DETERMINANTS OF CLOUD COMPUTING ADOPTION FOR HEALTH SERVICE DELIVERY BY PUBLIC HEALTH FACILITIES IN KISUMU COUNTY, KENYA

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A Research Thesis Submitted in Partial Fulfillment of the Requirements for the Conferment of the Degree of Master of Science in Health Systems and Informatics, Rongo University

2020

DECLARATION

Declaration by the Candidate

I declare that this research thesis is my original work and has not been presented in any other university

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This research thesis has been submitted for examination with our approval as university supervisors

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DEDICATION

To the Lord God, Almighty and to the strengthening of Healthcare Systems in Kenya through technological innovation

ACKNOWLEDGEMENT

I wish to thank the Lord for His Grace and Mercy by enabling me to undertake this work.

My supervisors Prof. George W. Odhiambo-Otieno and Dr. Gabriel Otieno for their comments, guidance and support.

My colleagues Dr. Richard Omore and Dr. Sammy Khaggayi for their mentorship and unending support.

I acknowledge, the Director of Health Kisumu County, Dr. Dickens Onyango, who granted me the authorization to conduct my research in public health facilities in Kisumu County.

I would also like to thank all the facility in-charges and health records and information officers who spared their time to be part of this study.

I am grateful to my fellow students and lecturers from the department of Information Science and Informatics who encouraged and guided me through this research process.

I appreciate my wife for her patience and unwavering support through this journey.

ABSTRACT

Cloud computing has emerged as a technological paradigm to reduce Information Technology (IT) costs, foster collaboration while increasing productivity. Cloud computing if adopted would offer economic benefits (less capital expenditure, lower maintenance costs, reduced IT labor costs and energy savings), operational advantages (enhanced collaboration, improved security, unlimited computing resources and 24-hour platform) and functional benefits (easy integration because it uses standard protocols) and these would improve health service delivery. The healthcare sector has been slower to adopt cloud computing compared to other industries. Furthermore, it has been established that cloud computing adoption is sector specific due to the different features and security levels they need and as such, cloud adoption studies should be sector specific. Locally, there is limited literature concerning the adoption and benefits of cloud computing in Kenyan healthcare sector. The study was done in Kisumu County and it focused on 57 public health facilities in the county. This study was based on a conceptual framework integrated from the Technological Acceptance Model, Theory of Planned Behaviour and Technology-Organization-Environment model. The objectives of the study were to assess the extent of cloud computing adoption, determine the influence of technological factors, establish the influence of organisational factors and evaluate the influence of behavioural factors in cloud computing adoption for health service delivery. The target population was 114 healthcare personnel (facility in-charges and health records officers). The sample size was 88 healthcare personnel and it was computed using Yamane formula (1967) and sample was drawn using stratified random sampling. The study employed a cross-sectional study using questionnaires to collect data from respondents. Data analysis was done using Stata 14.0 software; logistic regression was used to establish the association of health service delivery and determinants of cloud computing adoption. The findings showed that cloud computing prevalence was at 53% and these cloud implementations were deployed as hybrid clouds with Software-as-a-Service (100%) being the most common implementation. Cloud computing adoption influenced health service delivery (Odds Ratio [OR]=7.14, p=0.016).The study found out the following factors to be predictors of cloud computing adoption for health service delivery: Technological factors (technological infrastructure OR=10.29, p<0.0001; technical competency OR=12.27, p<0.0001; security OR=7.40, p=0.0010; privacy OR=11.70, p<0.0001; expert scarcity OR=4.83, p=0.001), organisational factors (Budgetary allocation for IT OR=2.96, p=0.048; firm size OR=21.79 p<0.0001) and behavioural factors (Perceived usefulness OR=10.29, p<0.0001, perceived ease of use OR=8.48 , p=0.002; social influence OR=3.44 p=0.016). From the study findings, I recommend increased adoption of cloud computing to improve health service delivery: bottom-up systems that are unique to facility needs. On technological factors, I recommend, improvement of technological infrastructure in all facilities. On organisational factors, I recommend increased budgetary allocation for IT in health facilities. On behavioural factors, I recommend building the capacity of healthcare personnel in cloud paradigm, related skills and its benefits. I also suggest that future studies can improve on this work by diversifying the target population to include other healthcare workers to better understand use and acceptance of cloud computing for health service delivery.

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LIST OF ABBREVIATIONS AND ACRONYMS

CA	Communications Authority
CIO	Chief Information Officer
COCIR	European Coordination Committee of the Radiological, Electromedical and Healthcare Information Technology
EMR	Electronic Medical Records
EU	European Union
HEAA	Health Facility Equipment Assessment Application
IaaS	Infrastructure-as-a-Service
IBM	International Business Machines
ICT	Information Communication and Technology
ICTA	Information Communication and Technology Authority
iHRIS	Health Workforce Information System
IS	Information System
IT	Information Technology
KHIS	Kenya Health Information System
KNBS	Kenya National Bureau of Statistics
KMFL	Kenya Master Facility List
KPMG	Klynveld Peat Marwick Goerdeler
NIST	National Institute of Standards and Technology
PaaS	Platform-as-a-Service

PU	Perceived Usefulness
SaaS	Software-as-a-Service
SME	Small and Medium-sized Enterprises
TAM	Technological Acceptance Model
TOE	Technology-Organization-Environment
TPB	Theory of Planned Behavior
USA	United States of America
UTAUT	Unified Theory of Acceptance and Use of Technology
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Cloud computing is defined as a model for enabling ubiquitous, expedient, on-demand network access to a shared pool of configurable computing resources (networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction according to the National Institute of Standards and Technology (NIST, 2011).

Before cloud computing, traditional server concept was used; the server was considered a whole unit, which included the hardware, the operating system, the storage and the applications. The virtual server concept, an improvement of traditional server concept, separates the hardware from the server software and servers end up as files stored in an enterprise storage or in a physical box. A virtual server can be serviced by one or more hosts and one host may host more than one virtual server (Steen & Tanenbaum, 2016). Cloud computing takes virtualization a step higher.

