need further training on DHIS2 to enable me use the system efficiently		

TA5:	My training on basic use of computers is adequate for using DHIS2		
TA6:	The DHIS2 training was well organized and easy to follow		
TA7r:	I need some further training on Internet and the World Wide Web to enable me use DHIS2 efficiently		
Voluntariness of Use (VO): the degree to which an individual believes that his or her use of DHIS2 is voluntary			
VO1.	Although it might be helpful, using DHIS2 is not compulsory in my job (i.e. my use of DHIS2 would be voluntary)	Kijsayanotin et al (2009); Venkatesh et al (2003) Moore &Benbasat (1991); Agarwal & Prasad (1997)	7 Point Likert Scale
VO2r	My use of DHIS2 would be for mandatory routine reporting		
VO3.	My use of DHIS2 would be for voluntary analysis of the health facility/sub-county data for informed decision making		
Behavioural Intention (BI): the degree to which an individual intends exert effort to use DHIS2			
BI1:	I intend to use [or continue using] DHIS2 in the next 3 months.	Venkatesh et al (2003) Venkatesh& Davis (1996) Bagozzi et al. (1992)	7 Point Likert Scale
BI2:	I predict I will use [or continue using] DHIS2 in the next 3 months.		
BI3:	I plan to use [or continue using] DHIS2 when I have access to computer and internet		
Technology Experience (Exp): the duration of past use of computer and internet; and the current frequency of using both.			
Exp1:	For how long have you been using a computer?	Kijsanayotin (2009);Thompson&Higgin (1994); Venkatesh et al (2003);	User Defined Scale[b]
Exp2:	Approximately how many hours per week do you use a computer?		
Exp3.	How long have you been using the Internet?		
Exp4:	Currently, how often do you use the Internet?		
Use Behaviour (UB): The current frequency of using DHIS2; and the average duration of each use session			
UB1:	On average, how often do you use DHIS2?	Venkatesh et al (2003); Taylor & Todd (1995); Venkatesh& Davis (2000); Ajzen (1991)	User Defined Scale[c]
UB2:	When you do use DHIS2, on average how much time do you spend on the system?		

Note:

[a]7 Point Likert Scale was defined as: 1= Strongly Disagree 2= Disagree 3= Slightly Disagree 4= Neither Agree nor Disagree 5 =Slightly Agree 6= Agree 7= Strongly Agree

[b]User Defined Scale for Technology Experience measured the user's duration of using computer and the internet (in Months and Years) and corresponding frequency of use (in days, weeks and months)

[c]User Defined scale for measuring Use Behaviour measured frequency of use of DHIS2 in Months and Days; and time in hours user spent on average during each session.

4.7. The Pilot Study

The objective of the pilot testing was to identify and eliminate potential problems of the questionnaire e.g. grammatical and phrasing issues. During this phase any part of the tool which was found to be causing misunderstanding, or was otherwise unclear or irrelevant was re-written or eliminated. The final tool was thus updated and finalized accordingly based on the feedback received, as well as the results of the different tests done in the pilot study. The specific tests done in the pilot are discussed below.

(i) Questionnaire understandability and Completion Time: This involved practically identifying and eliminating potential misunderstandings in the questionnaire e.g. due to grammatical and phrasing issues. The respondents noted the time they took to complete the survey and this was used to ensure the survey instrument was clear and concise.

(ii) Content Validity Testing: This was used as a preliminary screening procedure and it is defined as the degree to which the survey instrument is deemed to measure what it claims to measure. Simply this means the degree to which survey respondents believe the questions are relevant to the study investigation being conducted. Through focus group discussions with the pilot phase respondents, it was possible to gauge the instruments comprehensiveness in measuring the intending content areas.

(iii) Reliability of Construct Measurement: This was to test that the data collection instrument consistently measured what it was supposed to measure. Instrument reliability was assessed on the pilot data using measures for composite reliability as well as internal consistency reliability (Cronbach's alpha) whereby high measures of the reliability coefficient (alpha) are indicative of a highly reliable instrument. The recommended minimum acceptable reliability coefficient ranges from 0.7 to 0.8 (J. F. Hair et al. 2006; DeVellis 1991; Nunnally 1978). The constructs' discriminant validity, which is defined the extent to which a given construct is different from other constructs, was also measured. In PLS, adequate discriminant validity is demonstrated when a construct shares more variance with its indicators than

with other constructs. The variance shared between a construct and it indicators (measures) is estimated using the average shared variance (AVE) (Fornell & Larcker 1981).

For this pilot phase, an initial group of eleven participants drawn from the main referral hospital in the country were selected to fill in the questionnaire. After completing the survey, a focus group discussion (FGD) was held with this group to discuss their experience in completing the survey and receive feedback on any of the questionnaire items which needed to be modified. Only minor editing errors and clarification issues were pointed out. During the FGD, any item that had been completed erroneously due to lack of clarity was revised. Based on the feedback received, the survey instrument was slightly modified and then administered to eleven other participants from the Kenya Malaria Program. Thus overall a total of 22 respondents participated in the pilot study.

Results of the pilot phase of the study enabled the researchers to clarify any misconceptions and/or unclear wordings in the final tool. Some of the questionnaire items were re-formulated and re-arranged for easier flow of ideas, as well as well as to ensure they fully captured the essence of the constructs being investigated. The measurement items were also tested for validity and reliability, while the structural model was tested for convergent and discriminant validity. The key outcome of all these tests was to confirm the feasibility of the study as was designed and the suitability of the instrument to be used in collecting the empirical data for the study. A more detailed summary of the pilot study findings is included in **Appendix 7**.

4.8. Main Study Sample and Sampling Design

The basic idea of sampling is that by selecting some of the elements in a population, conclusion about the entire population may be drawn(Cooper & Schindler 2006). In order to do the sampling, the target population and the sampling technique have to be selected.

4.8.1 Defining the target Population

The unit of analysis for this study is the individual DHIS2 user either at the health facility, or at the regional health management team level and the national level. The target population of interest to the study included the facility Health Records Information Officer (HRIO) at health facility and sub-county levels; member of the sub-county and county Health Management Teams (HMT) in 47 counties in Kenya who have been trained on use of DHIS2, and Health Officers at the national level who have either been directly or indirectly trained on use of DHIS2. This target population consisted of approximately 1100 members and represented 3 distinct categories of health workers in the country which can be described as follows:

i. Data Management Team – These are the HRIOs at health facilities and sub-county levels who are primarily responsible for ensuring that routine monthly reporting of health service delivery data is conducted in a timely manner from all health facilities under their jurisdiction. The target population for this group was estimated at 800 members.
ii. Regional HMT – This group is responsible for developing health related operational plans and undertaking related health decision making in their regions. The target population among this group was estimated at 200 members.
iii. National Level Health Officers – This is a very diverse group in terms of education levels and professional orientation. However the group is stationed at the national level and uses the aggregated DHIS2 data to draw conclusions related to the programs or the MoH units under which they serve. Some of the reports they generate are in response to M&E requirements of external donors and other stakeholders. The target population for this group was estimated at about 100 members.

Only health workers associated with public health facilities of KEPH level 4 and above were targeted for inclusion in the study because these are the facilities that possess the requisite computing and internet infrastructure to access DHIS2, and whose health workers were trained on use DHIS2. The research study was conducted in

Kenya as a representative of a Developing Country context, specifically those countries in sub-Saharan Africa.

4.8.2 The Sample Size

For this study, the main consideration in determining the sample size was that it was to use structural equation modeling (SEM) in an exploratory study design. The objective was to have a large enough sample size to enable validation of the study model across the three different categories of public health workers in Kenya.

Like other statistical techniques, SEM requires an appropriate sample size in order to obtain reliable estimates of variables being analyzed. Guidelines regarding sample size estimation to allow generalizability of scientific results in this kind of study are provide by Hair et al. (2006) and include the following:

i. Sample sizes larger than 30 and less than 500 are appropriate for most research.
ii. When samples are to be divided into sub-samples, a minimum sample size of 30 for each category is necessary.
iii. In multivariate research, the sample size should be several times (at least 5 but preferably 10 times or more) as large as the number of variables in the study(J. F. Hair et al. 2006).

Chin et al recommend that when using PLS-SEM a sample size equal to the larger of two possibilities be used:

i. Ten times the number of indicators on the most formative research model constructs. This study does not use formative constructs; hence this recommendation is not directly applicable.
ii. Ten times the largest number of antecedent constructs used to determine a dependent variable. For this study this translates to ten times the five constructs used to determine behaviour intention or a minimum of 50 participants.

In addition to conducting data analysis with the entire data set collected, the research also targeted to conduct multi-group analysis across the 3 categories of health workers described in the previous section; hence each category would require to be represented by at least 50 survey respondents. To ensure that this target of 150 respondents was reached and even surpassed, the researcher distributed a total of 300 questionnaires across the 3 categories of health workers.

4.9. Data Collection Procedure

The main data collection instrument for this study was a structured questionnaire comprising a pre-formulated written set of statements adopted from Venkatesh et al. (2003) with some modifications to enable measurement for all the new constructs in the adapted acceptance model.

There are many different methods identified in literature that can be used for collection of quantitative data using a questionnaire. These include meeting face-to-face with participants, conducting telephone interviews, reaching participants through postal and electronic mail services and web-based survey completion.

This research used the self-administered survey method called drop-off whereby the researcher or their representative travels to the respondent's location and hand delivers the survey questionnaire to the respondents. The respondent is then given time to complete the questionnaire before collection by the researcher or their representative (Wilkinson & Birmingham 2003). The advantage of this kind of survey is that the survey administrator is available to answer any questions raised by the respondents and additionally he or she is able to interact directly with respondents and hence encourage them to complete the questionnaires.

To access this large number of survey participants at a reasonable cost, the researchers conducted the interviews at various DHIS2 refresher training workshops where the targeted interviewees were participating over the survey period between June and August 2014. Additionally the support of some county HRIOs was solicited

as they have access to the targeted participants at the regional level during the monthly county review meetings. Out of the 300 questionnaires distributed, 273 were returned, which represents a response rate of 91%. However five of those returned were discarded because they were only partially completed. Thus the total number of valid questionnaires returned was 269 which far surpassed the minimum acceptable sample size of 150. This number represents slightly more than 20% of the approximately 1100 health workers who have been trained on DHIS2 in Kenya, and these were drawn from at least 10 of Kenya's 47 counties to ensure a good representation of the entire country.

4.10. Preliminary Data Analysis

For this research, preliminary analysis of the quantitative data obtained from the cross-sectional survey was done used SPSS (PASW) version 18 Software Package. This is one of the softwares most commonly used by researchers in different disciplines to generate descriptive statistics (Zikmund 2003). Each question from the survey questionnaire was coded as a separate variable with a unique name which in most cases can quickly identify the type of information that the variable holds. Identification and treatment of missing data in key variables was done using SPSS before the subsequent descriptive analysis to obtain to obtain the frequencies, percentages, mean values, and standard deviations of the numeric variables. These analyses were performed for each variable separately. Additionally, this analysis was done to summarize the demographic profile of the respondents in order to get preliminary information about the measurement items used in the questionnaire, as well as overall information about the sampled population (Sekaran 2003).

Two other statistical measures obtained using SPSS (PASW) version 18for each of the 47 manifest variables used in this research's theoretical model were measures of skewness and kurtosis. These two measures are commonly used to establish the normality or non-normality of the sample distribution by identifying the shape of each numeric variable's distribution. Skewness measures the symmetry of a distribution while Kurtosis measures the peakedness of the distribution. A negative

skewness value indicates that the distribution is skewed to the left while a positive skewness value implies that the distribution is skewed to the right. The skewness for a perfectly normal distribution is zero, and any symmetric data should have skewness near zero. In practice the value of the skewness measure lies between +/- 1 and values outside this range indicate a high level of skewness in the distribution (Joanes & Gill 1998). Kurtosis measures the relative peakedness of the mean in a distribution. A high kurtosis value is associated with a high peak near the mean with a heavy tail in one direction whereas low kurtosis is associated with a flat top near the mean. Values of kurtosis outside of -4 / +4 range indicate a non-normal distribution (Joanes & Gill 1998). The normality of the distribution is a key factor for consideration when deciding on the kind of structural equation modeling that can be performed using the sample data.

4.11. Structural Equation Modelling

This study used Structural Equation Modeling (SEM) because of its general acceptance in literature in the field of behavioural science research for explaining causal relationships. SEM is a second-generation multivariate data analysis method that performs path-analytics modelling with latent or unobservable variables. It has the capacity to model complex relationships of multiple exogenous and endogenous variables, a task that cannot be achieved with first generation multivariate analysis methods such as multiple regression and analysis of variance. Using SEM data sets can be modelled based on measurements of indicators for each of the proposed variables (constructs) which the investigator is studying. SEM is capable of assessing both the reliability and the validity of the measures of the theoretical constructs, as well as estimating the relationships among the constructs (Barclay et al. 1995; Chin 1998; Chin & Newsted 1999; Fornell & Larcker 1981; Hair et al. 2011).

In an SEM path diagram, the structural model (also known as the inner model) specifies the path relationships between the constructs while the measurement model (also known as the outer model) specifies the relationships between the constructs and their observed indicators). There are two types of constructs in a

SEM: the exogenous latent variables (also known as independent variable) and the endogenous latent variables (also known as the dependent variable). In an SEM diagram, the exogenous variable has path arrows pointing outwards and is used to explain other constructs, whereas the endogenous variable has at least one path leading to it and represents the effects of other variables. A variable can technically act as either an independent variable or a dependent variable for different parts of the model depending on the SEM design.

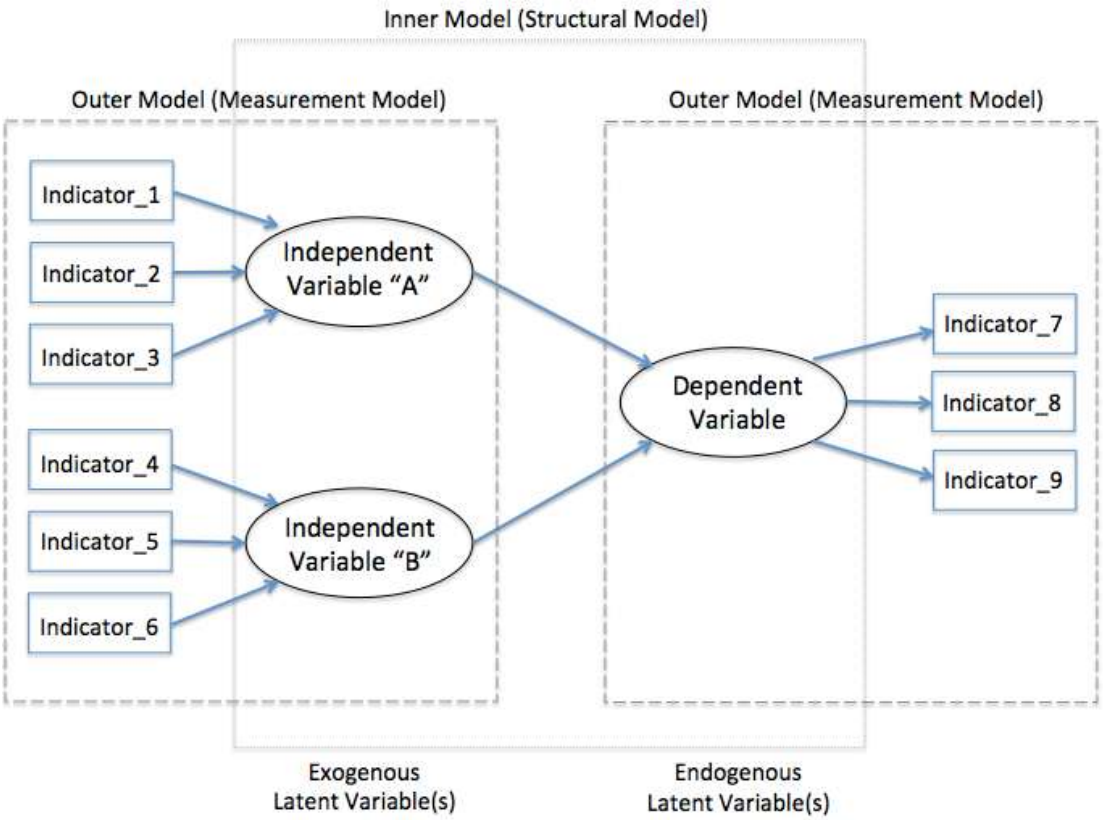


Figure 4.2 Illustration of a typical SEM diagram.

4.12. PLS SEM

SEM has two main analysis types: covariance-based analysis and the component-based analysis. The latter uses least square (LS) functions and is known as Partial Least Squares path modeling (PLS). A PLS model analyzes and interprets data in two stages: first it assesses the measurement model by examining the reliability and validity of the composite items measuring each of the constructs; subsequently it assesses the structural model.

Unlike the co-variance based SEM approach, the PLS method is less sensitive to the inaccuracies of real-world models and impurities of real data since it aims only at predictive consistency rather than at optimality in statistical inference (Falk & Nancy 1992; Barclay et al. 1995). Considering that the proposed study aimed at extending an existing theory to predict factors that influence IT acceptance and use rather than theory confirmation, PLS was the preferred SEM method to apply in this instance. In addition PLS has been successfully used by many researchers in technology acceptance and adoption studies, including by the researchers who developed the UTAUT model.

Hair et al (2011) provided some rules of thumb to aid researchers in making appropriate decisions on whether on whether to use PLS or CB SEM as the appropriate statistical method(Hair et al. 2011). These are summarized in Table 4.2.

Table 4.2 Rules of Thumb for Selecting CB-SEM or PLS-SEM
Adapted from (Hair et al. 2011)

	Use PLS-SEM...	**Use CB-SEM...**
Research Goals	• To predict key target constructs or identifying key "driver" constructs. • For Exploratory research or an extension of an existing structural theory.	• For theory testing, theory confirmation, or comparison of alternative theories
Measurement Model	• formative constructs are part of the structural model	• If error terms require additional specification, such as covariation
Structural Model	• If the structural model is complex (many constructs and many indicators.	• If the model is non-recursive
Sample Size	• If the sample size is relatively low • Notes: a) With large data sets, CB-SEM and PLS-SEM results are similar, provided that a large number of indicator	• If Your data meet the CB-SEM assumptions exactly

	variables are used to measure the latent constructs (consistency at large). b) PLS-SEM minimum sample size should be equal to the larger of the following: (1) ten times the largest number of formative indicators used to measure one construct or (2) ten times the largest number of structural paths directed at a particular latent construct in the structural model	
Data Distribution	• If the data are to some extent non-normal • If CB-SEM requirements cannot be met (e.g. model specification, identification, non-convergence, data distributional assumptions)	• For slightly more precise model estimates under normal data conditions
Model Evaluation	• If you need to use latent variable scores in subsequent analyses	• If your research requires a global goodness-of-fit criterion. • If you need to test for measurement model invariance

The cells highlighted in pink represent the main reasons why PLS-SEM was found to be most suitable statistical method for evaluation of the theoretical model in this study.

The research also followed the Systematic Process for applying PLS-SEM as recommended by Hair et al (2013) with the exception of step 5b which was not applicable in the evaluation of the purely reflective theoretical model. This process is

illustrated in figure 4.3. Details of the process components are discussed in details in the various chapters of this thesis.

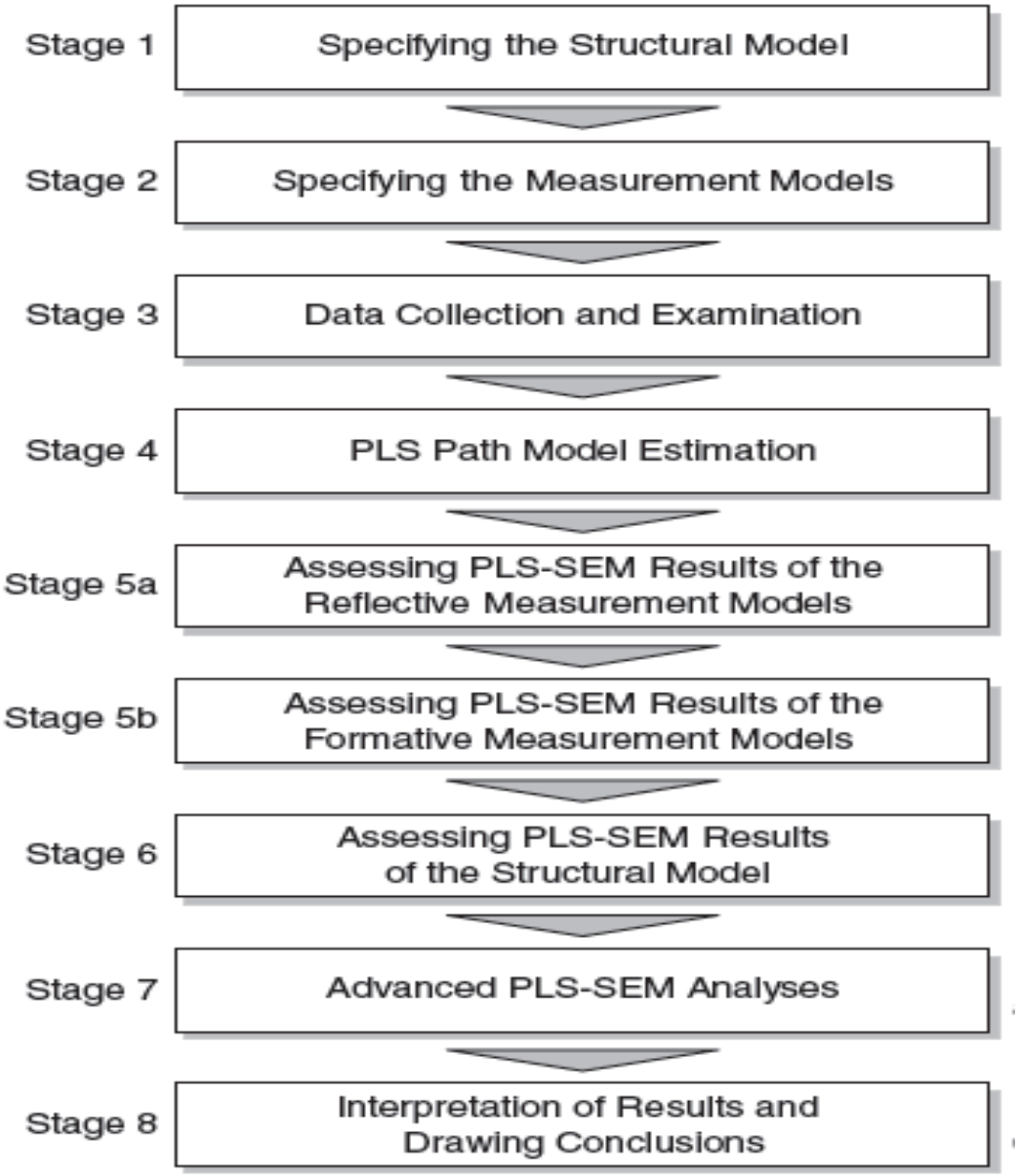


Figure 4.3 Systematic Process for applying PLS-SEM
Source: Hair et.al. (2013)

4.13. Approach to Model Validation using PLS-SEM

Applying PLS algorithm requires extensive model evaluation. This evaluation is done in two stages as recommend by Hair et al. (2006) (J. Hair et al. 2006). First the measurement model is evaluated to confirm that suitable indicators have been

selected for operationalization of the model's constructs. The types of evaluation conducted for the measurement model include tests for content validity, indicator reliability, construct reliability, convergent and discriminate validities. During this stage, any measurement item that is found to load poorly on its construct can be deleted. The second stage which involves evaluation of the structural model is only conducted once the evaluation of the measurement model has been completed with satisfactory results. PLS-SEM undertakes testing of both the measurement model and structural model simultaneously. As done in many other studies, this two-stage approach was adopted for this research

4.13.1 Assessing the Measurement Model

This sub-section describes in detail the tests undertaken in the evaluation the measurement model component of the overall study conceptual model.