Traditional business applications have been expensive and very complicated; the diversity of hardware, software and experts needed to implement and maintain them (Salesforce, 2018). Organizations are under increasing pressure to cut on costs, increase profitability and improve productivity in order to remain relevant in a dynamic business environment (Winans & Brown, 2009). The Healthcare industry is also evolving towards a consumer driven approach to care and the need for greater collaboration (World Health Organization, 2013; Green & Johnson, 2015).

The main goal of cloud computing is to reduce cost of IT while increasing productivity and enhancing collaboration (Brian, 2008). Cloud computing offers healthcare organizations an array of benefits; economic, operational and functional benefits. The economic benefits of cloud computing include less capital expenditure, lower maintenance cost, reduced IT labor costs and energy savings. The operational benefits include unlimited computing resources, enhanced collaboration, a 24 hour platform and improved security. Lastly functional benefits is the potential for broad interoperability and integration. (Cloud council, 2017; Saslow, 2014).

The primary objectives of any health delivery system are to enable all citizens to receive health care services whenever needed, and to deliver health services that are cost-effective and meet pre-established standards of quality according to World Health Organization (WHO, 2010). The health care delivery in both high-income countries and low and middle income countries have been shown to fall short of these ideals (Brandeau, Sainfort & Pierskalla, 2008). Health service delivery in Africa is facing even greater challenges with only 50% of its populace having access to modern health care facilities and most countries spend less than 10% of their gross domestic product (GDP) on healthcare (Oleribe et al., 2019; Clausen, 2015). Technology is one of the solutions that can be embraced to bridge this gap in health service delivery (Kenya Healthcare Federation, 2018). Cloud computing, due to its inherent characteristics and benefits, is an effective platform that healthcare organizations can leverage to improve health service delivery.

Cloud computing and storage infrastructure is growing at an annual rate of 33% worldwide (Cisco, 2018). Health Information Management Systems survey (2014) found out that 83% of IT healthcare organizations in the USA are using cloud services with Software-as-a-Service being the most popular service model at 67%, and the healthcare sector was ranked 7th out of Eight industries in cloud adoption (Silver linings, 2013). Cloud computing, in Europe, has evolved substantially; becoming more robust, secure, open and interoperable. However, the uptake in the European Healthcare sector has been slow; mainly due to a fragmented regulatory framework and security concerns according to the European Coordination Committee of the Radiological, Electromedical and Healthcare Information Technology (COCIR, 2016).

Researchers have indicated that actual adoption depends on sector and enterprise size because of the different features and security levels they need and that cloud adoption studies should be industry specific (Palian, 2018; Sawlani, 2017; Haug, Kretschmer & Strobel, 2015). Healthcare sector has also been slower to adopt cloud computing compared with other industries as was seen in USA (Silver linings, 2013) and Europe (COCIR, 2016). The adoption has been slowed by inadequate communication infrastructure, security concerns, a fragmented regulatory framework and issues of data security and safety arising from involvement of external cloud partners.

Cloud computing in African markets is in the early growth stages, although South Africa has a relatively higher cloud activity, with demand arising from the private sector. It is projected that over the next 5 years, Africa will see the most rapid growth in cloud services. Regionally, the uptake of cloud computing by Medium and Large

businesses was 50% in South Africa and 36% in Nigeria (Cisco, 2013) while overall adoption in Ghana was at 37% (Senyo and Addae, 2015).

The adoption of cloud computing by Medium and Large business in Kenya is at 48% (Cisco, 2013). According to a survey conducted by Communications Authority (CA) and Kenya National Bureau of Statistics (KNBS), 35.6% of public sector institutions use cloud computing services compared to 22.9% of private ventures (CA & KNBS, 2017). Lack of knowledge was the biggest drawback; 53.1% of public institutions not on the cloud and 37.1% of private businesses reported insufficient knowledge about cloud services. Cost, a poor regulatory framework and security concerns were also cited as hurdles. Cloud computing adoption in Kenya has been looked at in certain sectors; insurance companies in Nairobi (Akhusama & Moturi, 2016), Kenyan Universities (Muli & Kimutai, 2015) and Medium and High Tech industries in Nairobi (Wanjiku & Moturi, 2016). However, there is limited research within the Kenyan healthcare sector regarding the drivers of cloud computing adoption and their influence on health service delivery.

1.2 Statement of the Problem

The county government of Kisumu has under its jurisdiction 57 public health facilities (Level3-Level5) (Ministry of Health Kenya, 2018) and it has formulated the Kisumu County Health Bill, 2019 which highlights the need of developing research for health through improving and digitizing the health management information systems (Kisumu Assembly, 2019). Even as the county does this, the need to be able to store, access and share electronically generated data while minimizing costs, creates a technological

aperture that cloud computing would address because of its inherent characteristics and perceived benefits. However, a survey conducted on digital health systems in public health facilities (Muinga et al., 2020) found out that technological infrastructure challenges, computer illiteracy and negative attitude towards digitization, budgetary constraints and long procurement procedures were hindrances to adoption and use of digital health systems. The combined allocation to health by the national and county governments was at 7% of the GDP (Githinji, 2018). Furthermore, 64% of public sector institutions have not adopted cloud computing (CA & KNBS, 2017). Most Health facilities in the county (57%) have not integrated technology in their operations and patient information is still captured using patient books and hard copy forms (Brian, 2016) and as a result health service delivery still suffers from increased human errors, poor clinical outcomes, poor care coordination, practice inefficiencies, no tracking of data over time, limited collaboration and high financial costs (Alotaibi and Federico, 2017). Due to the sector specific-nature of cloud computing adoption and there being limited research on cloud computing adoption in the healthcare sector, this study sought to close this gap by understanding the determinants of cloud computing adoption and how they influence health service delivery by public health facilities within Kisumu County.

1.3 Purpose of the study

The purpose of the study was to establish the determinants of cloud computing adoption for health service delivery by public health facilities in Kisumu County.

1.4 Objectives of the study

i.) To assess the extent of cloud computing adoption by public health facilities in Kisumu County.

ii.) To determine technological factors influencing the adoption of cloud computing for health service delivery by public health facilities in Kisumu County.

iii.) To establish the influence of organisational factors on the adoption of cloud computing for health service delivery by public health facilities in Kisumu County.

iv.) To evaluate the behavioral factors influencing the adoption of cloud computing for health service delivery by public health facilities in Kisumu County.

1.5 Research Questions

i.) What is the extent of cloud computing adoption by public health facilities in Kisumu County?

ii.) What are the technological factors that influence adoption of cloud computing for health service delivery by public health facilities in Kisumu County?

iii.) How do organizational factors influence the adoption of cloud computing for health service delivery by public health facilities in Kisumu County?

iv.) What are the behavioural factors that influence adoption of cloud computing for health service delivery by public health facilities in Kisumu County?

1.6 Justification of the study

Cloud computing is the future of computing and it offers the health sector a strategic advantage in minimizing costs while increasing productivity and has the potential of improving health service delivery. However, the healthcare has been slower to adopt cloud computing compared with other industries. Furthermore, research has shown that cloud computing adoption is sector-specific and cloud adoption studies should be industry specific (Haug et. al, 2015; Sawlani, 2017; Palian, 2018). The study therefore sought to understand what drives or hinders the adoption of cloud computing in the Kenyan healthcare sector and how this would affect health service delivery.

This work will be helpful in understanding cloud computing adoption in healthcare by reveling the technological, organisational and behavioural contexts in cloud computing adoption in the Kenyan healthcare sector and how they influence health service delivery. This will provide a rich body of knowledge on cloud computing adoption and health service delivery that is currently missing and future studies can use this as a reference. Cloud computing providers will also get insight into the cloud computing technologies best suited for public health facilities in this setting.

1.7 Significance of the Study

This work will be beneficial to public health facilities and county health offices in understanding the different constructs that positively influence cloud computing adoption for health service delivery and enhancing them while mitigating against those that have a negative effect, thereby guide them in cloud computing adoption and improved health service delivery. Secondly, it will fill the gap of limited cloud

computing adoption studies in the healthcare sector and future researchers can benefit from this body of knowledge. The national health office will also benefit from this work in the development of policies and strategies targeted towards implementation of cloud computing in the operations of public health facilities to achieve improved health service delivery. Finally, the national government will benefit from this work in policy formulation around cloud computing by gaining a healthcare perspective.

1.8 Scope of the Study

This study focused on the determinants of cloud computing adoption (technological, organizational and behavioral contexts) and their influence on health service delivery. The study covered level 3- Level 5 public health facilities within the geographical context of Kisumu County. Level 1(Community) and Level 2(Dispensaries) are outside the scope of this study based on the assumption that they do not have the capacity to adopt cloud computing in terms of technological infrastructure and human resource. The study was targeted at Facility in-charges to get a management perspective and Health records officers to get a technical perspective to the adoption of cloud computing for health service delivery in this setting.

1.9 Limitations of the study

The study was conducted in the midst of an ongoing health workers go-slow in the county and it was challenging to get the healthcare personnel to be participate in this study. The internet connectivity, which cloud computing heavily relies on, is not homogenous across the country and there is likely to be a differential in the adoption of cloud computing in the county.

1.10 Delimitation of the Study

The researcher conducted mobilization through the sub-county health records officers to mitigate against the health workers go-slow. Despite lack of homogeneity in internet connectivity, uniformity is likely to be achieved over time with the maturity of the telecommunications industry and the development of county governments.

1.11 Assumption of the Study

Since a specific sample was used for the study, it was assumed that sample used would be representative and that facility in-charges and health records officers would give a comprehensive insight to the adoption of cloud computing for health service delivery covering both management and technical dimensions.

1.12 Operational Definitions of terms

Cloud: A technological platform that offers computing, storage and network services via an internet infrastructure.

Health service delivery: Realization of operational, functional and economic benefits of cloud computing in service delivery by public health facilities.

Technological factors: Technological infrastructure and human resource, which organisations can use in their operations.

Organisational factors: Institutional characteristics, structure and resources that drive operations; budgetary allocation, working environment, policy

Behavioural factors: psychological motives of human behavior; perceived usefulness, perceived ease of use, trust and social influence.

Public health facilities: All Level 3- Level 5 healthcare institutions in the county.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Cloud computing is defined as a model for enabling ubiquitous, expedient, on-demand network access to a shared pool of configurable computing resources (networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction according to the National Institute of Standards and Technology (2011). Cloud computing phenomenon is drastically shaking the waters of change in the Information technological environment and has emerged as a major technological innovation across industries to reduce IT costs, foster collaboration while increasing service delivery (Dwivedi & Mustafi, 2010; Choudray & Vithayathil, 2013).

According to the NIST, cloud computing has five essential attributes: *Broad network access*: Capabilities are availed over a network that can be accessed through standard mechanisms. *On-demand self-service*: A client can individually and unaided provision computing capabilities with minimal interaction with service provider. *Rapid elasticity*: computing capabilities that are unlimited and can be purchased in any quantity at any time, can be rapidly and elastically provisioned. *Resource pooling*: The computing resources of the provider are pooled to serve multiple clients employing a multi-tenant model, with the resources dynamically assigned and reassigned based on demand. *Measured Service*: A metering capability is leveraged on computing resources at some level of abstraction appropriate to the type of service e.g., storage, processing, bandwidth, and active user accounts. Resource usage are often monitored, controlled

and reported, providing transparency for both the provider and consumer of the utilized service.