Content Validity

Evaluation of content validity seeks to establish whether the research instrument provides a representative tool for measuring the intended content area as defined by the latent constructs. This includes examining the selected measurement items to determine whether they collectively capture the essence of the model's construct in a clear, easy to understand manner. Techniques for assessing content validity include literature review and expert forums or panels (Straub 1989; Cronbach 1951). Accordingly, content validity for our research instrument was assessed by literature review as well as conducting instrument pretesting using two different sets of survey respondents and subsequently holding feedback sessions with them.

Measurement Model's Reliability

Reliability is defined as the degree to which a test consistently measures what it is supposed to measure. Using PLS-SEM, reliability assessment is concerned with ensuring that the block of items selected for a given construct are suitable operationalization for that construct. Reliability of each construct is calculated separately and is independent on the reliability of the other constructs (Straub et al.

2004). For this research, two sets of measurements were obtained using SmartPLS path modeling software, and used to establish indicator reliability and the construct reliability.

(a)Indicator Reliability

The indicator reliability value for a reflective model can be obtained by squaring the outer loading of each manifest variable. A reliability value of 0.7 or higher is recommended, however in exploratory research, a value of 0.4 or higher is acceptable (Hulland 1999; Chin 1998). Generally indicators with loadings of between 0.4 and 0.7 are maintained in the model and only considered for removal if deleting them leads to improved composite reliability above recommended threshold value. It is however expected that indicators with loadings of 0.4 or lower will always be dropped from the reflective model (Hair et al. 2011).

(b)Construct Reliability

Traditionally, evaluation of the constructs' reliability is done by examining the internal consistency reliability (Cronbach's alpha). However Cronbach's alpha has been found to provide a conservative measurement when applied in PLS-SEM, so an alternative measure referred to as 'Composite Reliability' is recommended instead (Hair & Sarstedt, M., Ringle, C.M. & Mena 2012; Bagozzi & Yi 1988). For this study both values were measured (Fornell & Larcker 1981; Nunnally 1978).

Construct Validity

Construct validity is concerned with ensuring that the measurement items selected for a given construct do indeed collectively provide a reasonable operationalization of the construct. Using PLS-SEM reflective indicators, the construct validity focuses on convergent validity and discriminant validity, and these two were used to examine our measurement model.

(a)***Convergent Validity***

Convergent validity was measured by examining the factor loadings of the measurement indicators (manifest variables) of the model's constructs. Convergent

validity is displayed when the items load more highly on their pre-defined underlying constructs than on any other construct, and when the value of each latent variable's Average Variance Extracted (AVE) is at least 0.5 (Bagozzi & Yi 1988; Fornell & Larcker 1981). AVE is the measure of the variance shared between a construct and its measures, and this value should be greater that than the variance shared between the construct and other constructs.

(b)Discriminant Validity

A highly reliable measurement instrument is also expected to exhibit discriminant validity, which measures the extent to which constructs differ from each other. Adequate discriminant validity is demonstrated when a construct shares more variance with its measurement variables than with other constructs in the model. According to the Fornell-Larcker criterion, discriminant validity is confirmed when the AVE of each latent construct is higher than the construct's highest squared correlation with any other latent construct (Fornell & Larcker 1981). This is equivalent to comparing the square root of the AVE with the absolute values of the correlations between each construct and all the other constructs in the model. Adequate discriminant validity is confirmed if the diagonal elements are greater than the off-diagonal elements in the corresponding rows and columns

4.13.2 Assessing the Structural Model

The structural model covers relationships between the constructs, and these relationships are hypothesized in accordance with the researcher's theoretical and logical reasoning. The ultimate purpose of the study is to assess the causal or predictive relationships between the constructs, and subsequently confirm or disconfirm the study's conceptual model and the study hypotheses. The strength of these relationships is demonstrated by the amount of variance explained (R^2) in the endogenous variables as well as the inner model's path coefficient sizes, direction and significance (Chin 1998). Unlike covariance based SEM, PLS does not allow for statistical tests to measure the model's overall goodness of fit as it is based on the

assumption of distribution free variance This sub-section discusses the four key measures used to evaluate the structural model in this and other related studies.

Coefficient of Determination, R^2

The Coefficients of Determination of the exogenous variables are used to assess the predictive power of the structural model. R^2 is a normalized term whose value can range from 0 to 1. While there are no hard and fast rules about the acceptable threshold value, the larger the R^2 the larger the proportion of variance explained. According to Chin (1998) R^2 of 0.670 is substantial, 0.333 is average and 0.190 and lower is weak (Chin 1998).

Path Coefficient (β)

The individual path coefficients of the PLS structural model indicate the direction and strength of the relationships between latent variables. These can be interpreted as standardized beta coefficients of ordinary least squares regressions. Each path coefficient's significance can be assessed by means of a bootstrap procedure which is used to generate the corresponding T-statistics. Paths that are non-significant or show signs contrary to the hypothesized direction fail to support the a priori hypothesis, whereas significant paths showing the hypothesized direction empirically support the proposed causal relationship. There is a general suggestion that the magnitude of standardized path coefficient has to be more than 0.1 if a significant path relationship exists between the variables (Hair et al. 2011).

Effect Size, f^2

Effect size assesses the substantive impact of each independent construct on the dependent constructs. $\mathbf{f^2}$ is calculated as the change in the dependent variable's coefficient of determination, with and without the independent latent variable, relative to its unexplained variance. Values for f^2 of 0.02, 0.15, or 0.35 indicate the latent exogenous variable's weak, moderate or substantial influence on the particular latent endogenous variable (Chin 1998; Cohen 1988). The formula for calculating f^2 is given as:

$$f^2 = [R^2 \text{ (included)} - R^2 \text{ (excluded)}] / 1 - R^2 \text{ (included)}]$$

4.14. Overall Data management and quality assurance

Quality assurance procedures were applied throughout the data collection and management processes. To ensure quality in the collection process, the actual data collection was conducted primarily by the principal researcher, but the service of a few research assistants was also engaged to ease and hasten the process. A self-administered instrument in print format was physically handed to each respondent. The respondents were instructed not to put any personal identifiers on the questionnaire. Where the services of research assistants were employed, the researcher supervised the process closely to ensure good data collection practices.

Before data entry was initiated, all the returned questionnaires were screened by checking and adjusting for obvious errors, omissions, legibility and consistency in order to ensure its completeness and consistency. Data entry and management was undertaken using Epi Data application, with customized data entry screens that had in-built range and consistency checks. Questionnaires data was entered and completed data files compared for entry errors. Additionally, randomly sampled forms were double-entered by independent data entry clerks and completed data files compared for errors. Once stored, the data was pass-word protected and backed-up on alternative secure storage media. A copy of the data entered was exported to SPSS for further manipulation and analysis, but the original data entered was maintained intact for backup and future reference.

4.15. Ethical considerations

Before the survey was initiated, authority to conduct research in Kenya was sought and received from the Kenya National Council of Science and Technology (NCST). Ethical clearance was also obtained from the Kenyatta National Hospital (KNH)/ University of Nairobi (UoN) Ethics Review committee, as this study involved interviewing of human subjects. Additionally approval to conduct research in the

Health Ministry was obtained from the Director of Medical Services (DMS) at the National Level. Approval from relevant authorities that organized the workshops during which the participants were interviewed was also sought and received – the organizer was mostly the Division of Health Information Systems (DHIS). Where relevant, notification was also made to all relevant stakeholders in this process such as the sub-county directors of Health. Samples of these approval documents are contained in **Appendices 1 – 3**.

During the survey and prior to the interviews, all the targeted interviewees were provided with information summarizing the study objectives and requesting them to complete the survey. Additionally, clarification was provided to the effect that the interviews were not part of a supervision process, and that individual performances of the interviewees would not be judged or reported in a way that could be traced back to them. Participants were required to sign an informed consent form confirming their voluntary participation in the study.

Chapter 5: RESULTS & DISCUSSION

5.1 Introduction

This chapter presents details of the data analysis and results that were obtained. Though the primary focus of the data analysis was at the individual level and for the full data set model, additionally the data was separated into three health worker categories of interest and multi-group analysis done for comparison purposes. Subsequent sections present the results of the structural equation modelling analysis, first done for the measurement model level and then for the structural model. This is discussed initially for the full dataset and subsequently for the 3 health worker categories data sets. Additionally the impact of interaction with the proposed moderators of gender and age is also analyzed. All the proposed hypotheses are then evaluated against the results obtained to reach a conclusion on whether there was evidence to support them or not.

5.2 Data Sample and Categories

In the main phase the study, the finalized questionnaire was administered to health workers through a cross-sectional survey both at national and county / sub-county levels. The target population consists in the main phase of the study consisted of approximately 1100 health workers who had previously been trained or sensitized on the use of the DHIS2. This population was distributed across national, county and sub-county levels of the Kenya health system and can be broadly divided into distinct categories as discussed below

i. Data Management Team – This first category consists of Health Records Information Officers (HRIOs) at health facilities and sub-county levels. This group is primarily responsible for ensuring that routine monthly reporting of health service delivery data is conducted in a timely manner from all health facilities under their jurisdiction. The group made up the largest proportion of the target population, with approximately 800 members.

ii. Regional HMT – This category of health workers is found at the county and sub-county levels, and it is responsible for developing health related strategies and operational plans, as well as undertaking important health decision making at their levels. The group had about 200 members represented in the target population.

iii. National Level Health Officers – This last category is a very diverse group in terms of education levels and professional orientation. However all its members are stationed at the national level and use the aggregated DHIS2 data to draw conclusions related to the programs or the MoH units under which they serve. Some of the reports they generate are in response to M&E requirements of external donors and other stakeholders. The group had about 100 members eligible for inclusion in the study.

The study was designed in such a way as to ensure that at least 50 respondents were drawn from each of these categories of health workers as this is the minimum number recommended for use in PLS-SEM analysis of a model with the level of complexity represented in our conceptual model. Out of the total 300 questionnaires distributed in the survey, 273 responses were received resulting in a high response rate of 91%. Four of the responses were however disqualified because the questionnaires were only partially completed. Thus a total of 269 valid responses were available for use in the data analysis. This number represents approximately 24% of the target population, and the respondents were drawn from at least 10 of Kenya's 47 counties to ensure a good representation of the entire country. Figure 5.1 shows the distribution of the valid responses across the identified health workers' categories and gender.

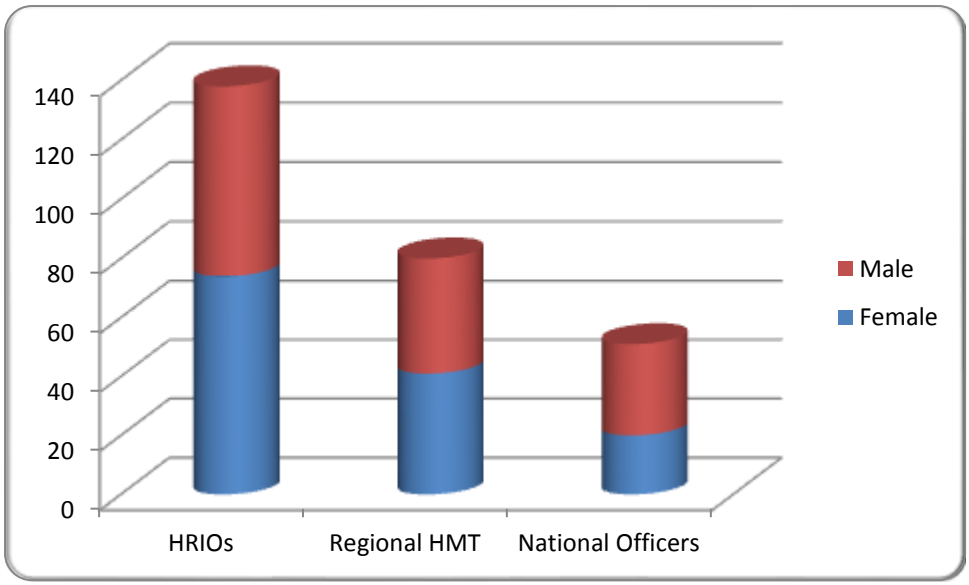


Figure 5.1Distribution of Respondents across categories and gender

5.3 Detailed Respondents Characteristics

Full Data Set

Examination of the full data set consisting of 269 valid responses showed that the two genders were represented equally well with 50.2% being female and 49.8% male respondents. The majority of the respondents (62%) were in the 30 – 49 years age bracket, while only 11.5% were in the over 50 years age bracket. The majority of the respondents had reached fairly low education levels with 53.9% being educated only up to diploma level. Professionally, 66.9% of the respondents are Health Records Information Officers while only 4.1% identified themselves as doctors.

Category-wise Analysis

The distribution of the demographics described above changed substantially when the data was broken down into the 3 distinct categories of health workers identified in the study. For example 97.1% of the Data Management group was made up of HRIOs and72.5% of respondents in this group were educated only up to diploma level. In contrast, Over 80% of the National Level group were holders of a University degree, and this is despite the fact that the group had 47.1% of its members who identified themselves as HRIOs professionally. Below is the complete table showing these demographic characteristics.

Table 5.1Respondents' Characteristics

		Full Dataset		HRIOs (Facility&Subcounty)		Regional HMT		National Officers	
		Freq	Percent	Freq	Percent	Freq	Percent	Freq	Percent
Gender	Female	135	50.2	74	53.6	41	51.3	20	39.2
	Male	134	49.8	64	46.4	39	48.8	31	60.8
	Totals	269	100.0	138	100.0	80	100.0	51	100.0
Age Category	20-29	70	26.0	48	34.8	11	13.8	11	21.6
	30-39	82	30.5	39	28.3	26	32.5	17	33.3
	40-49	86	32.0	39	28.3	28	35.0	19	37.3
	More than 50	31	11.5	12	8.7	15	18.8	4	7.8
	Totals	269	100.0	138	100.0	80	100.0	51	100.0
Education Level	High School	4	1.5	3	2.2	1	1.3	0	0
	Diploma	145	53.9	97	70.3	40	50.0	8	15.7
	Bachelors Degree	62	23.0	18	13.0	28	35.0	16	31.4
	Masters Degree	35	13.0	0	0	10	12.5	25	49.0
	PhD	1	.4	0	0	0		1	2.0
	Other	22	8.2	20	14.5	1	1.3	1	2.0
	Totals	269	100.0	138	100.0	80	100.0	51	100.0
Profession	HRIO	180	66.9	134	97.1	22	27.5	24	47.1
	Doctor	11	4.1	0	0	4	5.0	7	13.7
	Nurse	22	8.2	1	.7	21	26.3	0	0
	PHO	17	6.3	1	.7	12	15.0	4	7.8
	Pharmacist	5	1.9	0	0	3	3.8	2	3.9
	Clinical Officer	12	4.5	0	0	11	13.8	1	2.0
	Other	22	8.2	2	1.4	7	8.8	13	25.5
	Totals	269	100.0	138	100.0	80	100.0	51	100.0

5.4 Access to ICT Infrastructure and DHIS2

Analysis of five other questions posed to the respondents to assess their access to computer and internet infrastructure as well as the function they most commonly use in DHIS2 generated the statistics given in Table 5.2. Based on this, it was evident that National Level group was more privileged when it comes to access to ICT infrastructure. The majority in the other groups thought the internet access provided at their work place was inadequate, yet this is the place where they mostly access DHIS2. Nevertheless ownership of computers among the other categories was also high, most likely because of the MoH and partners' initiatives to provide health workers with these equipment.

Table 5.2 Access to ICT Infrastructure and DHIS2 by Category of Health Workers

		Full Dataset		**HRIOs**		**Regional HMT**		**National Officers**	
		Freq	Percent	Freq	Percent	Freq	Percent	Freq	Percent
Computer Owner?	NO	45	16.7	25	18.1	16	20.0	3	5.9
	YES	224	83.3	113	81.9	64	80.0	48	94.1
	Totals	269	100	138	100	80	100	51	100
Accesses Internet mostly via:	Never Use	3	1.1	2	1.4	1	1.3	0	.0
	ISP Network	93	34.6	36	26.1	18	22.5	39	76.5
	Mobile Provider's Modem	146	54.3	87	63.0	49	61.3	10	19.6
	CyberCafe	8	3.0	3	2.2	5	6.3	2	3.9
	Other	19	7.1	10	7.2	7	8.8	51	100.0
	Totals	269	100	138	100	80	100		
Internet Access at Workplace is:	ENOUGH	49	18.2	15	10.9	7	8.8	27	52.9
	NOT ENOUGH	215	79.9	121	87.7	72	90.0	22	43.1
	TOO MUCH	5	1.9	2	1.4	1	1.3	2	3.9
	Totals	269	100	138	100	80	100	51	100
Accesses DHIS2 mostly at the:	Never Use	12	4.5	5	3.6	6	7.5	1	2.0
	Home	13	4.8	5	3.6	8	10.0	0	0
	Office	231	85.9	122	88.4	59	73.8	50	98.0
	CyberCafe	7	2.6	2	1.4	5	6.3	0	.0
	Other	6	2.2	4	2.9	2	2.5	0	.0

	Totals	269	100	138	100	80	100	51	100
DHIS2 Function most frequently used is:	None	12	4.5	5	3.6	5	6.3	2	3.9
	Data Entry	115	42.8	88	63.8	23	28.8	4	7.8
	Standard Reports	111	41.3	36	26.1	43	53.8	32	62.7
	Advanced Reports	31	11.5	9	6.5	9	11.3	13	25.5
	Totals	269	100	138	100	80	100	51	100

It is apparent that the group at the national level is more advantaged when it comes to ease of access to ICT infrastructure. Additionally they seem to be at ease with use of DHIS2 as they are the ones most likely to use the advanced reporting function of DHIS2. Some of these findings are illustrated graphically in figure 5.2.

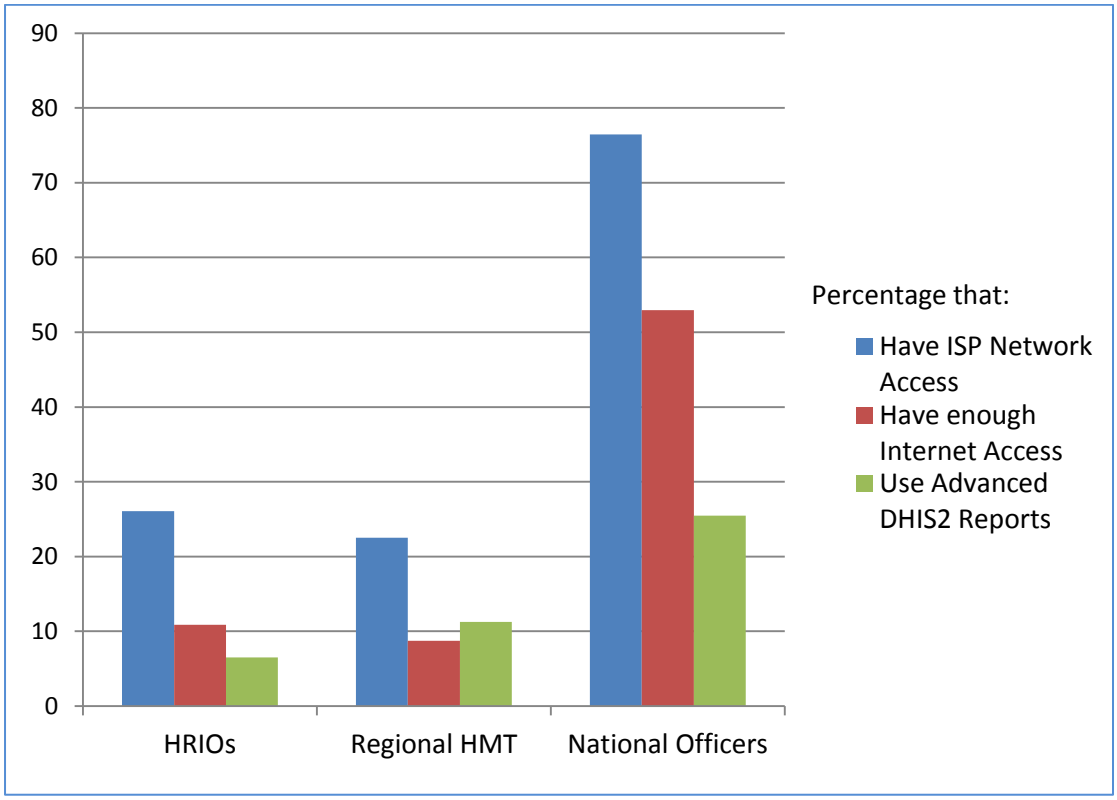


Figure 5.2 Indicators of Access to ICT Infrastructure

5.5 Preliminary Analysis of the Model Variables

The data was examined PASW version 18 software (commonly known as SPSS for basic statistics. Table 5.3 provides the item descriptions and the mean, standard

deviation, skewness, and kurtosis of all the 47 manifest variables (indicators) measured in this phase and subsequently used to evaluate the study's conceptual model.