Cloud computing is offered using three standard models; Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) (Voorylus, Broberg & Buyya, 2011). SaaS entails the consumer using provider applications over a cloud infrastructure through either a program interface or a client interface like a web browser. PaaS involves the consumer deploying consumer created or acquired applications created using programming languages, libraries, tools and services supported by the provider over a cloud infrastructure managed by the provider. In the IaaS model, the consumer rents processing, storage, networks and other computing resources over which they can deploy and run software like operating systems and applications.

Cloud computing can be deployed as a Private cloud, Public cloud or Hybrid cloud. Private cloud refers to a cloud infrastructure run solely for an organization while a public cloud refers to cloud infrastructure rendered over a network that is open to the public and Hybrid cloud refers to a combination of two or more clouds offering the benefits of multiple deployment methods but remain distinct entities (Zhang, Cheng & Boutaba, 2010).

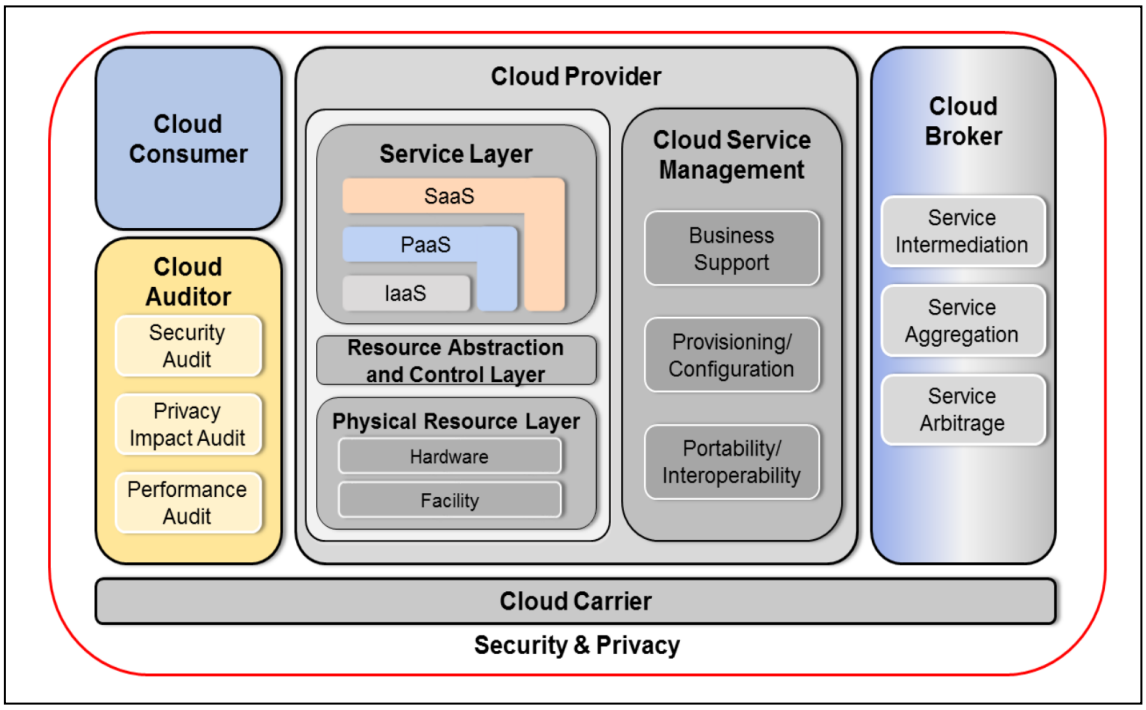

Figure 2.1 *Cloud computing Reference Architecture (NIST, 2018)*

2.2 Extent of cloud computing adoption

The extent of cloud computing adoption refers to the prevalence of cloud computing and the type of cloud service models implemented. The global cloud computing market is projected to grow to $266.4 billion in 2020 up from $196.7 billion in 2018 (Gartner, 2019). SaaS is forecast to still consume the largest market share being projected at $116 billion (44%) and this is largely due to the scalability of subscription-based software. IaaS emerges second with a projected market share of $50 billion (19%) with this demand largely driven by the requirements of modern applications and workloads that need infrastructure that is not tenable in traditional data centers. The breakdown of the global cloud services forecast is shown in **Table 2.1**.

Table 2.1 *Global Cloud Service Revenue Forecast (Gartner, 2019)*

Service Implementation Model	2018	2019	2020	2021	2022
Cloud Business Processing (BPaaS)	41.7	43.7	46.9	50.2	53.8
Platform-as-a-Service (PaaS)	26.4	32.2	39.7	48.3	58.0
Software-as-a-Service (SaaS)	85.7	99.5	116.0	133.0	151.1
Cloud Management and Security Services	10.5	12.0	13.8	15.7	17.6
Infrastructure-as-a-Service (IaaS)	32.4	40.3	50.0	61.3	74.1
Total Market	196.7	227.8	266.4	308.5	354.6

* Figures in Billions of U.S. Dollars

Manufacturing, High-Tech and telecommunications sectors reported the greatest pressure from executive management to fully move to the cloud. In the United Kingdom, 88% of business were using cloud computing while 10% were at the trial phase and only 2% were not in the cloud at all. It is also worth noting that the not only the private sector is using the cloud but the United Kingdom government also spent about £ 650 million in 2018 (John, 2018).