Table 5.3 Descriptive Statistics for the Model's Variables

Measurement Items (Indicators) n=269	Mean	Std. Deviation	Skewness Std. Error = .149	Kurtosis Std. Error = .296	Construct Definition
PE1:Using DHIS2 will enable me to accomplish tasks more quickly	6.29	.925	-2.089	6.950	**Performance Expectancy (PE):** – the degree to which an individual believes that using DHIS2 will enable him or her to attain gains in job performance
PE2:Using DHIS2 will allow me to accomplish more work than would otherwise be possible	6.13	.988	-1.705	4.578	
PE3:DHIS2 will enable me to make work related decisions based on better evidence	6.22	.885	-1.647	4.920	
PE4: If I use DHIS2, I will increase my chances of getting a promotion.	3.42	2.009	.240	-1.336	
PE5: Overall, I would find DHIS2 useful in my job.	6.33	.930	-2.081	6.096	
EE1: My interaction with DHIS2 is or would be clear and understandable.	5.84	1.026	-1.492	3.851	**Effort Expectancy (EE):** the degree of ease of use associated with the use of DHIS2
EE2: It would be easy for me to become skilful at using DHIS2.	5.95	1.167	-1.713	3.558	
EE3 Learning to operate DHIS2 is easy for me	5.61	1.178	-1.189	1.487	
EE4 Overall, I would find DHIS2 easy to use	5.77	1.167	-1.280	1.830	
ANX1. I feel nervous about using computer systems	1.76	1.298	2.006	3.386	**Computer Anxiety (ANX):** the degree to which anxious or emotional reactions are evoked when using computer technology
ANX2 It scares me to think I could cause loss of data in the system by hitting the wrong key	2.07	1.420	1.466	1.142	
ANX3 I would hesitate to use DHIS2 for fear of making mistakes I cannot correct	1.83	1.227	1.898	3.423	
ANX4r. The challenge of learning about computers is exciting.	3.37	2.206	.500	-1.322	
ANX5 DHIS2 is somewhat intimidating to me	1.79	1.118	1.734	2.768	
ANX6r I look forward to using a computer.	2.12	1.814	1.861	2.208	
ANX7r I am able to keep up with important technological advances in computers.	2.23	1.185	1.219	1.476	
ANX8 I feel nervous when using internet-based applications	1.92	1.424	1.732	2.250	
SI1: People who are important to me think	5.42	1.587	-.926	.115	**Social Influence**

that I should use DHIS2					**(SI):**the degree to which an individual perceives that his or her peers, supervisors, and important others believe he or she should use DHIS2
SI2: My colleagues think that I should use DHIS2.	5.70	1.467	-1.276	1.094	
SI3: The senior management has been supportive in the use of DHIS2 at my duty station	5.49	1.421	-.951	.388	
SI4: In general, use of DHIS2 has been supported and encouraged at my duty station	5.77	1.276	-1.193	1.340	
FC1: I have the resources (e.g. reporting forms, computer, antivirus, etc) necessary to use DHIS2	4.19	1.999	-.239	-1.313	**Facilitating Conditions (FC):** the degree to which an individual believes an organizational or technical infrastructure exist to support use of DHIS2
FC2: Access to the Internet is available any time I want to use DHIS2	4.02	1.682	.254	-1.227	
FC3: I have the knowledge necessary to use DHIS2.	5.45	1.244	-1.194	1.480	
FC4: DHIS2 is compatible with other systems that I use at my work.	5.03	1.281	-.582	-.199	
FC5: DHIS2 experts are available for assistance with DHIS2 difficulties	4.42	2.003	-.388	-1.177	
FC6: I have knowledge sources (e.g. books, documents, consultants) to support my use of DHIS2	4.72	1.531	-.351	-.950	
FC7: I think that using DHIS2 fits well with the way I like to work	5.46	1.016	-.709	.339	
TA1: The training received on DHIS2 is very helpful in my use of the system	5.71	1.393	-1.267	1.172	**Training Adequacy (TA):** the degree to which an individual believes that the training he or she received is enough to enable him or her use DHIS2 effectively
TA2: I have training reference documents that I can consult in my use of DHIS2	4.71	2.071	-.620	-1.090	
TA3: I feel the training received is adequate for my efficient use of DHIS2	5.00	1.520	-.572	-.571	
TA4r: I need further training on DHIS2 to enable me use the system efficiently	1.93	1.421	2.094	4.125	
TA5: My training on basic use of computers is adequate for using DHIS2	5.31	1.414	-.862	.162	
TA6: The DHIS2 training was well organized and easy to follow	5.23	1.409	-.841	.075	
TA7r:I need some further training on Internet and the World Wide Web to enable me use DHIS2 efficiently	2.98	1.982	.776	-.730	
VO1. Although it might be helpful, using DHIS2 is not compulsory in my job (i.e. my use of DHIS2 would be voluntary)	3.03	2.127	.566	-1.236	**Voluntariness of Use (VO):** the degree to which an individual believes that his or her use of DHIS2 is voluntary
VO2r My use of DHIS2 would be for mandatory routine reporting	3.17	2.146	.517	-1.281	
VO3. My use of DHIS2 would be for voluntary analysis of the health	3.82	2.152	.079	-1.542	

facility/sub-county data for informed decision making					
BI1: I intend to use [or continue using] DHIS2 in the next 3 months.	5.97	1.304	-1.501	1.685	**Behavioural Intention (BI):** the degree to which an individual intends to use DHIS2
BI2: I predict I will use [or continue using] DHIS2 in the next 3 months.	5.90	1.304	-1.418	1.628	
BI3: I plan to use [or continue using] DHIS2 when I have access to computer and internet	5.91	1.294	-1.462	1.695	
Exp1: For how long have you been using a computer?	6.51	.751	-1.961	5.863	**Technology Experience (Exp):** the duration of past use of computer and internet; and the current frequency of using both.
Exp2: Approximately how many hours per week do you use a computer?	6.21	1.027	-1.225	.876	
Exp3. How long have you been using the Internet?	6.40	.886	-2.037	6.314	
Exp4: Currently, how often do you use the Internet?	5.68	.709	-3.297	14.965	
UB1: On average, how often do you use DHIS2?	4.91	1.690	-.506	-.395	**Use Behaviour (UB):** The current frequency of using DHIS2; and the average duration of each use session.
UB2: When you do use DHIS2, on average how much time do you spend on the system?	4.67	1.390	-1.064	.505	

Note: All the manifest variables were measured on a 7-Point scale except for Exp4 and UB2 which were measured on a 6-Point Scale

Most statistical analysis procedures are based on the assumption of normally distributed data whereby the observations are arranged equally and symmetrically around the mean. Two statistical measures commonly used to establish the shape of sample distribution are skewness and kurtosis. Skewness measures the symmetry of a distribution while Kurtosis measures the peakedness of the distribution.

A negative skewness value indicates that the distribution is skewed to the left while a positive skewness value implies that the distribution is skewed to the right. The skewness for a perfectly normal distribution is zero, and any symmetric data should have skewness near zero. In practice the value of the skewness measure lies between +/- 1 and values outside this range indicate a high level of skewness in the distribution (Joanes & Gill 1998).

Kurtosis measures the relative peakedness of the mean in a distribution. The high kurtosis value is associated with a high peak near the mean with a heavy tail in one direction whereas low kurtosis is associated with a flat top near the mean. Values of kurtosis outside of -4 / +4 range indicate a non-normal distribution (Joanes & Gill 1998).

Based on these definitions of skewness and kurtosis, it is apparent that the distribution of data for some of the manifest variables is non-normal. As an example, figure 5.3 illustrates the distribution of the first indicator, PE1, and this is representative of the distribution of several other indicators in the study. The phenomenon on non-normal data distribution is typical in some other studies of technology acceptance (Chin et al. 2003; Compeau et al. 1999). Unlike covariance based SEM, PLS path modeling does not assume normal distribution of variables data and has the capacity to model latent constructs under non-normal condition. PLS-SEM is thus more suited for analysis of this study's data.

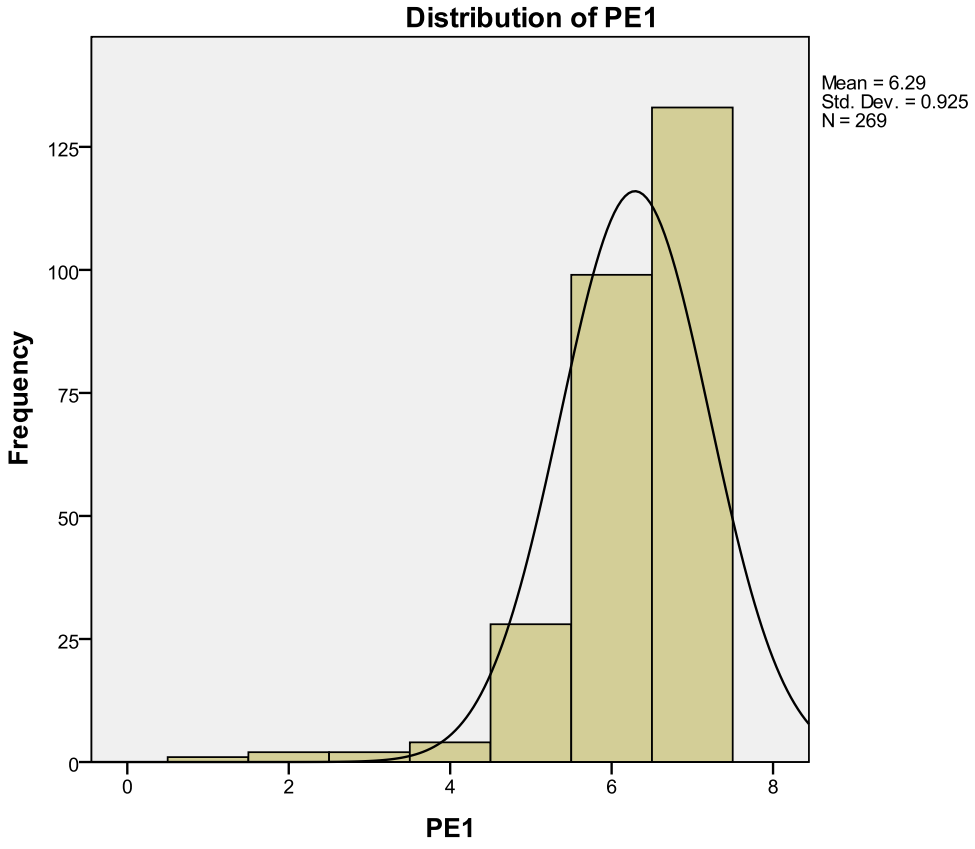


Figure 5.3 Non-normal Distribution of PE1 Variable

5.6 Measurement Model Reliability

Reliability is defined as the degree to which a test consistently measures what it is supposed to measure. Using PLS-SEM, reliability assessment is concerned with ensuring that the block of items selected for a given construct are suitable operationalization for that construct. Reliability of each construct is calculated separately and is independent on the reliability of the other constructs (Straub et al. 2004). For this research, two sets of measurements were obtained using SmartPLS path modeling software, and used to establish indicator reliability and the construct reliability.

- Indicator Reliability

The indicator reliability value for a reflective model can be obtained by squaring the outer loading of each manifest variable. A reliability value of 0.7 or higher is recommended, however in exploratory research, a value of 0.4 or higher is acceptable (Hulland 1999; Chin 1998). Generally indicators with loadings of between 0.4 and 0.7 are maintained in the model and only considered for removal if deleting them leads to improved composite reliability above recommended threshold value. It is however expected that indicators with loadings of 0.4 or lower will always be dropped from the reflective model (Hair et al. 2011). For our model, it was necessary to drop one performance expectancy indicator (PE4), two computer anxiety indicators (ANX4r and ANX6r), two facilitating condition indictors (FC1 and FC5); and three training adequacy indicators (TA2, TA4r and TA7r) in order to achieve the recommended level of indicator reliability.

- Construct Reliability

Traditionally, evaluation of the constructs' reliability is done by examining the internal consistency reliability (Cronbach's alpha). However Cronbach's alpha has been found to provide a conservative measurement when applied in PLS-SEM, so an alternative measure referred to as 'Composite Reliability' is recommended instead (Hair & Sarstedt, M., Ringle, C.M. & Mena 2012; Bagozzi & Yi 1988). For this study we measured both values and, as represented in table 2, after dropping some items

to achieve indicator reliability, measures of both composite reliability and Cronbach's alpha were higher than the recommended minimum level of 0.7 indicating a highly reliable measurement instrument (Fornell & Larcker 1981; Nunnally 1978).

Table 5.4 Full Dataset Model's Reliability and Validity Measures

Latent Variable	Indicators	Loadings	Indicator Reliability (= Loadings2)	Composite Reliability	Cronbach's Alpha	AVE
Behavioural Intention	BI1	0.967	0.935			
	BI2	0.959	0.919			
	BI3	0.928	0.862	0.966	0.948	0.905
Computer Anxiety	ANX1	0.827	0.683			
	ANX2	0.797	0.636			
	ANX3	0.833	0.694			
	ANX5	0.732	0.536			
	ANX7R	0.772	0.596			
	ANX8	0.749	0.562	0.906	0.876	0.618
Effort Expectancy	EE1	0.855	0.731			
	EE2	0.866	0.750			
	EE3	0.812	0.659			
	EE4	0.876	0.768	0.914	0.876	0.727
Facilitating Conditions	FC2	0.663	0.439			
	FC3	0.821	0.674			
	FC4	0.727	0.528			
	FC6	0.787	0.619			
	FC7	0.727	0.529	0.863	0.8023	0.558
Performance Expectancy	PE1	0.878	0.771			
	PE2	0.902	0.813			
	PE3	0.848	0.718			
	PE5	0.873	0.761	0.929	0.898	0.766
Social Influence	SI1	0.823	0.677			
	SI2	0.831	0.690			
	SI3	0.788	0.621			
	SI4	0.831	0.691	0.890	0.836	0.670
Technology Experience	Exp1	0.870	0.757			
	Exp2	0.753	0.567			
	Exp3	0.914	0.836			
	Exp4	0.799	0.638	0.903	0.855	0.700
Training Adequacy	TA1	0.848	0.718			
	TA3	0.815	0.665			
	TA5	0.796	0.633			
	TA6	0.867	0.752	0.900	0.854	0.692
Use Behaviour	UB1	0.928	0.860			
	UB2	0.902	0.813	0.911	0.806	0.837

Voluntariness	VO1	0.950	0.903			
	VO2r	0.956	0.913			
	VO3	0.886	0.785	0.951	0.925	0.867

5.7 Construct Validity

Construct validity is concerned with ensuring that the measurement items selected for a given construct do indeed collectively provide a reasonable operationalization of the construct. Using PLS-SEM reflective indicators, the construct validity focuses on convergent validity and discriminant validity, and these two were used to examine our measurement model.

Convergent Validity

The convergent validity was measured by examining the factor loadings of the measurement indicators (manifest variables) on the model's constructs. Convergent validity is displayed when the items load more highly on their pre-defined underlying constructs than on any other construct, and when the value of each latent variable's Average Variance Extracted (AVE) is at least 0.5 (Bagozzi & Yi 1988; Fornell & Larcker 1981). AVE is the measure of the variance shared between a construct and its measures, and this value should be greater that than the variance shared between the construct and other constructs. The measurement instrument in this study exhibited a high level of convergent validity with all manifest variables loading more highly on their associated constructs than on unrelated constructs. All the latent constructs AVE were also greater than the 0.5 threshold as shown in table 5.4.

Discriminant Validity

A highly reliable measurement instrument should also exhibit discriminant validity, which measures the extent to which constructs differ from each other. Adequate discriminant validity is demonstrated when a construct shares more variance with its measurement variables than with other constructs in the model. According to the Fornell-Larcker criterion, discriminant validity is confirmed when the AVE of each latent construct is higher than the construct's highest squared correlation with any

other latent construct (Fornell & Larcker 1981). This is equivalent to comparing the square root of the AVE with the absolute values of the correlations between each construct and all the other constructs in the model. In table 5.5, the diagonal elements are the square-root of AVE while the off-diagonal elements in the corresponding rows and columns represent the absolute values of the correlations between the constructs. Adequate discriminant validity is confirmed if the diagonal elements are greater than the off-diagonal elements in the corresponding rows and columns

Table 5.5 Discriminant Validity of the Full Dataset Model

	B.I.	**C.A.**	**E.E.**	**F.C.**	**P.E.**	**S.I.**	**T.E.**	**T.A.**	**U.B.**	**Vol**
Behavioural Intention **(BI)**	**0.952**									
Computer Anxiety **(Anx)**	0.172	**0.786**								
Effort Expectancy **(EE)**	0.414	0.242	**0.852**							
Facilitating Conditions **(FC)**	0.217	0.276	0.413	**0.747**						
Performance Expectancy **(PE)**	0.406	0.150	0.609	0.250	**0.875**					
Social Influence **(SI)**	0.492	0.044	0.449	0.352	0.446	**0.818**				
Technology Exp. **(Exp)**	0.104	0.322	0.025	0.236	0.067	0.007	**0.836**			
Training Adequacy **(TA)**	0.350	0.248	0.485	0.583	0.420	0.383	0.134	**0.832**		
Use Behaviour**(UB)**	0.199	0.307	0.198	0.419	0.205	0.184	0.387	0.449	**0.915**	
Voluntariness **(Vol)**	0.121	0.085	0.092	0.142	0.128	0.207	0.057	0.191	0.304	**0.931**

An alternative way of assessing discriminant validity is by comparing an indicator's loading with its associated latent construct with its loading on all remaining constructs. The latter is referred to as 'cross-loading'. Discriminant validity is established when an indicator's loading on a construct is higher than all of its cross loadings with other constructs, and this was confirmed to be the case for all the indicators in our research model. This is illustrated in table 5.6. The bold values are loadings on corresponding constructs, and as recommended they are all above 0.5.

Table 5.6Loadings and Cross-Loadings of the Measurement Items

	BI	ANX	EE	FC	PE	SI	EXP	TA	UB	VO
ANX1	-0.175	**0.827**	-0.239	-0.167	-0.205	-0.043	-0.334	-0.134	-0.219	0.071
ANX2	-0.098	**0.797**	-0.143	-0.206	-0.063	0.001	-0.282	-0.199	-0.182	0.030
ANX3	-0.098	**0.833**	-0.187	-0.228	-0.071	-0.030	-0.257	-0.208	-0.312	0.095
ANX5	-0.137	**0.732**	-0.191	-0.185	-0.140	-0.076	-0.201	-0.168	-0.275	0.105
ANX7R	-0.156	**0.772**	-0.223	-0.357	-0.141	-0.070	-0.232	-0.270	-0.246	0.078
ANX8	-0.156	**0.749**	-0.148	-0.156	-0.075	0.024	-0.193	-0.205	-0.199	0.004
BI1	**0.967**	-0.188	0.415	0.229	0.409	0.485	0.116	0.360	0.201	-0.133
BI2	**0.959**	-0.181	0.417	0.205	0.378	0.470	0.137	0.349	0.223	-0.112
BI3	**0.928**	-0.118	0.345	0.183	0.370	0.447	0.036	0.286	0.139	-0.097
EE1	0.386	-0.226	**0.855**	0.302	0.593	0.388	0.005	0.464	0.199	-0.091
EE2	0.400	-0.124	**0.866**	0.315	0.567	0.447	-0.008	0.359	0.153	-0.039
EE3	0.303	-0.285	**0.812**	0.406	0.427	0.300	0.049	0.414	0.142	-0.090
EE4	0.300	-0.213	**0.876**	0.414	0.455	0.376	0.054	0.420	0.179	-0.104
Exp1	0.065	-0.275	-0.003	0.135	-0.086	-0.036	**0.870**	0.108	0.290	0.016
Exp2	0.083	-0.235	-0.020	0.274	-0.050	0.001	**0.753**	0.097	0.340	-0.120
Exp3	0.138	-0.299	0.057	0.188	-0.076	0.026	**0.914**	0.086	0.306	-0.002
Exp4	0.056	-0.264	0.042	0.206	-0.006	-0.018	**0.799**	0.161	0.368	-0.101
FC2	0.156	-0.172	0.186	**0.663**	0.055	0.149	0.205	0.340	0.254	-0.069
FC3	0.132	-0.261	0.298	**0.821**	0.154	0.275	0.250	0.522	0.415	-0.140
FC4	0.189	-0.247	0.320	**0.727**	0.166	0.283	0.134	0.300	0.221	-0.036
FC6	0.138	-0.136	0.357	**0.787**	0.201	0.284	0.161	0.518	0.327	-0.087
FC7	0.226	-0.215	0.385	**0.727**	0.359	0.321	0.106	0.429	0.291	-0.170
PE1	0.301	-0.125	0.509	0.167	**0.878**	0.353	-0.079	0.329	0.168	-0.099
PE2	0.381	-0.112	0.550	0.232	**0.902**	0.391	-0.052	0.408	0.167	-0.097
PE3	0.353	-0.152	0.527	0.268	**0.848**	0.367	-0.028	0.380	0.192	-0.129
PE5	0.375	-0.136	0.540	0.200	**0.873**	0.442	-0.077	0.347	0.188	-0.122
SI1	0.391	0.059	0.371	0.217	0.386	**0.823**	-0.136	0.260	0.053	-0.189
SI2	0.420	0.007	0.366	0.179	0.426	**0.831**	-0.079	0.284	0.079	-0.152
SI3	0.365	-0.087	0.377	0.394	0.262	**0.788**	0.098	0.364	0.231	-0.206
SI4	0.430	-0.120	0.360	0.371	0.375	**0.831**	0.095	0.350	0.242	-0.137
TA1	0.302	-0.205	0.515	0.514	0.487	0.362	0.071	**0.848**	0.418	-0.199
TA3	0.231	-0.129	0.386	0.553	0.280	0.254	0.102	**0.815**	0.346	-0.145
TA5	0.354	-0.269	0.317	0.385	0.297	0.298	0.144	**0.796**	0.332	-0.101
TA6	0.237	-0.187	0.399	0.521	0.313	0.352	0.120	**0.867**	0.399	-0.205

UB1	0.162	-0.281	0.189	0.429	0.191	0.166	0.351	0.476	**0.928**	-0.320
UB2	0.207	-0.280	0.173	0.332	0.183	0.173	0.358	0.336	**0.902**	-0.229
VO1	-0.124	0.106	-0.108	-0.144	-0.143	-0.193	-0.050	-0.214	-0.338	**0.950**
VO2R	-0.125	0.045	-0.099	-0.156	-0.140	-0.227	-0.057	-0.185	-0.267	**0.956**
VO3	-0.075	0.093	-0.030	-0.077	-0.048	-0.141	-0.052	-0.112	-0.226	**0.886**

5.8 Structural Model Evaluation

As detailed in the previous section, the measurement model was examined and confirmed to exhibit good individual item reliability, convergent validity and discriminant validity, with all related measurement values falling within acceptable standard limits. This was achieved after dropping 8 of the initial manifest variables. Thus the final measurement model in this thesis demonstrates sufficient robustness needed to test the relationship among the exogenous variable and the endogenous variables. The causal structure of the model was assessed to examine the effects among the constructs defined in the proposed models through the estimation of the coefficient of determination (R^2), path coefficient (β), and effect size (f^2). Table 5.7 shows a summary of the proposed hypotheses which are all based on the nine causal paths of the study's conceptual model

Table 5.7 Study Hypotheses and Corresponding Causal Paths

Causal Path	**Hypothesis**
PE -> BI	**H1:** Performance expectancy will positively affect the health worker's intention to use DHIS2
EE -> BI	**H2:** Effort expectancy will positively influence the health worker's intention to use DHIS2
SI -> BI	**H3:** Social influence will positively affect the health worker's intention to use DHIS2
TA -> BI	**H4:** Perceived training adequacy will have a positive influence on health worker's intention to use DHIS2
VO -> BI	**H5:** Voluntariness of use will have a positive influence on behavioral intention.
BI -> UB	**H6:** Behavioral intention will have a significant positive influence on health worker's use of DHIS2.
FC -> UB	**H7:** Organizational facilitating conditions will positively affect the use of DHIS2
ANX -> UB	**H8:** Computer Anxiety will have a negative influence on health worker's use of DHIS2
EXP -> ANX	**H9:** Technology Experience will have a negative influence on Computer Anxiety

R^2 and Path Coefficients

The ultimate purpose of the study was to determine the explanatory power of the conceptual model by assessing the causal or predictive relationships between the constructs, and subsequently test the support for the model's hypotheses. The strength of these relationships is demonstrated by the amount of variance explained (R^2) in the endogenous variables as well as the inner model's path coefficient sizes and their significance (Chin 1998). Figure 5.4 represents the analytical results of the structural model of the full data set after elimination the few indicators which did not meet the minimum recommended reliability levels.

- **Structural Model's Coefficients of Determination (R^2)**

As illustrated in figure 5.4, the Variance Explained (R^2) for the first level endogenous variable (Behavioural Intention) was 0.309 while that for the Use Behaviour was 0.223. This means that the five latent variables of Performance Expectancy, Effort Expectancy, Social Influence, Voluntariness of Use and Training Adequacy were able to explain 30.9% of the variance in Behavioural Intention, while the latent variable Behavioural Intention, Facilitating Conditions and Computer Anxiety collectively explained 22.3% of the variance in Use Behaviour. Additionally, Technology Experience explained 10.4% of the variance in Computer Anxiety.

- **Structural Model Path Coefficients (β)**

The path coefficients indicate the direction and strength of the relationships between latent variables. There is a general suggestion that the magnitude of standardized path coefficient has to be more than 0.1 if a significant path relationship exists between the variables. This criterion was met in all the structural path relationships for this research model, except for the relationships between the independent variable Voluntariness of Use with the dependent variable of Behavioural Intention. The bootstrap procedure of Smart PLS was additionally used to test the significance of the structural path relationships using T-statistics and a summary of the results is given in Table 5.8. The procedure for this test is described by Hair et al. (2011) (Hair et al. 2011).

Figure 5.4 Causal Model for the full dataset (all health workers)

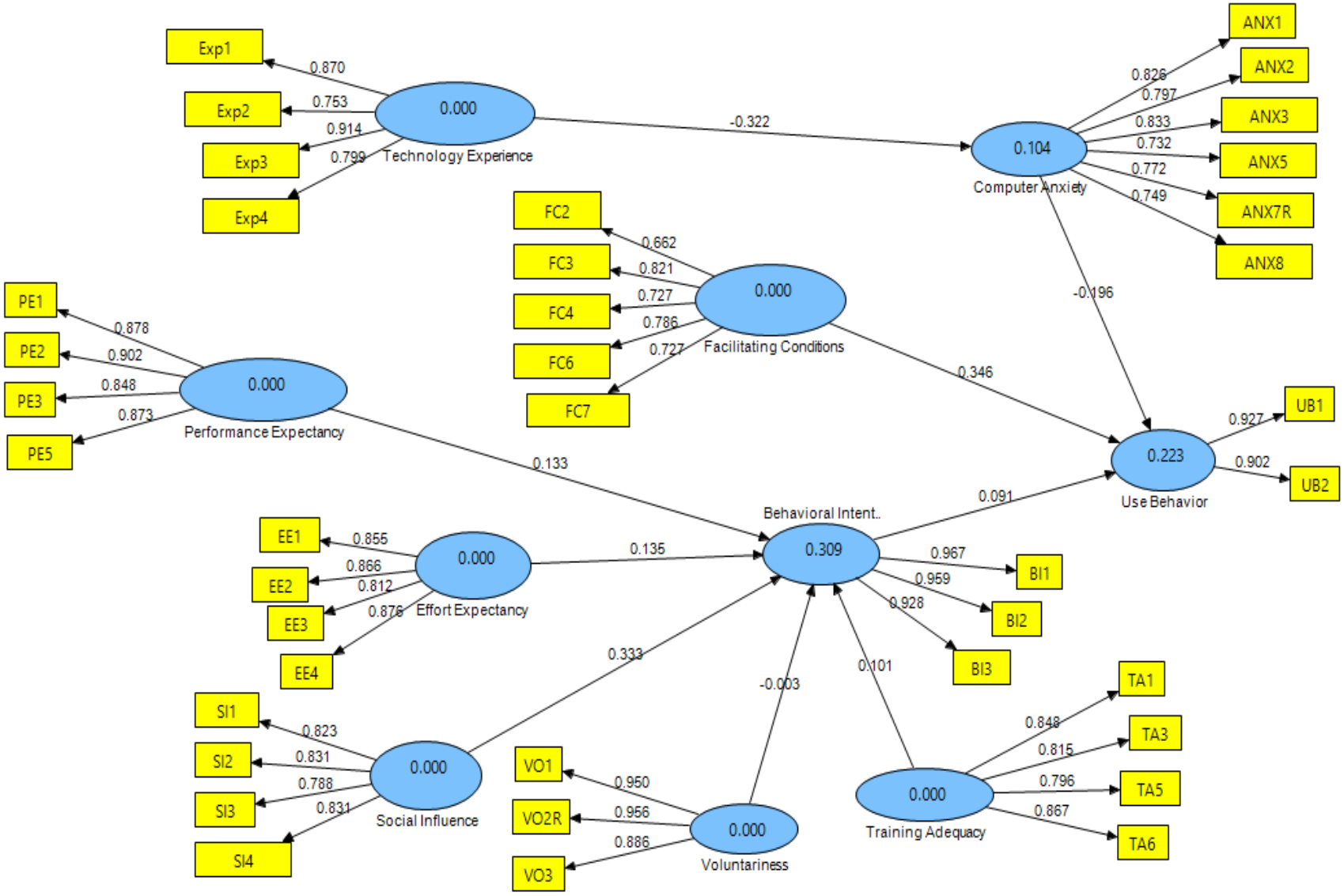


Table 5.8 T-Statistics for Full Dataset Model

Causal Path	Path Coefficients(ß)	T Statistics	Corresponding Hypothesis
EE -> BI	0.1347	1.8642*	H2
PE -> BI	0.1326	1.7898*	H1
SI -> BI	0.3328	5.2189***	H3
TA -> BI	0.1009	1.59	H4
VO -> BI	-0.0033	0.0949	H5
BI -> UB	0.0908	1.5636	H6
ANX -> UB	-0.1957	2.8203***	H8
FC -> UB	0.3457	5.6719***	H7
Exp ->Anx	-0.3218	5.4235***	H9

Note: The Critical T-values are 1.65 for a significance level of 10% (*); 1.96 for a significance level of 5% (**); and 2.58 for a significance level of 1% (***) in a two-tailed test

Examining the inner model containing the first level endogenous variable of Behavioural Intention, it was noted that Social Influence has the strongest effect on Behavioural Intention (β = 0.333); The beta coefficients of the paths from Effort Expectancy and Performance expectancy were also found to be significant, thought at a lower level of significance. For this full data set model the effects of Voluntariness of Use was found to be weak and insignificant. Though the effect of Training Adequacy was slightly higher at 0.10, it was also found to be non-statistically significant.

For the second level endogenous variable using the full dataset, the effect of Behavioural Intention on Use Behaviour was found to be quite weak at 0.091, especially compared with the stronger effect of Facilitating Conditions at 0.346. This result can most likely be explained by the fact that some respondents who were yet to start using DHIS2 still expressed high Intention to Use. Additionally there is evidence that facilitating conditions play an important role in resource-limited settings such as represented in this study. The effect of Computer Anxiety on Use Behaviour was statistically significant with a beta value of -0.196. As had been hypothesized, Technology Experience had a statistically significant negative effect on Computer Anxiety.

Effect Size

Effect size is calculated as the increase in variance explained (R^2) in an endogenous variable with and without an exogenous variable, relative to the endogenous variable's proportion of unexplained variance. Thus an effect size measure is used to determine whether of an exogenous latent variable has a substantial impact on an endogenous latent variable. According to Cohen (1988), when undertaking research in behavioural science values of effect size of 0.02, 0.13 and 0.26 respectively indicate that the predicting variable has a small, medium or large effect on an endogenous variable. Chin (1998) however proposed that the values should be slightly higher at 0.02, 0.15 and 0.35 respectively. Table 5.9 presents a summary of the effect size for all the structural paths defined in the study's theoretical model, when considering the full data set model (Cohen 1988; Chin 1998; Henseler et al. 2009).

Table 5.9The Effect Size of the Full Data Set Structural Model

Causal Path	Path Coefficients(ß)	T Statistics	Effect Size (f^2)
EE -> BI	0.1347	1.8642*	0.03
PE -> BI	0.1326	1.7898*	0.03
SI -> BI	0.3328	5.2189***	0.11
TA -> BI	0.1009	1.59	0.01
VO -> BI	-0.0033	0.0949	0.00
BI -> UB	0.0908	1.5636	0.01
ANX -> UB	-0.1957	2.8203***	0.04
FC -> UB	0.3457	5.6719***	0.14
Exp ->Anx	-0.3218	5.4235***	0.12

It is apparent that the magnitude of the effect size corresponds directly to the magnitude of the path coefficients. It is however good to note that this measures of effect and significance are affected by the size of the sample. The bigger the sample size the higher the tendency of obtaining statically significant values. It has thus been suggested that relative statistical importance of a variable is not the same as its "strategic" or "practical" significance (Ziliak & McCloskey 2008).

5.9 Testing the Moderator Variables

In addition to testing the direct effects of the exogenous variables on the endogenous variables, this study also sought to establish the effects of two moderating variables on the inter-constructs relationships. A moderating effect, also known as an interaction effect, is said to be evoked by variables whose variation influence the strength or the direction of a relationship between and exogenous and an endogenous variable. The causes of these moderating effects are referred to as moderating variables. Though testing of moderating effects adds value to the scientific understanding of the complex relationships in technology adoption studies, this model evaluation aspect is often neglected because the process of detecting and estimating such effects is considered to be difficult (Sekaran 2003; Henseler & Fassott 2010). The baseline theoretical model for this study, UTAUT, evaluated four moderator variables: gender, age, experience and voluntariness. Based on findings obtained from the qualitative feedback for the current research, only two moderator variables were included (age and gender) because experience and voluntariness of use were included as part of the direct effect variables.

The group comparison approach suggested by Hensler and Fasott (2010) was applied for this purpose and it encompassed the following steps:

1. First the data was split into two dataset based on the value of the gender moderating variable. This resulted in dataset for male respondents only (n = 144) and another for female respondents only (n = 145).

2. Both datasets were then loaded onto SmartPLS for further analysis of the measurement and structural model. SmartPLS feature was then used to add the age variable as a moderator for each of the two data sets.

3. After confirming the validity and reliability of the measurement models for both dataset, bootstrap function of SmartPLS was run to generate the path coefficients along with the related t-statistics and standard errors.

A summary of the findings from this process is illustrated in the table below and these were subsequently used to evaluate the moderating effect hypotheses.

Table 5.10 Testing the Moderating Effect of Age and Gender

	MALE		FEMALE		
Variance Explained(R^2) in:		Direct Effect		Direct Effect	**Corresponding Hypothesis**
BI	33.79%	33.65%	37.47%	32.24%	
UB	21.77%	19.52%	29.57%	27.04%	
Anx	12.97%	10.65%	9.10%	12.16%	
Path Coefficients(ß)	**(ß)**	**T Statistics**	**(ß)**	**T Statistics**	
AGE -> BI	0.1075	1.461	0.1973	2.329	
AGE -> UB	0.1251	1.7824	0.0381	0.65	
BI -> UB	0.0793	1.1219	0.068	1.1834	
Anx-> UB	-0.1869	1.9612	-0.211	2.0361	
Anx * AGE -> UB	-0.0982	1.2298	-0.0734	0.9385	H12
EE -> BI	0.0961	1.127	0.2318	2.1057	
EE * AGE -> BI	-0.1364	1.3429	-0.1836	2.199**	H11
FC -> UB	0.2617	2.6889	0.4031	5.0495	
FC * AGE -> UB	0.086	0.8628	0.0306	0.3186	
PE -> BI	0.2369	2.2218	0.0524	0.6251	
PE * AGE -> BI	0.1718	1.6875*	0.1585	1.3167	H10
SI -> BI	0.2782	2.8937	0.389	4.5592	
Exp ->Anx	-0.3263	3.3615	-0.3487	5.167	
TA -> BI	0.0577	0.8437	0.1207	1.5167	
Vol -> BI	-0.1066	1.5051	0.0563	0.9566	

5.10 Hypothesis Testing and Validation

Testing of the research hypotheses was done by considering the direction, magnitude and statistical significance of the path relations between exogenous and endogenous variables. Additionally the effect of two moderating variables, gender and age, was also tested. The main finding was that performance expectancy, effort expectancy and social influence were found to have a significant influence of behavioral intention, thus validating hypotheses H1, H2 and H3. Though the path coefficient from perceived training to behavioral intention was reasonably large and in the proposed direction, this effect was not found to be statistically significant, so H4 was only partially supported. Voluntariness of Use had negligible effect on behavioral intention, meaning hypothesis H5 was not supported. With regard to the

second level endogenous variable, the effects of organizational facilitating condition and computer anxiety were found to have a significant effect in the proposed direction, thus validating Hypotheses H7 and H8. Though there was indication of a positive influence of BI on use behavior as hypothesized, this influence was not found to be statistically significant.

For the moderated path relationships, the effect of effort expectancy on behavioural intention was found to bell be moderated by gender and age, such that the effect will be stronger for women and particularly for younger women, thus supporting hypothesis H11. Hypothesis H12 was however not supported as the effect of computer anxiety on Use Behaviour was not found to be moderated by either gender or age. Hypothesis H10 was found to be only partially supported because though the influence of performance expectancy on behavioural intention was moderated by gender and age, this effect was found to be stronger for older men rather than for younger men as had been hypothesized. A summary of these finding is presented in table 5.11.

Table 5.11 Hypothesis Testing [Full Dataset Model]

HYPOTHESIS	**Beta Coefficient**	**T-Statistic**	**MODEL TEST RESULTS**
H1: Performance expectancy will positively affect the health worker's intention to use DHIS2	0.1326	1.7898*	Supported
H2: Effort expectancy will positively influence the health worker's intention to use DHIS2	0.1347	1.8642*	Supported
H3: Social influence will positively affect the health worker's intention to use DHIS2	0.3328	5.2189***	Supported
H4: Perceived training adequacy will have a positive influence on health worker's intention to use DHIS2	0.1009	1.59	Partially Supported, not significant
H5: Voluntariness of use will have a positive influence on behavioural intention.	-0.0033	0.0949	Not Supported
H6: Behavioral intention will have a significant positive influence on health worker's use of DHIS2.	0.0908	1.5636	Partially Supported, not significant
H7: Organizational facilitating conditions will positively affect the use of DHIS2	0.3457	5.6719***	Supported
H8: Computer Anxiety will have a negative influence on health worker's use of DHIS	-0.1957	2.8203***	Supported

H9: Technology Experience will have a negative influence on Computer Anxiety	-0.3218	5.4235***	Supported
H10: The influence of performance expectancy on behavioural intention will be moderated by gender and age, such that the effect will be stronger for men and particularly for younger men.	Male: 0.1718 Female: 0.1585	1.6875* 1.3167	Partially Supported, stronger for men but more so for older men
H11: The effect of effort expectancy on behavioural intention will be moderated by gender and age, such that the effect will be stronger for women and particularly for younger women	Male: (0.1364) Female: (0.1836)	1.3429 2.199**	Supported
H12: The effect of computer anxiety on Use Behaviour will be moderated by gender and age, such that the effect will be stronger for women, particularly older women.	Male: (0.0982) Female: (0.0734)	1.2298 0.9385	Not Supported

5.11 Model Validation for Different Health Workers' Categories

Though the full dataset model was representative of health workers trained on use of DHIS2 in Kenya's public care sector, it was recognized that this is not a homogenous group as confirmed by the diverse demographic characteristics observed from the data. Three distinct heath workers categories were already recognized according to their assigned roles and functions. These three groups were: (1) Data Management Group; (ii) A Regional HMT Group and (iii) A national Level group. The generated model was thus tested for each of these group to enable understanding of the factor relationships that are most important for each group, and thus make appropriate study recommendations.

The variance explained in the two main endogenous latent variables (Behavioural Intention and Use Behaviour) increased when the data was separated into the 3 categories, and the path coefficients for some of the structural paths in each model also increased. As illustrated in Table 5.12, this variance explained increased to approximately 40% in each of the models representing the 3 different health workers' categories. However a more detailed scrutiny of each group's structural model statistics revealed that the strength of the various distinct causal paths in each model were quite different.

Table 5.12 Variance Explained for Different Categories of Health Workers

	Full Dataset	Data Management	Regional HMT	National Officers
Variance Explained(R^2) in:				
BI	30.90%	42.19%	38.73%	39.80%
UB	22.30%	27.05%	29.70%	23.90%
Anx	10.36%	7.89%	17.79%	0.90%
Path Coefficient(ß)	**(ß) T Statistic**	**(ß) T Statistic**	**(ß) T Statistic**	**(ß) T Statistics**
EE -> BI	0.1347 1.8642*	0.2333 1.8411*	0.1025 0.9458	0.1054 0.9129
PE -> BI	0.1326 1.7898*	-0.0084 0.1076	0.2753 2.1287**	0.2697 1.686*
SI -> BI	0.3328 5.2189***	0.3477 4.6565***	0.2234 1.4966	0.3699 2.9099***
TA -> BI	0.1009 1.59	0.1866 1.8412*	0.1749 1.7651*	0.1008 1.0179
VO -> BI	-0.0033 0.0949	-0.0708 1.2416	-0.1145 1.0919	0.0745 0.9512
BI -> UB	0.0908 1.5636	0.1574 2.0175**	0.0561 0.7871	0.3326 1.8571*
ANX -> UB	-0.1957 2.8203***	-0.2592 2.7762***	-0.137 1.3521	-0.1979 1.463
FC -> UB	0.3457 5.6719***	0.3121 3.6668***	0.4701 4.9595***	0.0865 0.722
Exp ->Anx	-0.3218 5.4235***	-0.2809 3.8382***	-0.4218 4.3826***	-0.0923 0.6072

Note: Critical t-valued are: 1.65 (*) for a significance level of 10%; 1.96 (**) for a significance level of 5%; and 2.58 (***) for a significance level of 1% in a two-tailed test

In summary it was observed that:

i. Perceived Usefulness was a significant contributor to Behavioural Intention for the National Level and Regional HMT groups, but not for the data management group

ii. Social Influence had a positive effect on Behavioural intention for all the 3 groups, but only significantly so for the Data management group and the National Level officers

iii. The positive effect of Effort Expectancy on Behavioural Intention was only significant in the data management group. Even the negative effect of Computer Anxiety on Use Behaviour was only found to be significant in this group

iv. Facilitating Conditions was a pertinent contributor to Use Behaviour for the data management and regional HMT groups; but not for the national level group

v. The effect of Training Adequacy on Behavioural Intention was significant for both the data management and the regional HMT groups

vi. The effect of Behavioural Intention on Use Behaviour was only significant in the Data management group.

The full model for each of these groups is as illustrated in Figures 5.5 - 5.7.