The uptake of cloud computing in the EU as a whole is rather slower with only 26% of enterprises on average using cloud computing in the EU region in 2018. There is a great disparity among EU member-states in terms of adoption with some countries having high adoption: Finland 65%, Sweden 58%, Denmark 56%, the Netherlands 48%, Ireland 46% and Belgium 40% while others like Bulgaria and Romania have very low adoption with less than 10% of enterprises using cloud computing adoption (Magdalena and Maria, 2018). This differential in cloud computing among EU member-states is largely due to a fragmented regulatory framework according to the European Coordination Committee of the Radiological, Electromedical and Healthcare Information Technology (COCIR, 2016). The fragmented regulatory framework has led

to significant differences among European Union (EU) countries concerning cloud computing adoption. Denmark, Sweden, Finland, Austria and Estonia have been much more open to remote storage and archiving of patient data than the Leading EU economies; France, Britain and Germany. Nordic countries lead in terms of cloud computing market maturity in the healthcare sector; the Netherlands, Estonia and Austria are in maturation phase while Belgium, France, Germany, Italy, Spain, Switzerland and Britain are emerging markets; each progressing at a different speed according to the (COCIR, 2016).The EU healthcare sector has a higher adoption in primary care and outpatient settings than in Acute care. This is mainly due to the need to host basic IT functions like scheduling, administration and billing and patient records. Furthermore, there was a higher preference for public cloud (18%) compared to private cloud (11%) in the EU region. In the Asia-Pacific region 90% of large business (more than $1 billion annual revenue) use or anticipate to use multi-cloud environment. Driven by need of consistency of security policy, minimized total costs and overall agility enhancements, 52% of large businesses are using or planning a fully integrated hybrid environment (Liam, 2019).

Despite the huge growth projected in cloud computing market in general, the global healthcare cloud computing market only contributes to a small piece of the pie; it is expected to reach $51.9 billion by 2024 up from $23.4 Billion in 2019 (Markets and Markets, 2019). The healthcare sector only contributes 9% of the projected global market share of cloud computing in 2020. The growth of the healthcare cloud computing market is largely driven by the increased uptake of big data analytics, wearable devices, internet of things and the perceived benefits of cloud computing.

Furthermore, the implementation of favorable regulatory frameworks and the proliferation of high-speed internet are also expected to drive growth. Issues of data security, privacy and data portability complications are expected to suppress the growth of the healthcare cloud computing market. In terms of deployment model, the private cloud had the largest share of the market and this could be explained by the extremely sensitive nature of patient data. While SaaS was the most used service implementation model in the global healthcare market share mainly because of quick deployment time, lower total cost of ownership and less capital expenditure.

The global cloud computing market in healthcare is stratified into two segments by product type; healthcare provider solutions and healthcare payer solutions. Majority of the global market share is dominated by healthcare provider solutions and it is expected to continue growing as more electronically generated data increases even as the healthcare sector evolves towards a consumer driven approach to care and the need for greater collaboration. The healthcare provider solutions include application such as Electronic Health Records, Picture Archiving and Communication System, Population Health Management Solutions, Telehealth solutions, Laboratory Information Systems, Radiology Information Systems, Pharmacy Information Systems, Financial Management Solutions, Healthcare Information Exchange Solutions, Supply Chain Management Solutions and Billing Accounts Management Solutions while healthcare payer solutions include Claims Management Solutions, Payment Management, Solutions Provider Network Management Solutions, Customer Relationship Management Solutions and Fraud Management Solutions (Markets and Markets, 2019; Allied Market Research, 2020).

Regionally, the African cloud computing market is in the early growth stages, although South Africa has a relatively higher cloud activity, with demand arising from the private sector. The uptake of cloud computing by medium and large businesses was at 50% in South Africa and 36% in Nigeria (Cisco, 2013). The overall adoption was 37% in Ghana. Healthcare was however, 7th out of 13 sectors at 31% behind; Telecommunications (100%), IT (83%), Financial (73%), Manufacturing (56%), Mining (40%) and Education (33%). An additional 38% of interviewed healthcare organizations had plans of adopting cloud computing (Senyo & Addae, 2015). But most importantly, it is projected that over the next 5 years, Africa will see the most rapid growth in cloud services. The regions cloud computing infrastructure is expected to grow at 42%, surpassing the global average of 33% (Cisco, 2018). This rapid growth is attributed to a high ratio of internet users connecting with mobile devices compared to traditional fixed point connections.

Locally, 48% of Medium and Large businesses were using cloud computing (Cisco, 2013). Furthermore, 35.6% of public sector institutions use cloud computing services compared to 22.9% of private ventures based on as survey conducted by Communications Authority and Kenya National Bureau of Statistics (CA & KNBS, 2017). Despite the cloud computing adoption accelerating, majority of public institutions and private businesses are not on the cloud. The survey found out that most businesses and public sector did not have a cogent plan of adopting cloud computing. It further shows that the biggest drawback was lack of knowledge; 53.1% of public institutions not on the cloud and 37.1% of private businesses reported insufficient

knowledge about cloud services. Cost, a poor regulatory framework and security concerns were also cited as hurdles.

The adoption of cloud computing by the healthcare institutions could help them to reduce cost, enhance collaboration and increase productivity, all these if realized would translate to improved health service delivery. However, the healthcare sector has been slower to adopt cloud computing compared with other industries as was seen in USA (Silver linings, 2013), Europe (COCIR, 2016) and Ghana (Senyo & Addae, 2015). Despite the growing interest in cloud computing in healthcare domain only few successful implementations yet exist (Griebel, Prokosch & Kopke, 2015). Despite there being some research in cloud computing adoption in other sectors; insurance companies in Nairobi (Akhusama & Moturi, 2016), Kenyan Universities (Muli & Kimutai, 2015) and Medium and High Tech industries in Nairobi (Wanjiku & Moturi, 2016), there is limited research within the Kenyan healthcare sector. Moreover, actual cloud adoption depends on sector and enterprise size because of the different features and security levels they need and cloud adoption studies should be industry specific (Palian, 2018; Sawlani, 2017; Haug, Kretschmer & Strobel, 2015). It is with this background that this study sought to establish the extent of cloud computing adoption by public health facilities in Kisumu County. This study sought to establish the prevalence of cloud computing among public health facilities in Kisumu County as well as the cloud service models implemented.