Figure 5.5 Model for the Data Management Group

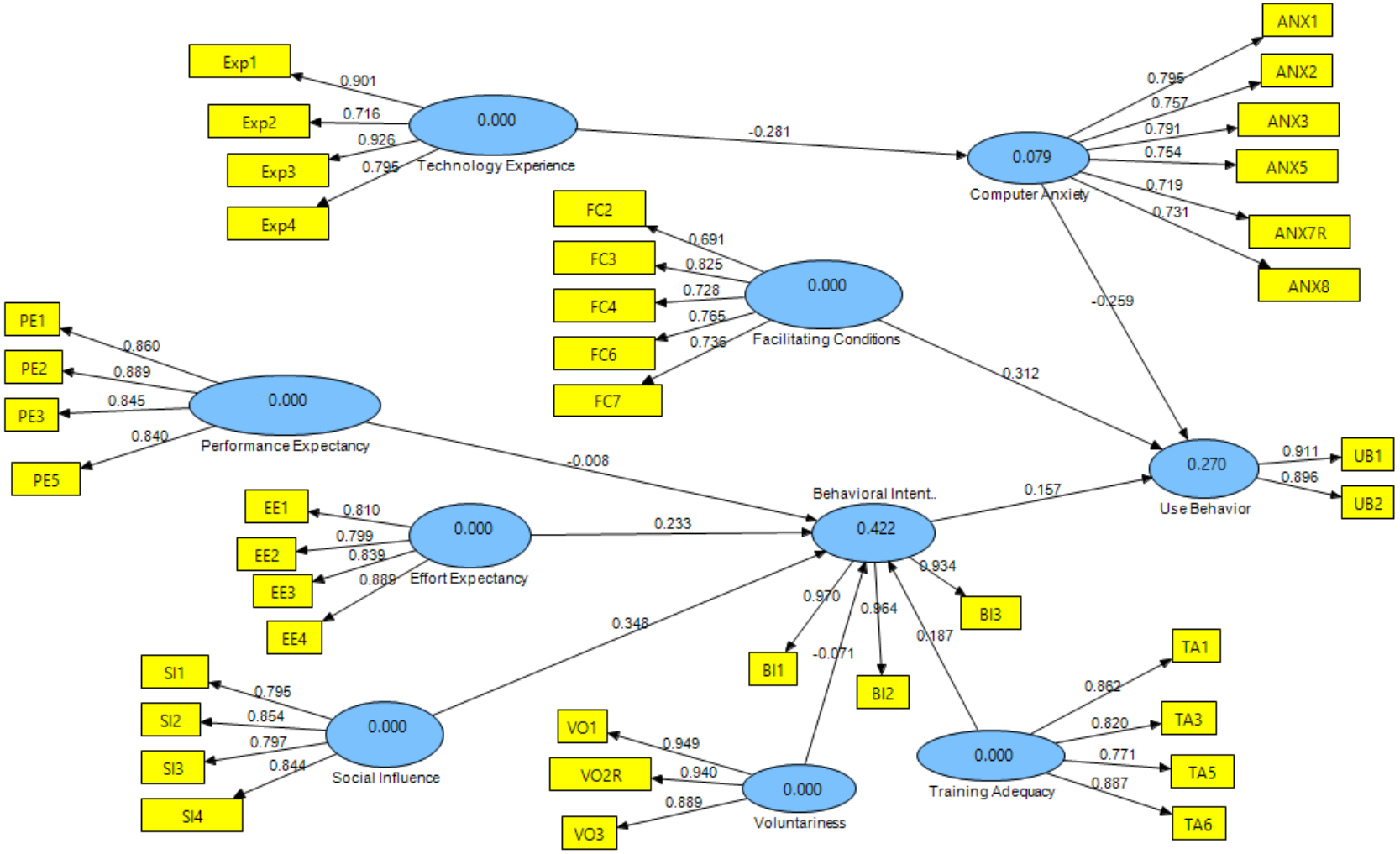


Figure 5.6 Model for the Regional Health Management Group

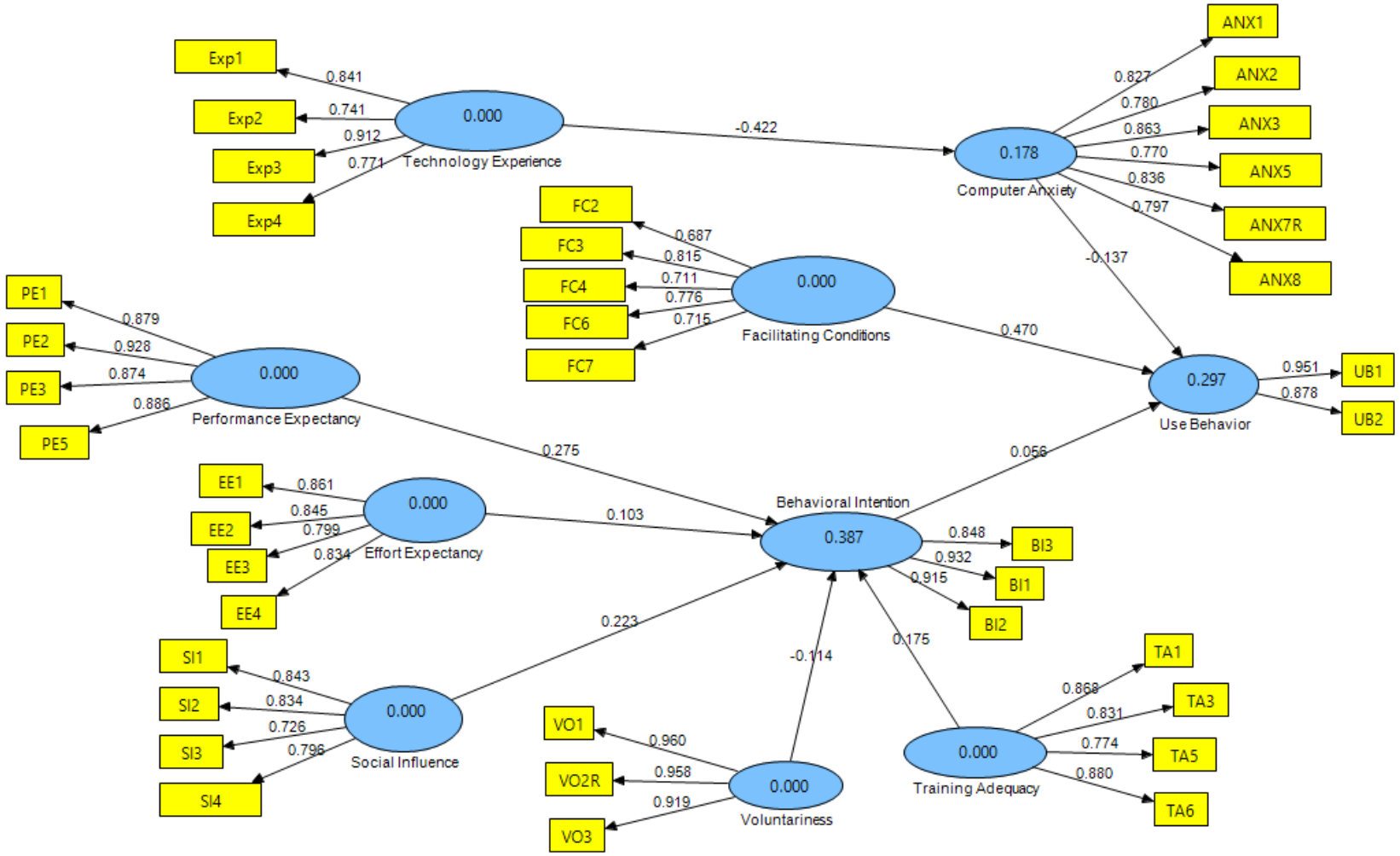
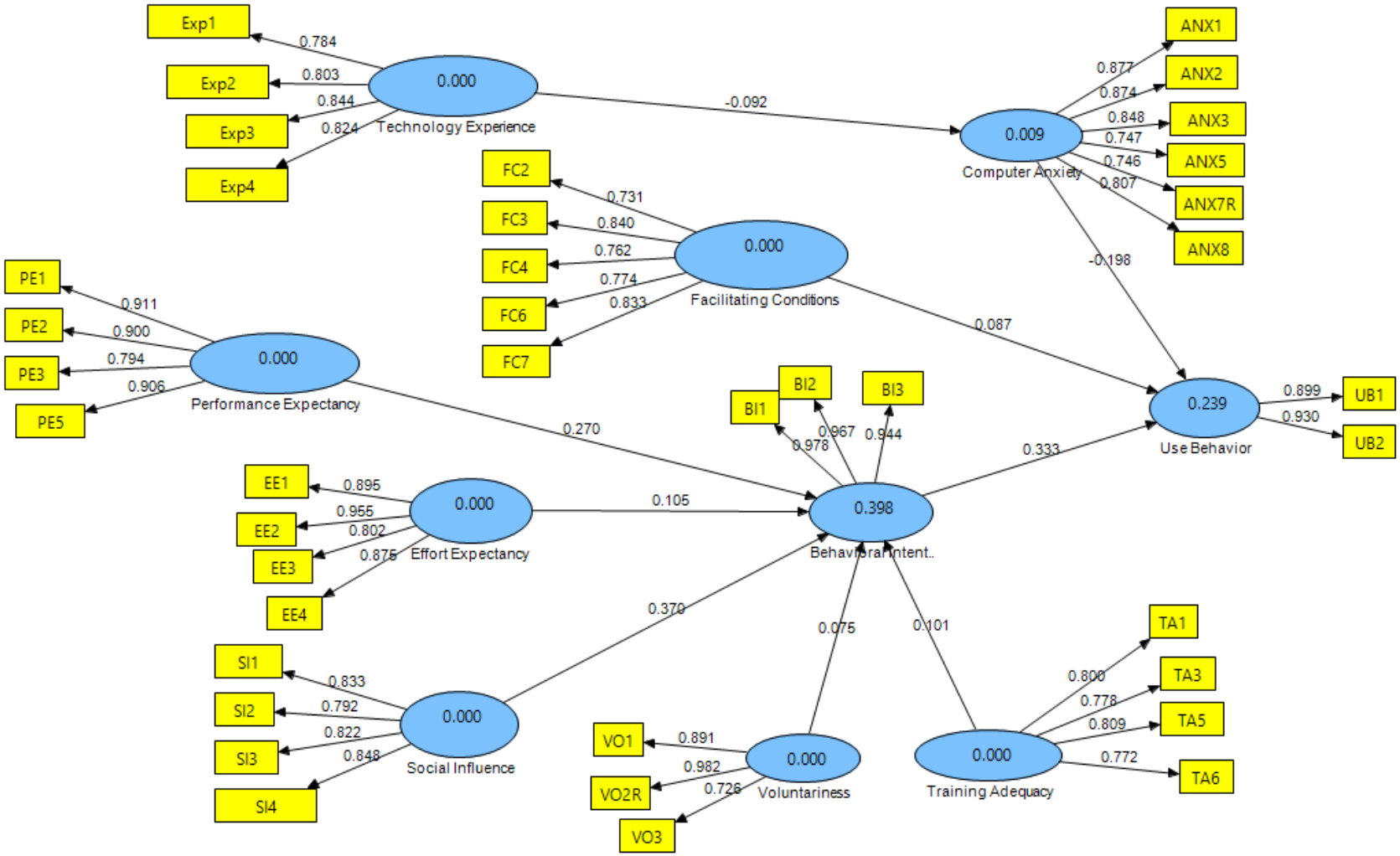


Figure 5.7 Model for the National Health Officers



Chapter 6: RECOMMENDATIONS & CONCLUSION

6.1 Introduction

This chapter summarizes the key findings from this research and their implications to the different stakeholders concerned with implementations of HIS in developing countries. The first section revisits the research objectives identified at the beginning of the study, and highlights how the research was able to contribute to addressing the identified research problem by responding to the research objectives and questions. The next section discusses the different categories of research contributions and implications in the theoretical, methodology, system implementation and managerial domains. Also contained in this chapter are the study limitations, recommendations for future research, overall study evaluation and conclusions that can be drawn from the research findings.

6.2 Linking the Study Findings to the Original Objectives

This study started by identifying the overall objective as "*to enhance knowledge and understanding of health I.T. adoption by building and validating a technology adoption model to study determinants of acceptance and use of national HIS in a developing country context*". This section of the thesis summarizes how the specific objectives were achieved and corresponding research questions responded to by the time the study was concluded.

Objective 1: *To develop a technology adoption model than can predict the complex relationships that affect adoption of routine HIS in a developing country's healthcare context*

The focus of this study was to extend the UTAUT model in order to identify factors that affect health workers intention to use and actual use of HIS in a developing country's context. The research started off by developing a study contextual model informed by the knowledge acquired through relevant literature review and an

understanding of the context within which computerization of health information systems is happening in Kenya. Further insights on this subject were gained from a qualitative pre-study done on acceptance and use of DHIS2 in Kenya (Karuri, Waiganjo & Orwa 2014). This led to adaptation of the UTAUT model to include **Training Adequacy** as a direct determinant of Behavioral Intention, and **Computer Anxiety** as a direct determinant of Use Behaviour. Additionally, **voluntariness of use** was included as a predictor of behavioural intention rather than a relationship moderator, while **Technology Experience** was hypothesized to predict the individual's computer anxiety. Only two moderators were included in the model, namely gender and age. Most of the indicators were operationalized based on definitions by Venkatesh et al (2003), but all were adapted to fit the local setting of the study. The research instrument for testing this model was developed and tested for understandability and content validity.

The pilot phase of the study enabled the researchers to test the research model's measurement items for validity and reliability, and also test the structural model for convergent and discriminant validity. Consequently the proposed study model including new constructs and measures was confirmed to be a valid and viable conceptualization of the complex relationships influencing user acceptance of HIS within the study context.

Thus the first research objective was achieved and the corresponding two questions answered based on theoretical investigation and qualitative research involving key stakeholders and subject experts:

i. *"What unique factors predict user adoption of a routine Health Information System in the public health care setting of developing countries?"*and
ii. *"Can existing technology acceptance and use models be leveraged upon to study contribution of the identified factors to acceptance and use of HIS in this context?"*

Objective 2: *Validate the model through Structural Equation Modeling (SEM) using empirical data collected from public health care workers in Kenya*

Validation of the extended study model was done using quantitative data obtained from 269 public health workers in Kenya. To ensure reliability of the measurement model, PLS-SEM was used to test that each block of items selected for a given construct were suitable operationalization for that particular construct. Indicator reliability was tested by squaring the outer loading of each manifest variable, while construct reliability was confirmed using both measures of Cronbach's alpha as well as for Composite Reliability. The validity of the model's construct was confirmed using tests for constructs' convergent validity and discriminant validity.

All these tests confirmed that the conceptualized model exhibited good individual item reliability, convergent validity and discriminant validity with all related measurement values within acceptable standard limits. Thus the measurement model in this study demonstrated the sufficient robustness needed to test the relationship among the exogenous variable and the endogenous variables. After the model validity was confirmed, the researchers then went on to assess the causal structure of the model and examine the strength of influence and relationships among the model constructs through the estimation of the coefficient of determination (R^2) for the endogenous variables, path coefficient (β), and effect size (f^2).

Objective 3: *Generate the final model and evaluate the strength of the relationships between the exogenous and endogenous constructs, hence deduce the factors that most contribute to the HIS Adoption and Use process*

The focus of the findings was to examine the extent to which the factors in the conceptual model were able to predict the two endogenous constructs: Behavioural Intention and Use Behaviour. Additionally the model also looked at the influence of HIS users' prior Technology Experience on their levels of Computer Anxiety. The

results showed that intention to use HIS was mostly influenced most by degree to which an individual perceives that his or her peers, supervisors, and important others believe he or she should use the technology. Though to a lesser extent, this intention was also influenced by degree of ease of use associated with the HIS (Effort Expectancy) and the belief that using the HIS would enable the health worker to attain gains in job performance (Performance expectancy).

Another factor that contributed to the prediction of behavioural intention was Training Adequacy with a β coefficient that was only slightly higher at 0.10. Training Adequacy was defined as *"The degree to which the health worker believed that he or she had received adequate training on the use of the HIS."*The predictive power of these four factors was found to account for about one third (30.9%) of the variance in behavioural intention. The perception that one has a choice to use or not use the HIS (Voluntariness of Use) was not found to significantly influence the behavioural intention. Though these results confirmed that the factors identified in UTAUT were also applicable in the context of this research, the fact that Social Influence was the most important factor was a contradiction to findings obtained when the model was tested in developed countries context. This is however consistent with studies that show Kenya and many other developing countries belong to a group of community that leans toward collectivism and high power distance, hence the high need for 'approval' by peers and supervisors (Hofstede et al. 2010; Biljon & Kotzé 2008)

Further model analysis revealed that the second level endogenous variable (Use Behaviour) was predicted by Behavioural Intention, Facilitating Conditions and Computer Anxiety. Together those three factors were able to explain 22% of the variance in use behaviour. One finding that was in contrast to previous findings when UTAUT was tested in developed counties was the fact that Facilitating conditions was the most influential factor for this endogenous construct, surpassing by far the influence of behavioural intention. As had been hypothesized, Technology Experience had a statistically significant negative effect on Computer

Anxiety. When the moderating effects of Gender and Age were included, the predictive power of the model was increased up to 37% for intention to use, and 29% for use behaviour.

Because of the common contextual background shared by Kenya with other countries in developing countries, particularly those in Sub-Saharan countries, these findings are able to respond to one of the original research questions, namely:

> *iii.* "*Which of the identified factors are most influential in contributing to the acceptance and use of routine HIS in developing countries?"*

Objective 4: *Cross-validate the model across different categories of healthcare workers via multi-group analysis.*

The full dataset model used in testing the study's hypotheses was representative of all health workers trained on use of DHIS2 in Kenya's public care sector. It was however recognized that this is not a homogenous group as confirmed by the diverse demographic characteristics observed from the data. Thus the researchers went on to group the data into three distinct heath workers categories which were already recognized according to their assigned roles and functions, and subsequently validate the extended model for each of these groups. The identified groups were: (1) Data Management Group; (ii) Regional Health Management Team and (iii) National Level health officers. The generated model was thus tested for each of these groups to enable understanding of the factor relationships that are most important for each group.

A test of instrument and construct validity and reliability proved that model as conceptualized was valid across the three categories of health workers. Further testing of the model using data for each health worker category revealed that the variance explained increased to approximately 40% in each of the models representing the 3 different health workers' categories. However a more detailed

scrutiny of each group's structural model statistics revealed that the strength of the various distinct causal paths in each model were quite different. This is consistent with prior literature findings that the influence of individual factors depend on perception of autonomy by different cadres of health workers – for example it is expected that physicians and health managers will be more autonomous in their decision making than the other categories of health workers, hence social influence will not be the most important factor in predicting their actions (Chismar & Wiley-patton 2003; Chau & Hu 2002; Chang et al. 2007; Duyck et al. 2010). On the other hand, lower cadre health workers act less autonomously and it is therefore quite plausible that they are more prone to influence by their peers and superiors in determining their technology acceptance decisions (Wills et al. 2008; Lee et al. 2008; Schaper & Pervan 2007).These finding confirm that health workers are not a homogenous group across functions and cadres, and this must be taken into account when considering factors that affect their acceptance of particular health technologies. The following key differences were identified across the 3 health workers categories.

Table 6.1 Differences across the Health Workers Categories

Relationships Noted	Possible Explanation
1. Perceived Usefulness was a significant contributor to Behavioral Intention for the National Level and Regional HMT groups, but not for the data management group	1. These two groups consist of higher proportions of more educated people operating in more senior positions. For many of them usefulness rather than mere fulfillment of duty will be a driving force for system acceptance
2. Social Influence had a positive effect on Behavioral intention for all the 3 groups, but it was only significantly so for the Data management group and the National Level officers	2. Social Influence has two dimensions – one has to do with culture which would be applicable across all people of a country. The culture of developing countries like Kenya lean towards collectivism and high power distance, hence influence of peers and supervisors is important across the board – but it is particularly

	important for lower cadre workers.
3. The positive effect of effort expectancy on behavioural Intention was only significant in the data management group. Additionally the negative effect of computer anxiety on use behaviour was also only found to be significant in this group	3. A major component of this group is people educated only up to diploma level. Again it is the group with the highest incidence of individual who do not own a computer. Yet for most of them it is mandatory to use DHIS2 for reporting. Hence this explains why EE and ANX would impact significantly on the group as a whole
4. Facilitating conditions was a pertinent contributor to use behaviour for the data management and regional HMT groups; but not for the National level group	4. Majority of these two affected groups indicated that the access to internet provided at their work place was not enough. Yet they need this in order to use DHIS2. At national level, more than 50% thought the internet provided was enough, and only 5.9% did not own an individual laptop or computer
5. The effect of training adequacy on Behavioral Intention was significant for both the data management and the regional HMT groups	5. Again this could be explained by the fact that the National level group is more exposed to modern ICT applications that the other two groups. A good proportion of the national level group indicated they had only received informal DHIS2 training, yet they were comfortable in using the system
6. The effect of Behavioral Intention on Use Behaviour was only significant in the Data management group.	6. Intensity of intention does not always translate to use, and this could be so especially for these two groups who are not mandated to use DHIS2. On the other hand, the Data management group does not have an option since they must report on the system regularly

These findings confirmed that the model is valid across different health workers categories, but they also confirmed that the strength of the factor relationships vary across the categories. This responds to the last research question identified, namely:

iv. *"Is the proposed theoretical model valid across different categories of healthcare workers?"*

6.3 Research Contributions and Implications

The findings from this study provide clear evidence that though the factors defined in the UTAUT model do contribute to predicting the intention to use and actual use of HIS in developing countries, they alone are not adequate and thus there is need to examine the contribution of other context-specific factors. This contributes to the body of knowledge that focuses on technology adoption by extending the UTAUT theory and validating it in a new context both in terms of technology (HIS) and low resources (developing countries). It provides new knowledge that will provide practical contribution to more effective development and implementation of public health IT in developing countries; as well as the associated formulation of health information policies and guidelines. The detailed contribution of the study can be classified into three categories, namely: Theoretical; Methodological; and Practical /Managerial as discussed below.

6.3.1 Theoretical contribution

The main theoretical contribution gained from this research was the extension and modification of the Unified Theory of Acceptance and Use of Technology (UTAUT) model to study technology acceptance in the context of healthcare in developing countries. Previously this model has mostly been applied for studies of user acceptance within developed countries context.

Additionally the well established baseline model, UTAUT, has now been extended to study acceptance and use of a new technology artifact in a new organizational setting. To the researchers' knowledge, this is the first ever scholarly research study based on UTAUT model to study behavior intention and actual use of a national level HIS in a public healthcare setting of any country.

Another major contribution is the unique extended model that identified and validated new factors (constructs) which impact on behavioral intentions and actual use of HIS: These new factors are: **Perceived Training Adequacy**, **Computer Anxiety** and users' prior **Technology Experience**. The contribution of **Voluntariness of Use**, which had also been proposed as a new factor, was also tested but not found to be significant. The new factors were combined with existing factors in UTAUT to produce *a unique research model* for predicting acceptance and use of DHIS2 among public health workers in Kenya as illustrated in figure 6.1.

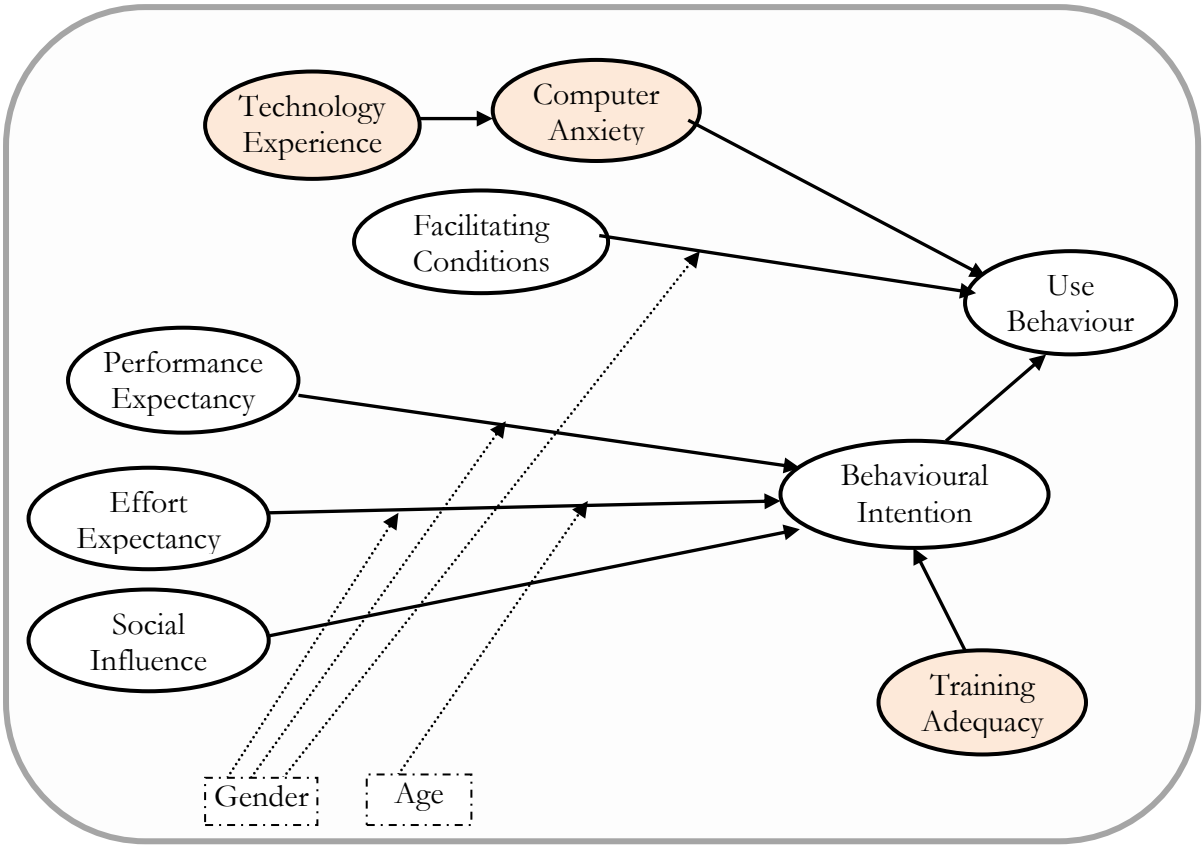


Figure 6.1 Revised Model for Acceptance and Use of DHIS2

An additional contribution to technology acceptance theory was the development of new or contextually adapted indicators to measure the constructs in the extended model. Development of these new indicators was informed both by relevant literature pertaining to context within which HIS is implemented in developing countries, and also to findings from the exploratory qualitative study that garnered

informed opinions from key stakeholders in implementation of DHIS2 in Kenya. These new or adapted indicators passed the tests of reliability and validity, and hence can be applied in any other research done in a similar context.

The contribution of Social Influence to behavioral intention proved to be the most important, contrary to findings from studies conducted in other contexts. All together the four factors of performance expectancy, effort expectancy, social influence and training adequacy contributed up to 30.9% of the variance in behavioral intention, and up to 37% when moderated by age and gender. This study also confirmed that Computer Anxiety does play a very significant role in actual use of HIS in a developing country context, and that facilitating condition is even more influential on use behavior than behavioral intention, which again is contrary to findings of studies done in developed countries' context. The development of the extended model for application in a new technology context (public sector HIS) and in developing countries context is an important contribution to research on technology adoption. Contribution of voluntariness of use to the predictive power of the model proved to be insignificant, contrary to findings in some previous studies (Kijsanayotin et al. 2009).

The analysis of the extended model indicated that technology acceptance models which are only tested in developed countries, and / or only in the limited settings of a few industries cannot be correctly applied to developing countries without specific contextual modifications. Though the original factors existing in UTAUT were also included in the extended model, it was apparent that the strength of contribution of most of these factors was contrary to what had been found when UTAUT model was tested in different contexts. In particular the most predictive factor for behavioral intention was found to be Social Influence, collaborating the findings from the exploratory study which had identified related items such as the need for champions, and the fact that most health workers will do as required of them by higher authorities. In tandem with the contextual finding that computer anxiety is

highly prevalent among health workers in developing countries' context, this factor was found to play a significant role in determining the actual use of DHIS2.

6.3.2 Methodological contribution

This research was conducted through the use of mixed method, and by meticulously going through 5 logical phases summarized as follows:

Phase 1: Model Adaptation based on existing contextual literature

Phase 2: Exploratory Qualitative Study to explore context specific technology acceptance issues and factors

Phase 3: Pilot study testing and validating the survey instrument as well as the research model constructs

Phase 4: Cross-sectional survey to obtain representative empirical data for the study

Phase 5: Quantitative Data Analysis and contextualization of the study findings

Future research in technology acceptance and use research can benefit from going through similar logical steps regardless of the study artifact and organizational context. A summary of key recommendations based on the methodology used in this study is given in this section

First, the importance of doing a thorough contextual investigation from existing literature cannot be over-emphasized. This helps the researcher to identify factors that have already been tested and the findings obtained, and so to clearly identify the gap to be addressed by the research. When testing a particular technology artifact like the DHIS2, the researcher also needs to conduct a desk review to fully understand the contextual setting of the study environment.

Second, researchers need to undertake exploratory qualitative study early on in their technology acceptance and use research. This provides them with important

feedback from subject level experts on the factors they consider as critical for the success of the technology artifact under study. Based on this the researchers are able to relate stakeholders' views on barriers and enablers of the technology adoption to measures and constructs in their research model.

Another important methodology step is the pilot study. Through this phase the researcher is able to a priori confirm the survey tool's completeness and understandability, and obtain focused feedback on how to improve the tool and thus enhance the chance of obtaining higher rates of valid survey responses. Also important is the ability to use the pilot data to test the proposed research model's reliability and validity and act on the results to improve the model accordingly.

This research sets an example of how to design an exploratory study for evaluating the causal relationships between different factors contained in a complex study model. For this kind of study second generation statistical techniques such as the partial least squares structural equation modeling (PLS-SEM) used in this study are much more suitable that first generation techniques such as multiple regression, ANOVA or t-tests. This is because SEM has the distinct advantage of being capable of analyzing unobservable or latent variables in a causal model, and this is not possible with first generation statistical techniques. Additionally when using SEM one is able to simultaneously estimate complex causal models which may include many indicators as well as several exogenous and endogenous constructs. Yet a review of the literature shows that many researchers prefer to user first generation techniques, probably due to lack of familiarity with second generation techniques. This study clearly and in a simplified manner details how PLS-SEM was applied for estimating the theoretical model. Future researchers can benefit from following the detailed methodology.

In addition even those researchers who use SEM have in the past been more inclined to use covariance-based SEM rather than PLS-SEM. This study clearly outlines the situation where it may be more advantageous to use PLS-SEM, and this is especially

so when dealing with complex causal models with a lot of constructs and indicators, yet having to work with a limited data set. PLS-SEM also has the advantage of having the capacity to work with non-normally distributed data and in exploratory research setting such as was the case in this study.

6.3.3 Managerial contribution

The findings from this study are not only relevant to researchers worldwide, but also have practical implications for management, including system implementation teams, on the approaches they should use if they want to achieve greater success in implementation of HIS and other public health IT in developing countries. By understanding the factors considered to be critical by users in determining their level of acceptance and use of HIS, this category of stakeholders can plan for more effective HIS systems deployment approaches, including advising system developers on the context specific customization they need to make on their software applications to make them more acceptable to the intended users.

One of the key findings was that when considering a cross-section of health workers across different cadres and levels of academic achievement, social influence is the most pertinent factor that influences intention to use the HIS. This collaborates the findings in literature that in developing countries, the prevailing culture is such that status and image are important motivators of behavioural change (Hofstede et al. 2010; Biljon & Kotzé 2008). In the exploratory phase of this study, the theme on the need for leadership to spearhead the use of the DHIS2 was very prominent, with the bottom line being that health workers will in most cases adapt their behaviour in accordance to what they perceive to be the expectations of their superiors. Additionally peer influence on health worker behaviour was found to play an important role, and hence respondents identified the need to provide more opportunities for sub-regional sharing of experiences in data reporting and use for decision making. These findings were also closely linked to the need for identifying of champions who would take a pro-active interest in promoting, using, and educating other health workers on the benefits of using HIS. Thus there is a close link between

social influence and the behaviour change necessary for health workers to accept and use DHIS2 in developing countries' context.

The other factors of performance expectancy and effort expectancy were also found to be important as identified in UTAUT, so system designers should also take these into this account by ensuring the system design is user friendly and that the end-users are involved in the customization to assure that indeed there will be value-add from using the system. The new factor of Training Adequacy was found to contribute to overall user acceptance of the system, and hence it would be beneficial for managers to carefully plan for this aspect of system deployment. It is important that management ensures that training on the HIS system is done effectively as this will enhance the targeted users' awareness of the system's usefulness and ease of use. One possible way of achieving this would be to introduce pre-service foundational courses on ICT and e-health in general as this would build a good foundation for more specialized training on specific HIS systems in future. Additionally, there might be need to use formal and informal assessment methods to do regular evaluations of training adequacy from the user perspective.

When considering the actual use of HIS systems, it emerged that availability of adequate facilitating conditions was the most important factor when considering the full set of health workers involved in this study. This is not surprising considering that it was already identified from literature that developing countries mostly operate from resource-limited settings which hinder effective implementation of computer based HIS. Thus this translates to mean that even where there is high acceptance and intention to use a system, if proper organizational facilitation for use of the system is not provided, then this intention may not translate to actual use of the system. Managers can provide this facilitation through provision of adequate ICT infrastructure such as access to computers and the internet, provision of responsive technical support and other knowledge resources.

Computer anxiety level was also found to be important factor that negatively affects users' actual use of HIS, and this was in turn predicted by the level of technology experience that these users had been previously exposed to. There is thus need for managers to proactively work to minimize this anxiety by ensuring that health workers are exposed to ICT training from early stages of their careers, and if possible mainstream such training to become a part of the health workers formal professional curriculum.

In addition to the above recommendations, managers also need to take into account the findings obtained after conducting multi-group analysis using data-sets representing the three different categories of health workers. Findings from this part of the analysis revealed that the model is not a one-size fit all among the different categories of health workers as factors which are most important for one category are in some cases not all that significant for the other categories of health workers. For example the National Level health workers group had health workers with the highest levels of academic qualifications and additionally for them there was no challenge in gaining access to the requisite facilitating conditions for use of DHIS2. For them facilitating condition is not an important factor in predicting their use of DHIS2. There is thus need to further investigate and further breakdown the factors related to the health workers duty stations, academic accomplishments, and functional responsibilities that might influence their decision to accept the use HIS.

6.4 Study Limitations

As occurs with practically all research studies, there were several potential limitations to this study. First despite the fact that the official roll-out of the HIS considered in the study was completed about 2 years prior to the commencement of this study, the number of targeted users who had actually used the system consistently was still very limited. This then meant that the target population that could be included in the study was also quite limited.

Another limitation was that the data collection for this study was done using a cross-sectional approach. Though this kind of study method has its benefits, the downside of it is that the study does not have the benefit of examining the change in construct relationships across time. The choice of cross-sectional survey is because the study intended to reach a fairly large sample size within a reasonable time period, in order to ensure the generalizability of the results obtained.

The third potential limitation was the necessity to use non-probability sampling in selecting the survey respondents. Purposive sampling was used as it was the only feasible option for accessing an adequate and representative sample across the three categories of health workers considered in this study. Care was however taken to ensure that these health workers were drawn from more than 20% of the country's 47 counties, to make the study even more representative across the entire country.

Another potential limitation is that fact the study relied on the perception of the study respondents and an assumption of their truthfulness in self reporting on their DHIS2 use behaviour. Though there is no evidence to suggest that they under or over exaggerated their system use characteristics, it might have been more authentic if this had been gauged directly from examining the system use logs as was done in the original UTAUT study. This was however not feasible under the current setting of DHIS2 implementation in Kenya.

These limitations notwithstanding, the study provided useful findings which contribute considerably to expanding knowledge and understanding of factors that influence acceptance of HIS in the public healthcare setting of developing countries. This can serve as a foundation to guide further research in this subject area.

6.5 Recommendations for Future Research

This study has successfully extended the UTAUT model to develop a unique model to explain acceptance and use of HIS in developing countries' setting, however there are still some aspects that would benefit from further exploration in future research.

First, it might be beneficial for future research to apply a longitudinal study approach in order to test the how the predictive effect of different factors varies across time. It would particularly be interesting to understand how the intention to use factor actually impacts on use behavior across time, and this cannot be tested in a cross-sectional study (Karahanna et al. 1999).

Though there are reasons to believe that the model can be extrapolated for application in similar settings involving implementation of HIS in developing countries, the model can be cross-validated by testing it in other similar settings. An assumption has been made that the cultural settings of countries in sub-Saharan Africa is similar, but primary research may need to be conducted to provide empirical evidence on which to base such an assumption.

As much as practicable, the use of probability sampling in identifying the study respondents should be applied, thus increasing the confidence of generalizing study findings across entire populations.

There might be need to decompose some of the factors that were found to be most important in explaining intention and use behavior of HIS in developing countries. This is because even the literature review and the exploratory study identified social influence and facilitating conditions as very important determinants of technology acceptance and use in low-resource countries. However the indicators that can be attributed to these two factors are many and quite diverse and may not be fully captured in single constructs. Some suggested factors to be tested in future studies include the influence of: User Attitude, Peer Influence, Culture; Self efficacy; End-user Support; Infrastructural Adequacy and Managerial Support.

From the study, the moderating effect of gender was quite apparent, however this was not so in the case of age as a moderating variable. This could be explained by the fact that the research collected age data already grouped into only five subcategories which may have caused some loss of precision in the data obtained. Future research could require the respondents to indicate their actual age.

Finally the extended model was only able to explain up to 40% of the variance in intention to use and 30% of actual use variance even when the moderators were included or in the case of multi-group analysis across the different health workers categories. This is comparable to what UTAUT was able to explain when considering direct effects only. However this also means that there still remained a large proportion of unexplained variance both in intention to use as well as actual use behavior. Additional factors identified in the exploratory study could be included in future tests of this model as already suggested.

Though the study was conducted primarily in Kenya's public healthcare setting, faith-based and lower level private sector health facilities in the country operate in similar settings and face similar challenges. We would recommend that implementation of DHIS2 be supported in such settings while addressing the identified adoption determinants. Future research can also be done to confirm the validity of the study model in such settings.

6.6 Conclusion

This research study set out to extend the UTAUT model by including new constructs and measures, to create a new model capable of evaluating user acceptance and actual use of HIS in developing countries context. The findings from this study contribute to the technology adoption literature by examining theoretical validity and practical applicability of UTAUT in a different country setting and in the rarely examined area of a national-level public health IT adoption.

The results show that social influence is the most pertinent predictor of behavioral intention in such settings, but other factors identified in UTAUT like performance expectancy and effort expectancy do also exert an influence on behavioral intention. Additionally, the newly introduced factor of training adequacy was also found to influence intention to use DHIS2. The results also show that facilitating condition and computer anxiety play a significant role in influencing the health workers use of DHIS2. However the results also show that the level of computer anxiety is minimized by the extent to which intended users have prior experience in use of ICTs. Literature suggests that behavioral intention is most important in predicting user behavior, but this was not found to be the case in this study's setting.

In conclusion, the study does confirm that UTAUT model is applicable to developing country context, but the factors currently included in UTAUT were not found to be adequate to explain acceptance and use of HIS in developing countries. Hence the need to include and test other relevant determinants as informed by contextual findings in literature and through conducting exploratory studies. In agreement with studies conducted within other settings, the multi-group testing of the extended model among different categories of health workers show that the pertinence of identified factors do vary according to the functional role of the health workers, and whether this calls for more or less autonomy in the health worker's day to day work-related decision making.

With the increasing effort by many developing countries especially those in Sub-Saharan Africa to computerize their national HIS, this study has important implications for the customization and deployment of such systems, and of other public health IT systems in similar settings. Ultimately addressing the factors that affect adoption of DHIS2 will lead to enhanced data demand and use by all the targeted stakeholders. It is recommended that future research test more variables and moderators to increase the overall predictive levels of the model.

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APPENDICES

APPENDIX 1: NCST RESEARCH AUTHORIZATION

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349
254-020-310571, 2213123, 2219420
Fax: 254-020-318245, 318249
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: NCST/RCD/13/012/73

Date: 21st November 2012

Josephine Karuri
University of Nairobi
P.O.Box 30197-00100
Nairobi.

RE: RESEARCH AUTHORIZATION

Following your application dated *1st November, 2012* for authority to carry out research on ***"Adoption and use of the District Health Information System (DHIS2) in Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Selected Provinces** for a period ending **31st December, *2014.***

You are advised to report to **the Provincial Commissioners and the Provincial Directors of Education, Selected Provinces** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR M.K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The Provincial Commissioners
The Provincial Directors of Education
Selected Provinces.

APPENDIX 2: KNH/UON ETHICAL APPROVAL

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
(254-020) 2726300 Ext 44355

KNH/UON-ERC
Email: uonknh_erc@uonbi.ac.ke
Website: www.uonbi.ac.ke
Link:uonbi.ac.ke/activities/KNHUoN

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref. No.KNH/ERC/R/69

5th June 2014

Josephine Karuri
Principal Investigator
P O BOX 21586, 00505
NAIROBI

Dear Josephine

Re: Approval of annual renewal – Adapting UTAUT Model to evaluate factors affecting HIS Adoption in Developing countries: The case of DHIS2 in Kenya (P584/10/2012)

Refer your communication of May 19, 2014.

This is to acknowledge receipt of the study progress report and hereby grant you annual extension of approval for ethical research Protocol **P584/10/2012.**

The approval dates are 14th March 2014 to 13th March 2015.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH/UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH/UoN- ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH/UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH/UoN-Ethics & Research Committee for each batch of shipment.

g) Submission of an *executive summary* report within 90 days upon completion of the study
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

For more details consult the KNH/UoN -ERC website **www.uonbi.ac.ke/activities/KNHUoN**

Kindly forward the informed consent documents for endorsement with updated stamp.

Yours sincerely

PROF. M.L. CHINDIA
SECRETARY, KNH/UON-ERC

c.c. The Principal, College of Health Sciences, UoN
The Deputy Director CS, KNH
The Chairperson, KNH/UoN-ERC

APPENDIX 3: MoH APPROVAL TO CONDUCT RESEARCH IN KENYA

MINISTRY OF HEALTH
OFFICE OF THE DIRECTOR OF MEDICAL SERVICES

Telegrams: "MINHEALTH", Nairobi
Telephone: Nairobi 2717077
Fax: 2713234
When replying please quote

AFYA HOUSE
CATHEDRAL ROAD
P.O. Box 30016
NAIROBI

Ref: MOH/ADM/1/1/81 **10th June 2014**

Josphine Karuri
School of Computing and Informatics
University of Nairobi
P.O. Box 30197 00100
Nairobi

RE: REQUEST FOR APPROVAL TO CONDUCT HEALTH INFORMATICS RESEARCH IN KENYA

Reference is made to your letter dated 9th June 2014 on above subject.

The office has no objection in conducting the research entitled **"Adapting UTAUT Model to Evaluate Factors Affecting his adoption in developing countries'.**

All county and sub-county Health Management teams are requested to provide the necessary assistance for the success of the research.

DR. FRANCIS KIMANI
DIRECTOR OF MEDICAL SERVICES

Copy to: All Chief Officers

APPENDIX 4: KEY INFORMANT INTERVIEW STUDY GUIDE

Evaluating the factors that influence Acceptance and Use of the District Health Information System (DHIS2) in Kenya.

Name: …….

Organization / Department: ……

Designation: ……

Phone: ……

E-mail: ……

Interview Time: ……

Section A. Introduction

Introduction talk for adopters (to set the stage, 1-2 minutes or less, warm-up opening statements that give context to the potential participants).

My name is Josephine Karuri and I am a PhD student undertaking a research study under the supervision of Professor Peter Waiganjo Wagacha at the School of Computing and Informatics, University of Nairobi, Kenya. As you are aware, the Division of HIS in Kenya has since 2011 been in the process of implementing and scaling-up the use of a new web-based system for collection, analysis and management of national health information. We know that this system has a great potential to improve use of health data to inform policy and decision making at all levels of the Kenya health system. However there is no guarantee that because DHIS2 is a good system the targeted users will accept and use this system as anticipated. I am conducting a study on this topic for a doctoral degree program, specifically to evaluate the individual, technology and organizational factors affecting user acceptance DHIS2. Your kind participation in this interview will provide me with

broader insight into the key factors I should take into consideration to ensure that my study model takes into account the contextual environment under which DHIS2 is being implemented here in Kenya Please note that your participation in this study is voluntary and all information provided would be treated confidentially and used for research purposes only. If you will agree, this interview will be recorded on audio tape for ease of reference.

Section B: The Study Guide Questions

(1) What is your understanding of the role DHIS2 in management of health information, and how is this expected to be different from what the previous HIS systems were able to provide?

(2) What role have you played in supporting implementation and/or use of DHIS2 in Kenya, or in your organization? And how successful have you been in this role?

(3) Please describe how, in your opinion, the implementation process for DHIS2 has progressed so far. What are the ways in which this process could be enhanced?

(4) What do you see as the main enabling factors for successful adoption of DHIS2 by:
   a) The public health facilities in Kenya?
   b) Health decision makers at all levels of the Kenya health system i.e. district, county and national levels?
   c) The Private and NGO sector?

(5) What in your opinion are the main barriers to comprehensive adoption and use of DHIS2 by the 3 categories of users outlined above? Please also give any suggestions you might have on how some of these barriers can be eliminated.

(6) Would you say that the following factors will have a significant role in the adoption and use of DHIS2 at the levels we have mentioned? Please explain:
   a) The expectation that a health worker's performed can be enhanced by use of DHIS2?
   b) The ease or complexity associated with use of DHIS2?

c) The level of training the health worker has received on use of DHIS2
d) The user's overall comfort or discomfort in general use of computer technology?
e) Whether an Individual considers use of DHIS2 as mandatory or voluntary?
f) Influence by other people who are important to the targeted DHIS2 user?
g) The level of organizational and technical infrastructure available to support use of DHIS?
h) Demographic factors such as age and gender?

(7) Apart from the above, what other factors do you think will play an important role in determining the success of DHIS2 at the various user levels?

(8) What would you say causes some users at one level of the health system to adopt and use DHIS2 while others at the same level do not?

(9) Do you have any other comment or recommendation you would wish to make on this subject?

Section C: Closing Remarks

(10) Do you have any closing remarks?

Thank you very much for your participation in this interview. At a later date, I will invite you to attend a workshop where the results of this and other interviews will be shared.

APPENDIX 5: SURVEY PARTICIPANTS INFORMED CONSENT

Consent for participation in a study to assess the determinants of Acceptance and Use of the District Health Information System (DHIS2) in Kenya

Why are you being given this form?

We are giving you this form so that you can learn more about the study. We will be happy to answer all questions you may have. Once you have understood the explanation we have given to you, you can decide if you wish to participate in the study.

Who is doing this study?

My name is Josephine Karuri. I am a PhD student undertaking this research study under the supervision of Professor Peter Waiganjo Wagacha at the School of Computing and Informatics, University of Nairobi.

What is the purpose of this study?

The purpose of the study is to evaluate the determinants of acceptance and use of Kenya's national HIS (DHIS2) by healthcare workers in the public health sector of Kenya. The information obtained from the study will be used to provide practical suggestions to policy makers, system developers and implementers on interventions that can lead to more successful HIS deployment in developing countries.

What happens in this study?

We will visit approximately 50 public health facilities of KePH Levels 4 and above, which have been randomly selected from 3 of Kenya's provinces. At these facilities we will request the HRIO and the overall Facility In Charge to take a few minutes to complete the attached self-administered questionnaire. We will also request the DHRIO and DMOH of the corresponding district to complete the same questionnaire. As one of the targeted respondents, we are inviting your voluntary participation in the survey. We emphasize that this data collection

exercise is not part of any regular HMT supervisory visits or MoH audits. Individual's performance will not be judged and survey results will be used only for study purposes.

Risks and discomforts:

There is no known risk and discomfort associated with the study. When completing the survey questionnaire you may seek any further clarifications from the person administering the survey.

What are the benefits to being in this study?

You will receive no direct benefit from your participation in this study. However, your participation will help the investigators to better understand the determinants of technology acceptance in Kenya's public health sector, and hence to provide practical suggestions to systems implementers and policy makers on interventions that will lead to more successful HIS deployment in developing countries.

What are the possible costs to participating?

There are no costs to you for participating in this study.

Confidentiality:

The data collected from the study will be used for the purpose of the study only. Your name and responses will not be made public by the study team. The results of the study may be published in scientific conferences and journals, but your names will not be included in any of publications.

Compensation for Research Related Injury:

This research is non-intrusive and hence no research related injuries are anticipated.

Your rights to participate, not participate, or to withdraw from the study

Taking part in this study is voluntary. You have the right to refuse to take part in this study. If you agree to participate in the study but then change your mind

you may withdraw from the study at any time. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them as soon as possible.

INFORMED CONSENT FORM

I (full name of health worker) ……..……..have read the above information / the above information has been explained to me by (full name of person taking consent) ……., and I have fully understood the information. I have had opportunity to ask questions, and all my questions have been answered to my satisfaction. I understand that I may at any time during the study revoke my consent without any loss or penalty. I consent to be enrolled in the study.

Signature……..
(Health worker)

Signature……
(Person taking consent)

Signature……..Name (Print)……..
(Witness)

Date……..

If you require any further clarifications, please contact the study's primary investigator using the contact information below:

Josephine Karuri
PhD. Candidate, Registration No: **P80/85062/2012**
Contact phone: +254 733 749969

APPENDIX 6: SURVEY COVERING LETTER AND QUESTIONNAIRE

PART I: Survey Covering Letter

University of Nairobi
School of Computing & Informatics
P. O. Box 30197 – 00100 GPO
Nairobi

Date_____

Dear Respondent,

I am a PhD student undertaking a research study under the supervision of Professor Peter Waiganjo Wagacha and Dr. Daniel Orwa at the School of Computing and Informatics, University of Nairobi, Kenya. We would like to invite you to be a part of this research study which is entitled: *Evaluating Critical Determinants of Acceptance and Use of the District Health Information System (DHIS2) in Kenya.* The proposed study will apply a technology adoption model based on the unified theory of acceptance and use of technology (UTAUT) to evaluate the individual, technology and organizational factors affecting user acceptance of the newly implemented national Health Information System, the DHIS2.

Reliable and accurate public health information is essential for monitoring health, and for evaluating and improving delivery of a country's health-care services and programs. Kenya undertook successful customization and national rollout of the DHIS2 between March and December 2011. Among other functions, the web-based DHIS2 is intended to capture health facility service delivery data and allow analysis at that level, promoting data use at all levels for decision making. For the country to reap the expected benefits from the DHIS2 implementation, it is important that the system gains wide acceptance from the targeted users.

As a current or potential user of DHIS2, we are inviting your voluntary participation as one of the respondents for the survey. Attached therefore please find a 4 page questionnaire which we ask that you kindly answer as accurately and honestly as possible. For the success of this study, kindly ensure that you do answer each and every question in the questionnaire as per the instructions provided. Please be assured that the information you provide will be kept **strictly confidential** and will not in any way be attributed to you as an individual or to your organization.