2.3 Technological factors of cloud computing adoption

Technological factors refers to internal and external technologies as well as the human resource that health organizations can use in their operations (Low, Chen & Wu, 2011). External technologies are those that are available in the market but are not used by the organization while internal technologies are those in use by the organization (Alshamaila, Papaginiadis & Li, 2013). Internal technology in a health organization determine the scope and limit of technological change the organization can take consequently affecting decision to adopt cloud computing. External technologies influence adoption decision by highlighting how organizations can transform by accepting new technologies. Technologies that exist beyond an organization's boundaries can bring the following transformations: incremental, synthetic or discontinuous changes. Incremental changes refer to situations where external technologies only add new features to internal technologies and is normally the least risky transformation. Synthetic changes result from internal technologies being combined in novel ways and this transformation is considered moderately risky. Lastly, discontinuous changes involve external technologies that are radically different from internal technologies (Amini, 2014). Technological resource-infrastructure, technical skills, developers and user time have an effect on successful adoption of IT by an organization (Low et .al, 2011). Firms with high technological competency show a higher likelihood of adopting new technology. Technological context has six constructs: technological readiness (Technological infrastructure and technical competency), service quality (Security, privacy and timeliness) and expert scarcity.

Technological readiness refers to availability of technological infrastructure and human resource which influence adoption of new technology (Low et .al, 2011; Oliviera & Martins, 2011). Technological infrastructure refers to installed network technologies and enterprise systems that provide a platform on which cloud computing can be built on while human resource refers to knowledge and skills needed to implement cloud computing (Wang, Wang & Yang, 2010). Cloud computing adoption would likely be considered if the required infrastructure and technical competence is available in an organization. Organizations vary in terms of technological readiness, from those that are first to adopt new technology to those that are not technologically motivated. Some researchers have found technological readiness to positively influence adoption of cloud computing (Cegielski, Farmer, Wu & Hazen, 2012; Tweel, 2012; Zhu, Dong, Xu & Kramaer, 2008). Contrarily, other researchers found that technological readiness did not significantly impact cloud adoption (Low et .al, 2011; Abdullah & Seng, 2015; Alharbi, Atkins & Stainer, 2016). The differential in influence of technological readiness on adoption of cloud as well as the sector specific nature of cloud computing adoption warranted understanding the influence of technological readiness; technological infrastructure of public health facilities and technical competency of healthcare personnel on the adoption of cloud computing for health service delivery.

Service Quality refers to the customer's perception of the overall quality or superiority of a service with respect to its intended purpose. It is a reflection of cloud computing in the eyes of the client's. It also refers to the entirety of characteristics of a service that bear on its capability to satisfy implied and stated needs of the clients (Odun-Ayo, Ajayi & Falade, 2018). Favorable outcomes in comparison between actual and ideal

performance result in higher customer loyalty. Actual performance short of ideal performance causes physcological tensions in customers. Five measures; tangibility, reliability, responsiveness, assurance and empathy, have been proposed to evaluate service quality of an innovation in organisations (Javed, 2020). Tangibility refers to the physical evidence of the service; physical facilities, equipment used to provide the service and visibility of personnel. Reliability pertains to consistency of performance and dependability. Responsiveness refers the willingness of personnel to provide service; timeliness of service. Assurance relates to knowledge and courtesy of personnel and their ability to inspire trust and confidence. Empathy corresponds to caring; personalized attention to clients (Egedigwe, 2015). Provision of cloud services require effort as the cloud service providers must determine the best software and hardware configurations that will be most appropriate in terms of quality of service for the user while ensuring optimal use of resources. Quality of service guarantees performance and availability and provides a level of certainty that the resource requirements of an application is supported. Service quality is based on characteristics that can be measured, enhanced on and to some extent be guaranteed in advance. In this study service quality was looked at in terms of security, privacy and timeliness.

Security refers to the combination of confidentiality, prevention of unauthorized disclosure of information, integrity, and prevention of unauthorized amendment or deletion of information, and availability, prevention of unauthorized withholding of information (Rouse, 2017). Security remains an important issue related with implementing cloud computing as a technology. There is a paradigm shift with the cloud that increases security concerns. Security concerns vary from physical security

(access to equipment and facilities), logical security, industry compliance requirements and auditability. Perceived security issues include: Insecure interfaces and application programing interfaces, account or service hijacking**,** malicious insiders**,** failure of compliance with government regulations, data ownerships and service and data integration. Adopting cloud computing also offers certain security benefits: Smart scalable security benefits (the ability to extend the security features to multiple locations, edges networks, timeless of response and threat management.), cutting edge cloud security market (cloud providers have the best security experts as well current security techniques in protecting the their cloud platforms and services), standardized security interfaces, cloud security auditing , service level agreement audit enforcement and resource concentration (Alassafi, Alharthi, Alenezi, Walters & Wills, 2016). Researchers have proposed a number of techniques for data protection and attaining highest level of data security in the cloud that would build the confidence of prospective clients on security of the cloud (Yunchuan, Junsheng, Yongping, & Guangyu, 2014). Researchers have found security to have a significant effect on cloud computing adoption (Amini, 2014; Salah, Bin, & Salah, 2015; Zadok, 2018; Sadoughi, Ali & Erfannia, 2019). Prospective clients that believe cloud services that are secure are likely to adopt cloud computing and as a result realize benefits thereby improving service delivery. Cloud computing raises security concerns more than traditional systems, it is therefore worth investigating the effect of security on cloud computing adoption for health service delivery by public health facilities in Kisumu County.