One of the results expected from this study will be the generation of a research model which will contribute to knowledge regarding the determinant of adoption and use of Health ICT. The study findings will also inform policy makers as well as system designers and implementers on future approaches that will increase the likelihood of achieving successful implementation of healthcare related information systems, especially in developing countries.

Thank you very much for your time and responses.

Cordially,

Josephine Karuri
PhD. Candidate, Registration No: **P80/85062/2012**
Contact phone: +254 733 749969

PART II: Survey Questionnaire – *Please answer **ALL** questions*

SECTION A: User Opinion on the use of District Health Information System (DHIS2):

In the subsections that follow, please indicate by way of ticking in the right column, the extent, to which you agree with the given statements in relation to DHIS2 and it use at your duty station, where : 1= Strongly Disagree 2= Disagree 3= Slightly Disagree 4= Neither Agree nor Disagree 5 =Slightly Agree 6= Agree 7= Strongly Agree

Please check √ only one the one option that most closely fits your opinion for each statement

	1= Strongly Disagree 2= Disagree 3= Slightly Disagree 4= Neither Agree nor Disagree 5 =Slightly Agree 6= Agree 7= Strongly Agree							
Subsection A: Performance expectancy (PE)		1	2	3	4	5	6	7
PE1:	Using DHIS2 will enable me to accomplish tasks more quickly.							
PE2:	Using DHIS2 will allow me to accomplish more work than would otherwise be possible.							
PE3:	DHIS2 will enable me to make work related decisions based on better evidence.							
PE4:	If I use DHIS2, I will increase my chances of getting a promotion.							
PE5:	Overall, I would find DHIS2 useful in my job.							
Subsection B: Effort expectancy (EE)		1	2	3	4	5	6	7
EE1:	My interaction with DHIS2 is or would be clear and understandable.							
EE2:	It would be easy for me to become skilful at using DHIS2.							
EE3	Learning to operate DHIS2 is easy for me.							
EE4	Overall, I would find DHIS2 easy to use.							
Subsection C: Computer Anxiety (ANX)		1	2	3	4	5	6	7
ANX1	I feel nervous about using computer systems.							
ANX2	It scares me to think I could cause loss of data in the system by hitting the wrong key.							
ANX3	I would hesitate to use DHIS2 for fear of making mistakes I cannot correct.							
ANX4	The challenge of learning about computers is exciting.							

ANX5	DHIS2 is somewhat intimidating to me.							
ANX6	I look forward to using a computer.							
ANX7	I am able to keep up with important technological advances in computers.							
ANX8	I feel nervous when using internet-based applications.							
Subsection D: Social influence (SI)		1	2	3	4	5	6	7
SI1:	People who are important to me think that I should use DHIS2.							
SI2:	My colleagues think that I should use DHIS2.							
SI3:	The senior management has been supportive in the use of DHIS2 at my duty station.							
SI4:	In general, use of DHIS2 has been supported and encouraged at my duty station.							

	1= Strongly Disagree 2= Disagree 3= Slightly Disagree 4= Neither Agree nor Disagree 5 =Slightly Agree 6= Agree 7= Strongly Agree							
Subsection E: Facilitating conditions (FC)		1	2	3	4	5	6	7
FC1:	I have the resources (e.g. reporting forms, computer, antivirus, etc) necessary to use DHIS2.							
FC2:	Access to the Internet is available any time I want to use DHIS2.							
FC3:	I have the knowledge necessary to use DHIS2.							
FC4:	DHIS2 is compatible with other systems that I use at my work.							
FC5:	DHIS2 experts are available to assist with DHIS2 difficulties.							
FC6:	I have knowledge sources (e.g. books, documents, consultants) to support my use of DHIS2.							
FC7:	I think that using DHIS2 fits well with the way I like to work.							
Subsection F: Training Adequacy (TA)		1	2	3	4	5	6	7
TA1:	The training received on DHIS2 is very helpful in my use of the system.							
TA2:	I have training reference documents that I can consult in my use of DHIS2.							
TA3:	I feel the training received is adequate for my efficient use of DHIS2.							
TA4:	I need further training on DHIS2 to enable me use the system efficiently.							
TA5:	My training on basic use of computers is adequate for using DHIS2.							
TA6:	The DHIS2 training I received was well organized and easy to follow.							
TA7:	I need some further training on using Internet resources to enable me use DHIS2 efficiently.							
Subsection G: Voluntariness of Use		1	2	3	4	5	6	7
VO1	Although it might be helpful, using DHIS2 is not compulsory in my job (i.e. My use of DHIS2 would be voluntary)							
VO2	My use of DHIS2 would be for mandatory routine reporting							
VO3	My use of DHIS2 would be for voluntary analysis of the health facility/sub-county data for informed decision making							

Subsection H: Behavioral intention to use the DHIS2 (BI)		1	2	3	4	5	6	7
BI1:	I intend to use [or continue using] DHIS2 in the next 3 months.							
BI2:	I predict I will use [or continue using] DHIS2 in the next 3 months.							
BI3:	I plan to use [or continue using] DHIS2 when I have access to computer and internet.							

SECTION B: Technology Experience *[Please tick only one option]*

a. For how long have you been using a computer?

Never used ( )
Less than 1 month ( )
1–6 months ( )
7–12 months ( )
1–2 year ( )
2–5 years ( )
More than 5 years ( )

b. Approximately how many hours per week do you use a computer?

Never Use ( )
Less than 1 hour ( )
1-2 hours a week ( )
2-4 hours a week ( )
4-6 hours a week ( )
6-8 hours a week ( )
More than 8 hours ( )

c. How long have you been using the Internet?

Never used ( )
Less than 1 month ( )
1–6 months ( )
7–12 months ( )
1–2 year ( )
2–5 years ( )
More than 5 years ( )

d. Currently, how often do you use the Internet?

Never Use ( )
Less than once a month ( )
Once a month ( )
A few times a month ( )
A few times a week ( )
At least once a day ( )

SECTION C: DHIS2 Usage Behaviour *[Please tick only one option]*

UB1: On average, how often do you use DHIS2?

Do not use at all ( )
Less than once a month ( )
Once a month ( )
A few times a month ( )
A few times a week ( )
At least once a day ( )
Several times a day ( )

UB2: When you do use DHIS2, on average how much time do you spend on the system?

Do not use at all ( )
Less than 15 mins ( )
15mins to 1/2 hour ( )
1/2hr – 1hr ( )
1-2hrs ( )
More than 2hrs ( )

SECTION D: Access to Internet and to DHIS2 *[Please tick only one option]*

a. Do you own a desktop or laptop computer? Yes ( ) No ( )

b. How do you mostly access the Internet for your work? Through:

Never Use for Work ( )
Internet Service Provider (ISP) network ( )
Mobile Provider's Wireless Modem ( )
Cybercafé ( )
Other:_____ [if other, please write it down]

c. Currently, how would you rate the internet access provided at your workplace?

Enough ( )Not Enough( ) Too Much ( )

d. At what places do you mostly access DHIS2?

Not Using DHIS2 Yet ( )
At Home( )
In the Office ( )
At a Cybercafé ( )
Other:_____ [if other, please write it down]

e. Which function of DHIS2 do you mostly use?

None ( )
Data Entry ( )
Viewing Reports [Standard Reports, Dataset Reports, etc] ( )
Advanced Reports [Pivot Tables; Data Visualizer; etc] ( )
Other _____ [if other, please write it down]

SECTION E: Demographic Information*[Please tick the correct option]*

The few questions below will enable us to analyze the data collected based on certain demographic factors such as age, gender and education.

1. What is your Age in years?

Below 20 ( )
20-29 ( )
30-39 ( )
40-49 ( )
More than 50 ( )

2. What is your Gender? Male ( ) Female ( )

3. What is the Highest Education Level you have attained?

High School ( )
Diploma ()

Bachelors' Degree ( )
Master's Degree ( )
PhD ( )
Other …… [if other, please write it down]

4. What is your Profession?

Health Records Information Officer ( )
Doctor ( )
Nurse ( )
Public Health Officer ( )
Pharmacist ( )
Clinical Officer ( )
Other _____ [if other, please write it down]

5. At what level do you currently work?

Health Facility ( )
Sub-county ( )
County ( )
National Health Program ( )
MoH, National Level ( )

SECTION F: Recommendations

1. **Please indicate at most 3 <u>top-most</u> reasons why you think that use of DHIS2 is a good idea:**
   (a)……
   ……
   (b)……
   ……
   (c)……
   ……

2. **Please indicate at most 3 <u>top-most</u> challenges that need to be addressed to make DHIS2 more acceptable / beneficial to users.**
   (a)……
   ……
   (b)……
   ……
   (c)……
   ……

3. **Any other comment related to DHIS2.**
   ……
   ……

APPENDIX 7: SUMMARY OF THE PILOT FINDINGS

1. PILOT STUDY APPROACH

A structured survey questionnaire was used as the main data collection instrument for this phase of the study. The questionnaire comprised a pre-formulated written set of questions adapted from Venkatesh et al. (2003) which were designed to capture information about each of the constructs in the conceptual model. Design of indicators for the new constructs which are not included in the UTAUT model was informed by both the contextual literature review as well as the rich information obtained during the key informant interviews with diverse stakeholders. The reasons for using a structured and self-administered questionnaire as the main data collection tool were the following:

a) This tool provided the quantifiable information required make inferences of the study population's behavioral intentions to use DHIS2 system.

b) A structured questionnaire is the most efficient and effective data collection tool especially when the study had defined variables to measure. Sekaran(2003) agrees that field studies often use questionnaires to measure variables of interest.

c) A questionnaire can be administered to a large number of individual respondents simultaneously; is less expensive, less time consuming and does not require a lot of skills, compared to conducting interviews (Mugenda 2008).

Almost all the constructs were measured using a 7-point Likert Scale ranging from 'strongly disagree' to 'strongly agree'. The exception was the measurement items for Technology Experience and Use Behaviour which used a different measurement scheme as defined by the researchers.

For this pilot phase, an initial group of eleven participants drawn from the main referral hospital in the country were selected to fill in the questionnaire. After completing the survey, a focus group discussion with this group to discuss their experience in completing the survey and receive feedback on any of the questionnaire items which needed to be modified. Only minor editing errors and clarification issues were pointed

out. During the FGD, any item that had been completed erroneously due to lack of clarity was revised. Based on the feedback received, the survey instrument was slightly modified and then administered to eleven other participants from the Kenya Malaria Program. Thus overall a total of 22 respondents participated in the pilot study.

2. PILOT STUDY RESULTS AND DISCUSSIONS

5.1 Content Validity

Evaluation of content validity check seeks to establish whether the research instrument provides a representative tool for measuring the intended content area as defined by the latent constructs. This includes examining the selected measurement items to determine whether they collectively capture the essence of the model's construct in a clear, easy to understand manner. Techniques for assessing content validity include literature review and expert forums or panels (Straub 1989; Cronbach 1951).

Content validity for our research instrument was assessed by literature review as well as conducting instrument pretesting using two different sets of survey respondents and subsequently holding feedback sessions with them. Overall participants in the pilot survey found the research instrument to be comprehensive and adequate in covering all areas relevant to address user acceptance of DHIS2 by health workers in Kenya. Most of the measurement items were also found to be comprehensive and easy to understand. There were however a few suggestions to re-word and re-arrange some items for more comprehensiveness and good overall flow of the questionnaire. All the suggested modifications were implemented in developing the final research instrument whose items are represented in Table 1.

5.2 Descriptive Statistics

Of the 22 respondents in the pilot phase of the study, 59% were female while 41% were male. 77% had a bachelor's or higher level degree. Half of them (50%) held the position of Health Records Information Officers (HRIO) at a public health facility, while the remaining 50% were either doctors, nurses, public health officers, clinical officers or data managers at a national health program. 27% of the respondents used DHIS2 for data entry, 45% for viewing standard reports, and 5% for generating advanced reports while the rest (23%) were yet to use DHIS2.

Table 1 provides the item descriptions and descriptive statistics of all the 47 manifest variables (indicators) measured in this phase and subsequently used to evaluate the study's conceptual model. Most statistical analysis procedures are based on the assumption of normally distributed data whereby the observations are arranged equally and symmetrically around the mean. Two statistical measures commonly used to establish the shape of sample distribution are skewness and kurtosis. Skewness measures the symmetry of a distribution while Kurtosis measures the peakedness of the distribution.

A negative skewness value indicates that the distribution is skewed to the left while a positive skewness value implies that the distribution is skewed to the right. The skewness for a perfectly normal distribution is zero, and any symmetric data should have skewness near zero. In practice the value of the skewness measure lies between +/- 1 and values outside this range indicate a high level of skewness in the distribution (Joanes & Gill 1998).

Kurtosis measures the relative peakedness of the mean in a distribution. The high kurtosis value is associated with a high peak near the mean with a heavy tail in one direction whereas low kurtosis is associated with a flat top near the mean. Values of kurtosis outside of -4 / +4 range indicate a non-normal distribution (Joanes & Gill 1998). Based on these definitions of skewness and kurtosis, it is apparent that the distribution of data for some of the manifest variables is non-normal. Unlike covariance-based SEM. PLS path modeling does not assume normal distribution of variables data and it is thus more suited for analysis of our pilot data.

Table 1: Descriptive Statistics of the Manifest Variables Data

Measurement Items (Indicators)	Mean	Std. Deviation	Skewness Std. Error = .491	Kurtosis Std. Error = .953	Construct Definition
PE1:Using DHIS2 will enable me to accomplish tasks more quickly	5.77	1.378	-1.353	1.642	**Performance Expectancy (PE):** – the degree to which an individual believes that using DHIS2 will
PE2:Using DHIS2 will allow me to accomplish more work than would otherwise be possible	5.86	1.320	-1.639	2.902	
PE3:DHIS2 will enable me to make work related decisions based on better evidence	6.41	.854	-1.455	1.681	

PE4: If I use DHIS2, I will increase my chances of getting a promotion.	3.00	2.204	.910	-.659	enable him or her to attain gains in job performance
PE5: Overall, I would find DHIS2 useful in my job.	6.32	.839	-.693	-1.208	
EE1: My interaction with DHIS2 is or would be clear and understandable.	6.09	.811	-.764	.640	**Effort Expectancy (EE):** the degree of ease of use associated with the use of DHIS2
EE2: It would be easy for me to become skilful at using DHIS2.	6.18	.958	-1.826	4.833	
EE3 Learning to operate DHIS2 is easy for me	6.00	.926	-1.584	4.286	
EE4 Overall, I would find DHIS2 easy to use	6.23	.869	-.963	.408	
ANX1. I feel nervous about using computer systems	1.64	1.497	2.939	8.603	**Computer Anxiety (ANX):** the degree to which anxious or emotional reactions are evoked when using computer technology
ANX2 It scares me to think I could cause loss of data in the system by hitting the wrong key	1.64	1.136	1.881	2.944	
ANX3 I would hesitate to use DHIS2 for fear of making mistakes I cannot correct	1.55	1.101	2.229	4.491	
ANX4r. The challenge of learning about computers is exciting.	2.18	1.651	1.566	2.117	
ANX5 DHIS2 is somewhat intimidating to me	1.55	1.011	2.299	5.805	
ANX6r I look forward to using a computer.	1.55	.671	.860	-.242	
ANX7r I am able to keep up with important technological advances in computers.	1.55	.596	.553	-.524	
ANX8 I feel nervous when using internet-based applications	1.36	.848	2.277	4.270	
SI1: People who are important to me think that I should use DHIS2	5.18	2.062	-.770	-.878	**Social Influence (SI):** the degree to which an individual perceives that his or her peers, supervisors, and important others believe he or she should use DHIS2
SI2: My colleagues think that I should use DHIS2.	5.50	1.896	-.899	-.733	
SI3: The senior management has been supportive in the use of DHIS2 at my duty station	5.86	1.246	-.856	-.319	
SI4: In general, use of DHIS2 has been supported and encouraged at my duty station	5.36	1.706	-1.264	.993	
FC1: I have the resources (e.g. reporting forms, computer, antivirus, etc) necessary to use DHIS2	4.05	2.380	-.222	-1.735	**Facilitating Conditions (FC):** the degree to which an individual believes an organizational or technical infrastructure exist to support use of DHIS2
FC2: Access to the Internet is available any time I want to use DHIS2	4.18	2.281	-.140	-1.647	
FC3: I have the knowledge necessary to use DHIS2.	5.77	1.193	-1.185	.996	
FC4: DHIS2 is compatible with other systems that I use at my work.	4.00	1.826	.052	-.959	
FC5: DHIS2 experts are available for assistance with DHIS2 difficulties	3.50	1.970	.575	-.958	
FC6: I have knowledge sources (e.g. books, documents, consultants) to support my use of DHIS2	3.36	1.840	.819	-.452	
FC7: I think that using DHIS2 fits well with the way I like to work	6.05	1.290	-1.116	-.028	

TA1: The training received on DHIS2 is very helpful in my use of the system	5.68	1.615	-1.293	.761	**Training Adequacy (TA):** the degree to which an individual believes that the training he or she received is enough to enable him or her use DHIS2 effectively
TA2: I have training reference documents that I can consult in my use of DHIS2	5.55	1.625	-.785	-.486	
TA3: I feel the training received is adequate for my efficient use of DHIS2	4.68	1.555	-.499	-.744	
TA4r: I need further training on DHIS2 to enable me use the system efficiently	1.73	1.638	2.627	6.318	
TA5: My training on basic use of computers is adequate for using DHIS2	5.50	1.596	-1.005	.283	
TA6: The DHIS2 training was well organized and easy to follow	5.64	1.465	-.795	-.148	
TA7r:I need some further training on Internet and the World Wide Web to enable me use DHIS2 efficiently	4.45	2.650	-.442	-1.766	
VO1. Although it might be helpful, using DHIS2 is not compulsory in my job (i.e. my use of DHIS2 would be voluntary)	3.82	2.403	.122	-1.631	**Voluntariness of Use (VO):** the degree to which an individual believes that his or her use of DHIS2 is voluntary
VO2r My use of DHIS2 would be for mandatory routine reporting	3.59	2.323	.399	-1.515	
VO3. My use of DHIS2 would be for voluntary analysis of the health facility/sub-county data for informed decision making	3.73	2.097	.227	-1.553	
BI1: I intend to use [or continue using] DHIS2 in the next 3 months.	6.55	.596	-.933	.025	**Behavioral Intention (BI):** the degree to which an individual intends to use DHIS2
BI2: I predict I will use [or continue using] DHIS2 in the next 3 months.	6.55	.739	-2.121	5.725	
BI3: I plan to use [or continue using] DHIS2 when I have access to computer and internet	6.45	.671	-.860	-.242	
Exp1: For how long have you been using a computer?	6.59	1.008	-2.731	7.576	**Technology Experience (Exp):** the duration of past use of computer and internet; and the current frequency of using both.
Exp2: Approximately how many hours per week do you use a computer?	6.36	1.002	-2.085	5.141	
Exp3. How long have you been using the Internet?	6.50	1.102	-2.349	4.920	
Exp4: Currently, how often do you use the Internet?	5.77	.528	-2.394	5.459	
UB1: On average, how often do you use DHIS2?	2.32	1.359	.611	-.729	**Use Behaviour (UB):** The current frequency of using DHIS2; and the average duration of each use session.
UB2: When you do use DHIS2, on average how much time do you spend on the system?	2.77	1.798	.429	-1.253	

Note: All the manifest variables were measured on a 7-Point scale except for Exp4 and UB2 which were measured on a 6-Point Scale

5.3 Evaluation of the Measurement Instrument's Reliability

Reliability is defined as the degree to which a test consistently measures what it is supposed to measure. Using PLS-SEM, reliability assessment is concerned with ensuring that the block of items selected for a given construct are suitable operationalization for

that construct. Reliability of each construct is calculated separately and is independent on the reliability of the other constructs (Straub et al. 2004). For this research, two sets of measurements were obtained using SmartPLS path modeling software, and used to establish indicator reliability and the construct reliability.

Indicator Reliability

The indicator reliability value for a reflective model can be obtained by squaring the outer loading of each manifest variable. A reliability value of 0.7 or higher is recommended, however in exploratory research, a value of 0.4 or higher is acceptable (Hulland 1999; Chin 1998). Generally indicators with loadings of between 0.4 and 0.7 are maintained in the model and only considered for removal if deleting them leads to improved composite reliability above recommended threshold value. It is however expected that indicators with loadings of 0.4 or lower will always be dropped from the reflective model (Hair et al. 2011). For our model, it was necessary to drop one performance expectancy indicator (PE4), one computer anxiety indicator (ANX4r), one social influence indicator (SI4); two facilitating condition indictors (FC3 and FC7); and one training adequacy indicator (TA4r) in order to achieve the recommended level of indicator reliability.

Construct Reliability

Traditionally, evaluation of the constructs' reliability is done by examining the internal consistency reliability (Cronbach's alpha). However Cronbach's alpha has been found to provide a conservative measurement when applied in PLS-SEM, so an alternative measure referred to as 'Composite Reliability' is recommended instead (Hair & Sarstedt, M., Ringle, C.M. & Mena 2012; Bagozzi & Yi 1988). For this study we measured both values and, as represented in table 2, after dropping some items to achieve indicator reliability, measures of both composite reliability and Cronbach's alpha were higher than the recommended minimum level of 0.7 indicating a highly reliable measurement instrument (Fornell & Larcker 1981; Nunnally 1978).

Table 2: Measures to determine the Model's Reliability and Validity

Latent Variable	Indicators	Loadings	Indicator Reliability (=	Composite Reliability	Cronbach's Alpha	AVE
Performance	PE1	0.975	0.951	0.926	0.919	0.760
	PE2	0.983	0.966			
	PE3	0.670	0.449			

Expectancy	PE5	0.822	0.676			
Effort Expectancy	EE1	0.899	0.808	0.934	0.906	0.781
	EE2	0.828	0.686			
	EE3	0.872	0.760			
	EE4	0.932	0.869			
Computer Anxiety	ANX1	0.613	0.376	0.897	0.842	0.690
	ANX2	0.911	0.830			
	ANX3	0.858	0.736			
	ANX5	0.904	0.817			
Social Influence	SI1	0.921	0.848	0.925	0.876	0.806
	SI2	0.974	0.949			
	SI3	0.789	0.623			
Facilitating Conditions	FC1	0.948	0.899	0.935	0.913	0.745
	FC2	0.952	0.906			
	FC4	0.751	0.564			
	FC5	0.871	0.759			
	FC6	0.772	0.596			
Training Adequacy	TA1	0.902	0.814	0.939	0.920	0.754
	TA2	0.889	0.790			
	TA3	0.825	0.681			
	TA5	0.814	0.663			
	TA6	0.906	0.821			
Voluntariness of Use	VO1	0.966	0.933	0.974	0.962	0.926
	VO2r	0.949	0.901			
	VO3	0.972	0.945			
Behavioral Intention	BI1	0.990	0.980	0.963	0.943	0.897
	BI2	0.943	0.889			
	BI3	0.907	0.823			
Technology Experience	Exp1	0.944	0.891	0.956	0.941	0.846
	Exp2	0.881	0.776			
	Exp3	0.953	0.908			
	Exp4	0.899	0.808			
Use Behaviour	UB1	0.985	0.970	0.987	0.973	0.974
	UB2	0.988	0.976			

5.4 Construct Validity Measurements

Construct validity is concerned with ensuring that the measurement items selected for a given construct do indeed collectively provide a reasonable operationalization of the construct. Using PLS-SEM reflective indicators, the construct validity focuses on convergent validity and discriminant validity, and these two were used to examine our measurement model.

Convergent Validity

The convergent validity was measured by examining the factor loadings of the measurement indicators (manifest variables) of the model's constructs. Convergent validity is displayed when the items load more highly on their pre-defined underlying constructs than on any other construct, and when the value of each latent variable's Average Variance Extracted (AVE) is at least 0.5 (Bagozzi & Yi 1988; Fornell & Larcker 1981). AVE is the measure of the variance shared between a construct and its measures,

and this value should be greater that than the variance shared between the construct and other constructs. The measurement instrument in this study exhibited a high level of convergent validity with all manifest variables loading more highly on their associated constructs than on unrelated constructs. All the latent constructs AVE were also greater than the 0.5 threshold (table 2).

Discriminant Validity

A highly reliable measurement instrument should also exhibit discriminant validity, which measures the extent to which constructs differ from each other. Adequate discriminant validity is demonstrated when a construct shares more variance with its measurement variables than with other constructs in the model. According to the Fornell-Larcker criterion, discriminant validity is confirmed when the AVE of each latent construct is higher than the construct's highest squared correlation with any other latent construct (Fornell & Larcker 1981). This is equivalent to comparing the square root of the AVE with the absolute values of the correlations between each construct and all the other constructs in the model. In table 3, the diagonal elements are the square-root of AVE while the off-diagonal elements in the corresponding rows and columns represent the absolute values of the correlations between the constructs. Adequate discriminant validity is confirmed if the diagonal elements are greater than the off-diagonal elements in the corresponding rows and columns

Table 3: Checking Discriminant Validity

	BI	**Anx**	**EE**	**FC**	**PE**	**SI**	**Exp**	**TA**	**UB**	**Vol**
Behavioral Intention **(BI)**	**0.947**									
Computer Anxiety **(Anx)**	0.191	**0.831**								
Effort Expectancy **(EE)**	0.630	0.147	**0.883**							
Facilitating Conditions **(FC)**	0.342	0.206	0.218	**0.863**						
Performance Expectancy **(PE)**	0.165	0.262	0.339	0.222	**0.872**					
Social Influence **(SI)**	0.656	0.075	0.506	0.546	0.561	**0.898**				
Technology Experience **(Exp)**	0.149	0.379	0.243	0.117	0.375	0.135	**0.920**			
Training Adequacy **(TA)**	0.355	0.086	0.476	0.436	0.644	0.537	0.203	**0.868**		

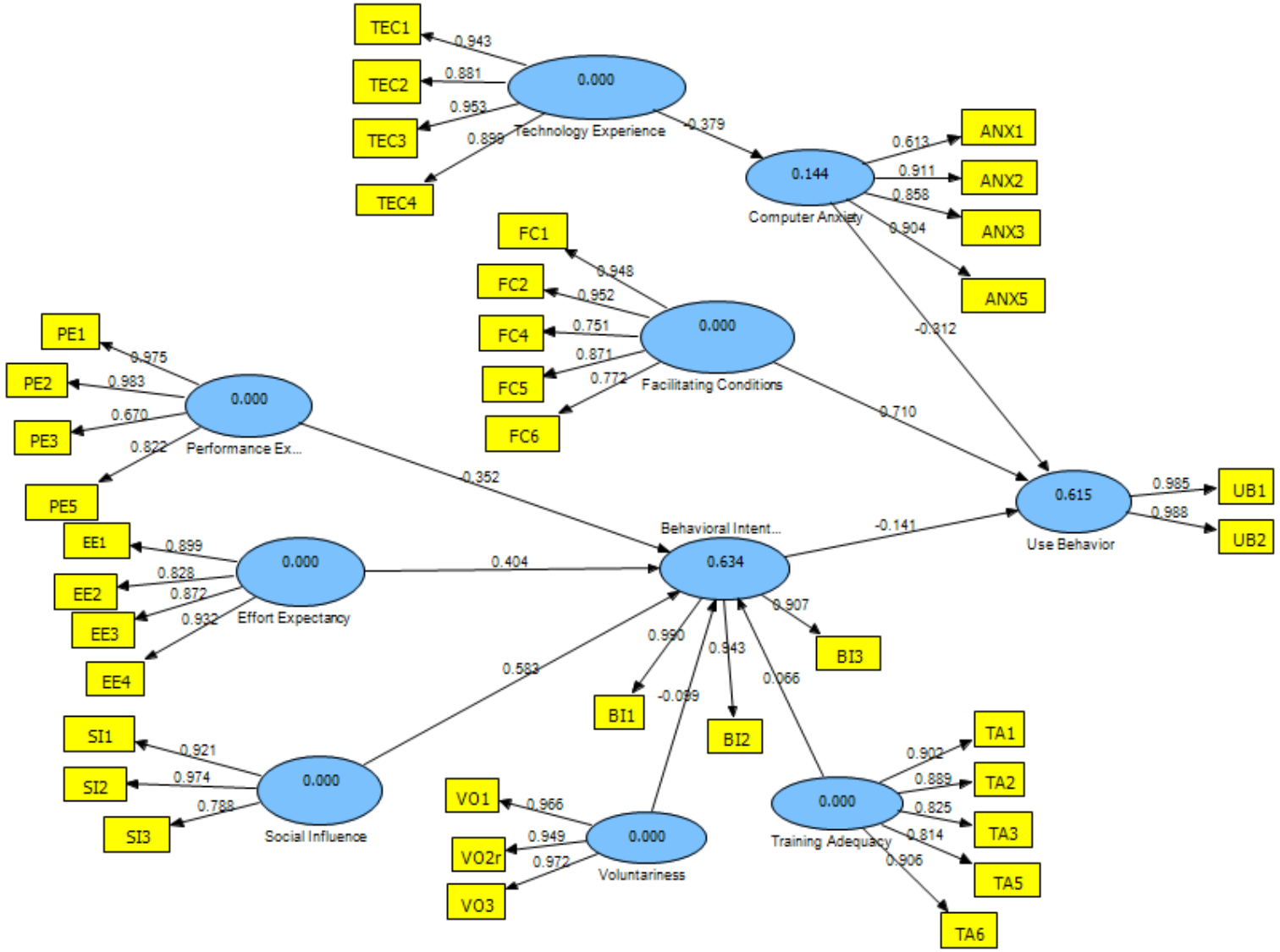
Use Behaviour**(UB)**	0.443	0.192	0.557	0.694	0.347	0.468	0.293	0.744	**0.987**	
Voluntariness **(Vol)**	0.322	0.321	0.191	0.193	0.105	0.302	0.099	0.106	0.173	**0.962**

An alternative way of assessing discriminant validity is by comparing an indicator's loading with its associated latent construct with its loading on all remaining constructs. The latter is referred to as 'cross-loading'. Discriminant validity is established when an indicator's loading on a construct is higher than all of its cross loadings with other constructs, and this was confirmed to be the case for all the indicators in our research model.

5.5 Path Model Estimation (Preliminary Results)

The ultimate purpose of the study is to assess the causal or predictive relationships between the constructs, and subsequently confirm or disconfirm the study's conceptual model and the study hypotheses. The strength of these relationships is demonstrated by the amount of variance explained (R^2) in the endogenous variables as well as the inner model's path coefficient sizes and their significance (Chin 1998). Figure 2 represents the analytical results of structural model after elimination the few indicators which did not meet the minimum recommended reliability levels.

Figure 2: *Results of PLS-SEM Analysis*



Endogenous Variables Variance

The Variance Explained (R^2) for the first level endogenous variable was 0.634 while that for the Use Behaviour was 0.615. This means that the 5 latent variables of Performance Expectancy, Effort Expectancy, Social Influence, Voluntariness of Use and Training Adequacy were able to explain 63.4% of the variance in Behavioral Intention, while the latent variable Behavioral Intention, Facilitating Conditions and Computer Anxiety collectively explained 61.5% of the variance in Use Behaviour. Additionally, Technology Experience explained 14.4% of the variance in Computer Anxiety.

Structural Model Path Coefficients

Examining the inner model shows that Social Influence has the strongest effect on Behavioral Intention (0.583) followed by Effort Expectancy (0.404). Surprisingly the effect of Performance on Behavioral Intention is moderate but negative (-0.352), suggesting that the respondents strong intention to use DHIS2 is not motivated by expectations to attain gains in job performance. For the pilot data, the results indicate that the effects of Voluntariness of Use and Training Adequacy on Behavioral Intention are quite weak at -0.099 and 0.066 respectively.

Another surprising result is the weak and negative effect of Behavioral Intention (-0.141) compared with the strong effect of Facilitating Conditions (0.710) on the second level endogenous variable, Use Behaviour. This result can be explained by the fact that even respondents who were yet to start using DHIS2 still expressed high Intention to Use. As expected the effect of Computer Anxiety on Use Behaviour is relatively strong and negative (-0.312). Finally and also as expected, Technology Experience has some relatively strong but negative effect on Computer Anxiety.

Significance of the Path Relationships

The path coefficients indicate the direction and strength of the relationships between latent variables. There is a general suggestion that the magnitude of standardized path coefficient has to be more than 0.1 if a significant path relationship exists between the variables. This criterion was met in all the structural path relationships for this research model, except for the relationships between the independent variables Voluntariness and Training Adequacy with the dependent variable of Behavioral Intention. The bootstrap procedure of Smart PLS could additionally have been used to test the significance of the structural path relationships using T-statistics, however this was

deemed not useful in this pilot phase of the study considering the very small sample size involved (Hair et al. 2011).

3. CONCLUSION

The purpose of the research was to apply a modified UTAUT model in understanding the factors that influence acceptance of a national health information system by public healthcare workers in Kenya. The pilot phase of the study whose results are discussed in this paper was very useful in confirming the suitability of the proposed study model which was adapted from UTAUT model. The model adaptation was based on information available from Literature review and also based on the findings of a pre-study done through conducting key informant interviews.

The PLS-SEM structural equation modeling done using SMART PLS software was used to ensure the reliability and validity of the blocks of indicators selected to measure each of the constructs in the model. It was necessary to drop a few of the manifest variables in order to achieve reliable and valid measures of constructs prior to drawing conclusions regarding the relationships of the structural model.

The study findings suggested that the adapted model is able to explain high levels of variance in the first and second order endogenous variables at 63.4% and 61.5% respectively. We however recognize that there may be bias in the results primarily due to the very small sample size involved. Nevertheless the pilot phase served the crucial role of refining the research instrument in preparation for the next phase of the research. This subsequent phase involves a large scale survey and adequate data for credibly evaluating the research model. The moderating effects of age and gender are tested in the main phase of the study.

APPENDIX 8: Overall Evaluation of the Study and its Contribution

This overall evaluation of the research study approach and contribution was done based on recommendations by Whetten (1989) in his paper titled "What constitutes a Theoretical Contribution?" Whetten suggested that the value of a research study could be judged by examining two key items, namely:

- The building blocks used in the theory or conceptual model development
- The value-added contributions it makes to theory development

Sub-Section 6.6.1 and 6.6.2 address these two items comprehensively with regard to the current research study.

Appendix 8.1 The Building Blocks of the Study's Theoretical Model

Whetten (1989) referred to other theory development authorities and came up with the argument that a complete theory required four elements namely *what, how, why* and a combination of *who, where and when*(Whetten 1989).

(i) What, How and Why

What refers to the factors included in the theory development and whether they were logically selected to ensure parsimony and comprehensiveness. *How* refers to how the identified set of factors are visually conceptualized to graphically depict their interrelationships which are under consideration. Finally *why* ties up all these three elements by providing the logic and rationale for selecting the factors and relationships. So whereas *What* and *How* describe the study framework, *Why* provides plausible explanation on why we should expect the proposed relationships in our data.

For the current study, conceptualization of the research model followed a detailed approach where information acquired through comprehensive literature review was jointly synthesized with an understanding of the context within which computerization of health information systems is happening in Kenya, gained from

an exploratory qualitative pre-study on acceptance and use of DHIS2 in Kenya (Karuri, Waiganjo & Orwa 2014). This led to an extension of the UTAUT model to include Training Adequacy and Voluntariness of Use as direct determinants of Behavioural Intention, and Computer Anxiety as a direct determinant of Use Behaviour. Technology Experience was also included and postulated to predict the individual's Computer Anxiety. Only two moderators were included in the model, namely gender and age.

While several studies have been identified in literature that used UTAUT to evaluate acceptance of health related technology among health workers, only one of those studies was conceived for a developing country context(Kijsanayotin et al. 2009). And even that one only evaluated acceptance of general heath IT rather than that of an organization level system that is of higher economic importance to entire countries or regions. Therefore, it was important to assess the applicability of UTAUT to developing countries when considering a particular Information System artifact from the healthcare sector. Examining of technology acceptance studies done under different contexts than the ones originally tested has proved the need to modify theories to fit context specific applications. In particular the unique characteristics and challenges faced by developing countries must be taken into account when applying and testing technology acceptance and use studies. By applying the UTAUT model to evaluate acceptance of a public health IT system in developing countries, this model is extended to a new application, a new professional domain (healthcare) and a new geographic zone (Africa).

(ii) Who, Where and When

Whetten proposes that the combination of Who, Where and When are the temporal and contextual factors which set the boundaries of the proposed theory's generalizability, and as such constitute the range of the theory. While conceding that theories cannot be expected to cater for all possible boundary constraints, he stresses that the need to strive to achieve generalizability of the core propositions.

This target population consists of approximately 1100 DHIS2 users representing three distinct categories of health workers in the country who are trained on the use of this system in Kenya. These three categories consisted of Data Management team located either at the health facility or sub-county levels; Regional health management team; and health officers working at the national level. A large sample size of 269 valid responses was obtained for this study, which far surpassed the minimum acceptable sample size of 150. This number represents slightly more than 20% of the approximately targeted 1100 health workers, and these were drawn from at least 10 of Kenya's 47 counties to ensure a good representation of the entire country. Because of the similar ICT implementation environmental characteristics as well as other cultural and political characteristics that Kenya shares with other developing countries, particularly countries in sub-Saharan Africa, the findings from this study can be extended for application in other developing countries.

Appendix 8.2 Identifying the value-added contributions

Whetten (1989) suggested a set of seven questions that can be used to judge a particular study's value-add based on clarity of expression, impact on research, timeliness and relevance. In this sub-section, these questions are addressed in summary form with reference to the current study. Details of the study's value-add are included in section 6.3 of this thesis.

(i) Does the study make significant value-added contribution to current thinking?

The study makes value-added contribution to the current thinking by providing clear evidence that though the factors defined in the UTAUT model do contribute to predicting the intention to use and actual use of HIS in developing countries, they alone are not adequate. There is thus need to examine the contribution of other context-specific factors which have been identified in this study. In addition, the importance of the factors identified in the UTAUT model varies according to the context of implication, with Social Influence playing an unusually significant role in the Kenya setting. Overall testing the extended model contributes to the body of

knowledge that focuses on technology adoption by extending the UTAUT theory and validating it in a new context both in terms of technology (HIS) and low resources (developing countries).

(ii) Will the study change the research practice in the target area?

The target area under consideration in this study was acceptance and use of HIS in developing countries. In addition to the theoretical findings, this study's findings have far reaching practical applications. One of the key findings was that when considering a cross-section of health workers across different cadres and levels of academic achievement, social influence is the most pertinent factor that influences intention to use the HIS. This collaborates the findings in literature that in developing countries, the prevailing culture is such that status and image are important motivators of behavioural change. The other factors of performance expectancy and effort expectancy were also found to be important as identified in UTAUT, so these should also be taken into account by ensuring that the system design is user friendly and that end-users are involved in the system customization. The new factor of Training Adequacy was found to contribute to overall user acceptance of the system, and hence it would be beneficial for managers to carefully plan for this aspect of system deployment. Management needs to ensure that training on the HIS system is done effectively as this will enhance the targeted users' awareness of the system's usefulness and perceived ease of use. When considering the actual use of HIS systems, it emerged that availability of adequate facilitating conditions was most important factor for the full set of health workers involved in this study. This is not surprising considering that it was already identified from literature that developing countries mostly operate from resource-limited settings which hinder effective implementation of computer based HIS. Thus this translates to mean that even where there is high acceptance and intention to use a system, if proper organizational facilitation for use of the system is not provided, then this intention may not translate to actual use of the system. Managers can provide this facilitation through provision of adequate ICT infrastructure such as access to computers and the interne, provision of responsive technical support is not provided and knowledge

resource. Computer anxiety level was also found to be important factor that negatively affects users' actual use of HIS, and this was in turn predicted by the level of technology experience that these users had been previously exposed to. Managers can thus use findings from this study to proactively work to minimize this anxiety by ensuring that health workers are exposed to ICT training from early stages of their careers. If possible such training can be mainstreamed to become a part of the health workers formal pre-service training.

(iii) Are the underlying logic and supporting evidence compelling?

Selection of the factors and relationships studied in this research was backed by rigorous review of the existing literature. This review identified UTAUT as a good foundational theory that can be used to build the unique theory that explains acceptance and use of health information systems in developing countries' context. In summary the researchers made a rigorous effort to provide compelling evidence and justification for the model development by undertaking the following three activities:

- A thorough literature review to gain more understanding both of technology acceptance theories as well as of the of the context in which computerization of health information systems is happening in the low-resource developing countries, of which Kenya is part.
- An exploratory qualitative study was conducted to gain an understanding, from the perspective of key stakeholders, of factors considered as critical to the successful scale up and use of DHIS2 in Kenya.
- Subsequent analysis and synthesis of the findings from the literature review and the exploratory study was done to identify the factors needed to develop an UTAUT-based research model that covers all of the important elements of adopting HIS in developing countries.

(iv) Does the study convey completeness and thoroughness?

This research was conducted in such a way that comprehensively addressed all the building blocks identified by Whetten (1989) as useful in theory or conceptual model

development. The *What*, *How* and *Why* were thoroughly addressed through the rigorous literature review and exploratory qualitative study, both of which were synthesized to inform development of the study's conceptual model. The model was then tested for validity and reliability before testing the proposed relationships between the model factors. Through this rigorous process, the researchers were able to bring forth arguments and recommendations that reflect a broad and current understanding of acceptance and use of technology in public health care setting of developing countries. The qualitative exploratory study and the pilot study provided apt opportunities for the researchers to interact with peers and other stakeholders in the research area. Additionally the researcher published their findings in peer-reviewed publications during the course of the study.

(v) Is the thesis well written and does it flow logically?

The study thesis is written in a logical and easy to follow manner with the aim of appealing to wide readership and more importantly conveying the important findings and recommendations that arose from this research. The first chapter introduces the issues related to the topic under investigation i.e. acceptance and use of health information systems in the public healthcare context of a developing country. In addition to providing an outline of the overall structure of the study, the first chapter also provided the theoretical background and the study motivation. Subsequently it defined the research problem, research objectives and corresponding research questions, as well as the context within which this study was undertaken. Chapter two focused on review of literature that relates to the context of the study. It discusses in detail various technology adoption theories which have been used in the past to explain user acceptance of technology in general. It then zeroes in on use of UTAUT theory specifically in healthcare context, and provides a summary of key findings from studies done in this context. Based on existing literature, the chapter also discusses implementation of routine HIS in developing countries, and the critical role DHIS continues to play in this area in Kenya and beyond. In the third chapter findings from the literature review are synthesized with those from a qualitative pre-study conducted to provide contextual understanding of

the factors considered as barriers or enablers of HIS adoption in Kenya. It is against this background that the research's conceptual model and the twelve associated hypotheses to be tested and analyzed were developed.

Chapter four presents the study methodology which leads up to the testing of the proposed research hypotheses. It includes an elaborate description of the data analysis methods used, including justification for the choice of the statistical techniques, and a presentation of the tests for reliability and validity of the latent constructs included in the research model. Chapter five reports the results of data analysis undertaken in the pilot test and the main phase of the study using different data analysis tools. It reports the results of the descriptive analysis of the quantitative data using PASW Software version 18. Then it goes on to elaborate on all of the steps conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) technique, and the findings obtained in each step. This chapter also reports the outcome of the model constructs reliability and validity tests, and the subsequent evaluation of the 12 proposed research hypotheses to determine whether or not they are supported by the empirical evidence. This last chapter presents a more detailed discussion of the implications of the study results, linking them to the overall study objectives and research questions. It goes on to discuss these implications from theoretical; methodological; and practical systems implementation / managerial perspectives, before discussing possible study limitations of the study and making recommendations for future research.

In addition to this logical flow of ideas in the research, the thesis is written in clear and concise language and formatted in a neat and appealing manner.

(vi) Is the research topic of contemporary interest to researchers in this area?

Researchers are increasingly conducting studies on acceptance and use of ICT in different domains because they seek to understand the factors that influence people to accept and use these ICT systems. Acquiring such understanding adds value to different categories of stakeholders including the system designers, organization

management and even higher level policy makers. Though the use of technology in the health sector has increased rapidly in recent years, especially in developed countries, the number of technology acceptance studies conducted in this sector on acceptance and use of ICT is quite limited(Schaper & Pervan 2007). Yet user acceptance of technology remains one of the barriers to ICT use. In this respect only a few studies are available in literature which cite the application of UTAUT model to study acceptance of technology in the health sector, and the situation is dire when one considers availability of such research in developing countries' context. Thus this study which leveraged the UTAUT model to evaluate the acceptance and use of DHIS2, the newly introduced system for collection and analysis of routine health information in public health sector of Kenya and other developing countries, is both timely and contemporary. It is expected that findings from the study will stimulate further interest in extending and contextualizing technology adoption studies in the developing world context, both in healthcare as well as in other domains.

(vii) Is the topic covered of interest to a broad audience, including academic readers?

The study contributes to the body of knowledge that focuses on technology adoption by extending the UTAUT theory and validating it in a new context both in terms of technology (HIS) and low resources (developing countries). It provides new knowledge that will provide practical contribution to more effective development and implementation of public health IT in developing countries; as well as the associated formulation of health information policies and guidelines. The study also makes a contribution to research methodology by setting an example of how to design an exploratory study for evaluating the causal relationships between different factors contained in a complex study model. For this kind of study second generation statistical techniques such as the partial least squares structural equation modeling (PLS-SEM) used in this study are much more suitable that first generation techniques such as multiple regression, ANOVA or t-tests. This is because SEM has the distinct advantage of being capable of analyzing unobservable or latent variables in a causal model, and this is not possible with first generation statistical techniques.

Additionally using SEM one is able to simultaneously estimate complex causal models which may include many indicators as well as several exogenous and endogenous constructs. Finally the research findings have practical implications for management, including system implementation teams, on the approaches they should use if they want to achieve greater success in implementation of HIS and other public health IT in developing countries. By understanding the factors considered to be critical by users in determining their level of acceptance and use of HIS, this category of stakeholders can plan for more effective HIS systems deployment approaches, including advising system developers on the context specific customization they need to make on their software applications to make them more acceptable to the intended users.

Judging from the available literature, this research represents the first empirical study to apply the UTAUT model in an effort to understand the factors underlying adoption of a national HIS in any context. Findings from this study will inform future approaches in implementation of HIS and other national level public health IT, especially in developing countries. The outcomes from this research should inform different categories of stakeholders to take appropriate course of action by highlighting most influential user acceptance factors and thus enabling them to focus their effort in addressing such relevant factors.