Privacy refers to the ability of a person or a group to conceal themselves or information about themselves, only revealing it selectively (Krumm, 2009). Privacy has three

elements: When, how and extent. In cloud computing, privacy refers to the right to self-determination, that is, the right of individuals to ‘know what is known about them’, be aware of stored information about them, control how that information is communicated and prevent its abuse (International Telecommunications Unit, 2012). Privacy also means whenever users visit sensitive data, the cloud service provider can prevent potential adversary from inferring the user's behaviour by the user's visit model. In institutions, privacy involves applications of laws, mechanisms, standards and processes by which individually identifiable information is managed. The cloud computing paradigm transforms the way in which information is managed, especially as concerns personal data processing. Clients can access cloud services without having any expert knowledge of the underlying technology. The features of cloud computing bring up issues of traditional security, trust and privacy mechanisms. Clients consume cloud services without having knowledge of the physical location of the servers or the configuration of the processing of personal information. A number of privacy and security questions arise in cloud computing adoption and use. Can cloud service providers be trusted? Is the reliability of cloud servers sufficient? What happens if data get lost? What about lock-in and privacy? Will switching to another cloud be difficult? Privacy issues in the cloud can be classified into four subcategories namely: First, enabling users to have control over their data when the data are stored and processed in cloud and preventing theft, nefarious use, and unauthorized resale. Second, guaranteeing data replications in a jurisdiction and consistent state and preventing data loss, leakage, and unauthorized modification or fabrication. Third, responsibility of each party in ensuring legal requirements for personal information. Lastly, what extent of

involvement of cloud subcontractors in processing information (Pearson & Benameur, 2010). The main privacy challenges for cloud computing include: Complexity of risk assessment in a cloud environment, emergence of new business models and their implications for consumer privacy and achieving regulatory compliance. There are concerted global efforts towards development of technical standards, guidelines and methodologies for implementation of privacy by design principles, including assessment of risks to personal information in the cloud which can then be used as best practices by cloud computing service providers to ensure protection of personal information and compliance with legal frameworks (International Telecommunications Unit, 2012). Proper consideration of privacy issues would promote the confidence of prospective users. If healthcare professionals have confidence in the privacy of cloud services then they are likely to adopt cloud computing and realize its benefits which would translate to improved service delivery. Researchers have found privacy to be a predictor of adoption (Salah et al., 2015; Gao & Sunyaev, 2019). Because of the privacy concerns that arises with cloud computing, investigating the effect of privacy on the adoption of cloud computing for health service by public health facilities in Kisumu County, Kenya is worthwhile.

Timeliness refers to how long a customer must wait for service, and if it is completed on time. Enterprises must know what their applications can do on the cloud and whether migration would meet their goals. Issues like the response time needed to process a demand and throughput, how much transaction is possible over a period of time, are important (Ardagna, Casale, Ciavotta, Pérez & Wang, 2014). The ability of cloud services to be processed in a timely manner wins the confidence of clients. Perceived

Service Quality was found to be a predictor of cloud computing adoption and renewal of service among businesses (Padilla, Milton & Johnson, 2015). Learning institutions in Saudi Arabia were also not adopting cloud computing due to perceived service quality, they believed performance, availability and scalability were not fully guaranteed in service level agreements (Almajalid, 2017). Some researchers found service quality have a significant effect on cloud computing adoption (Alsanea & Barth, 2014; Tsai & Hung, 2014; Alkhater, Walters & Wills, 2018). It was important therefore to determine the influence of perceived service quality on the adoption of cloud computing by public health facilities in Kisumu County.

Expert Scarcity refers to lack of qualified and reputable IT professionals in the cloud service market. The cloud ambitions of most Chief Information Officers (CIOs) is pegged on the foundation of a skewed skill base; there are few IT professionals with broad technical competence and working knowledge of cloud platform (Mishra, 2017; Hameurlin et al., 2017; Hudson, 2013). Organizations need cloud-ready skills to help them articulate their cloud computing plans, determine what and how to move into the cloud, how to manage integration with on-site systems along with securing the entire ecosystem. Getting well-rounded cloud engineers and seasoned experts with, is a challenge, skills in the whole range of possibilities of cloud's native services and tools, and DevOps approach to effectively manage configurations, infrastructure, software deployment, and integration. Platform architects, virtualization specialists, scripters, managers and SaaS experts will all be required and there is a chance that positions will remain unfilled. The shortage is projected to be about 5 million globally within the next decade, if nothing is done to mitigate it (Hudson, 2013). Some researchers found expert

scarcity to be a significant factor in cloud adoption (Hameurlin *et al.*, 2017, Almabhouh, 2015). Cloud adoption studies in Kenya have not looked at the influence of expert scarcity on adoption coupled with the sector-specific nature of cloud adoption, investigating of expert scarcity as a predictor of cloud computing adoption for health service delivery was therefore warranted.

2.4 Organisational factors influencing cloud computing adoption

The organisational factors refers to the characteristics, structure and resources of the organization. Organisational structure is important in technology adoption and has an impact on the social interaction among the company's employees (Baker, Dwivedi, Wade, & Schneberger, 2012). The constructs in organisational context are top management support (Budgetary allocation for IT and working environment), policy, firm size and individual difference factors.

Top management support has a role in initiating, implementing and adopting new technologies (Gangwar *et .al*, 2015). Top managers typically support initiatives and get involved in making decisions of adopting new technologies (Bose & Luo, 2011). Top managers set organisational strategy and establish direction for new technologies like cloud computing. The awareness of top management on the potential benefits of adopting cloud computing is essential to manage potential organisational change through an expressed vision and commitment, sending signals of confidence in the new technology to employees in the organization (Low *et .al*, 2011). Internal barriers and opposition to change can be avoided by such support. Top management support is therefore vital for organizations seeking to have a competitive environment while

providing the needed resources to adopt cloud computing. Top management support was investigated in terms of budgetary allocation for IT and nature of the working environment (enabling environment by top management support). Some Researchers have found top management support to be a predictor of adoption in cloud computing (Yigitbasioglu, 2015; Borgman, Bahli, Heier & Schewski, 2013; Ramdani & Kawalek, 2007). Conversely other studies have shown no relation between Top management support and adoption (Gutierrez et .al, 2015; Hassan, 2017). Cloud computing adoption being sector-specific, it was worth investigating the influence of top management support on adoption of cloud computing for health service delivery by public health facilities in Kisumu County, Kenya.

Policy refers to principles, rules, and guidelines formulated to reach certain long-term goals and provide an enabling environment. Cloud computing transcends location, geography and involves cross border data hosting and outsourcing and because of this very nature several grey areas arise concerning privacy, security and intellectual property. Government regulation plays an important role in adoption of technological innovation and as such cloud computing adoption can be encouraged or discouraged by existing regulation (Lai, Lin & Tseng, 2014; Oliveira, Thomas & Espanadal, 2014; Baker et.al, 2012).While cloud computing as a utility is escalating among individuals and organizations, policy issues based on cloud computing are not being extensively recognized (Ali, Soar, Yong & McClymont, 2015; Jaeger, Linn & Grimes, 2008). There is therefore need for more research on policy context with regards to cloud computing. The influence of policy context on the adoption of cloud computing has so far not been addressed by adoption studies in Kenya.

The government has made laudable efforts in developing legislation and policy frameworks regarding the adoption and use of ICTs in the country including emerging technologies such as cloud computing, internet of things, big data among others. Thorough the ministry of ICT, it has come up with the National ICT policy 2016, ICT Authority(ICTA) cloud computing standards and the Data protection Act, 2019.

The National ICT policy 2016 was developed with the overarching objective that the government will ensure that the entire public sector, including service delivery in health, education, and infrastructure, is fully supported by high-quality ICT infrastructure. It highlights appropriate infrastructure is needed because of the increased uptake of internet based and other ICT related services so as to realize social and economic growth. Sustainable growth in the sector relies on the development and provision of a robust ICT infrastructure. The government will continue to promote availability and access to reliable, efficient and affordable ICT infrastructure at county and National level through building secure, high-speed, mobile and ubiquitous new generation ICT infrastructure networks with high-speed links and high-speed wireless broadband networks at village and town levels. Despite the devolved system of governance under the 2010 constitution, telecommunications and ICT is still a mandate of the National government. The Government is thus putting in place measures to encourage investments and rollout of ICT services in the counties. Licensed operators under the Unified Licensing framework, who will be given incentives plus equitable coverage obligations with the support of Universal Service Fund, will address underserved and unserved areas in the counties. Last mile access to solutions will be offered by county-

based service providers supported for licensing by Communications Authority (Ministry of ICT, 2016).

The government will ensure availability and reliability of broadband connectivity through a continued monitoring of the market and through the setting up of quality of service regulatory framework. It will also provide access to government-owned infrastructure assets to industry players, guarantee more affordable internet connection prices as well as promote competitiveness among ICT players. Make available spectrum for and ensure orderly deployment of ultra-high-speed mobile/wireless technologies such as Long Term Evolution/4G and other advance mobile communications networks. Quality of service .Data Centre infrastructure buildout carried out in awareness of globally approved standards will be promoted by the government for purposes of ensuring quality of service under open access. It will also develop incentives to ensure and protect investment in the field of data Centre. The government will facilitate the development and enactment of legislation on localization to support growth in IT service consumption-as an engine to spur data center growth. It will also ensure that Data is processed fairly and lawfully in accordance with the rights of citizens and obtained only for specific, lawful purposes. In order to grow broadband penetration, there is need for affordable devices for citizens to ensure they can access services. There is need for manufacturers to avail low priced devices that are affordable to majority of the Kenyan population. Towards this end, the government will support local production/assembly line for electronic devices through establishment of special economic zones. The government will also promote ICT friendly tax regimes (Zero-rated/Tax holidays) on devices to ensure affordability and penetration of ICT services.

The government will also work towards discouraging counterfeit/substandard devices by enhancing collaboration between government agencies to ensure enforcement of device standards from the point of entry/manufacture to their availability in the market. The government will also support standardization and compatibility through harmonization of device standards that support different technologies. The government through Kenya Bureau of Standards will ensure the design, use and disposal of ICTs is sensitive to the environmental requirements (Ministry of ICT, 2016).

Persons with disabilities are also covered by the policy. In order to enable persons with disabilities to take full advantage of ICTs, the government will ensure that ICT service and emergency communications made available to the public are provided in alternative formats for persons with disabilities. In terms of consumer protection, the government will strive to build a secure and reliable cyber space by prioritizing policy measures that establish a self-adaptive regulatory mechanism. Cross-border and cross sector initiatives will also be developed to further foster international cooperation and policy implementation of consumer protection initiatives.

The policy also addresses e-Health: e-Health delivery systems reinforces fundamental human rights by improving equity of access to healthcare and quality of life. The Government will promote use of ICT in health delivery by building a health network that enables institutions and individuals to exchange electronic records, share information and deliver quality services in both urban and rural areas. The government will also improve performance of health care facilities through the deployment of health management systems, using electronic systems to guarantee a coherent and standardized process for recording patient information. The government will also provide IT facilities

in all public health facilities for administration and management of health processes as well as providing IT training to medical staff. The government will also set standards and norms for IT in the healthcare system. It will also develop legislation governing health information systems and telemedicine. A national resource center for IT in the healthcare system will be established. A centralized database on disease and treatment to be used will be developed as a shared resource tool medical personnel across the country to enhance prompt curative services and better public health management (Ministry of ICT, 2016).

The dynamic nature of ICT's continues to create new and emerging issues that pose new challenges in the governing, administration and regulation of ICT usage. Technological changes in ICT demand that there is corresponding changes in ICT infrastructure, applications, devices, legal and regulatory environment among others. These technological changes come with immense challenges in terms of resources, skills, infrastructure, and other amenities required in order to adapt to the new and emerging ICT technologies such as internet of things, big data and machine-to-machine communications.

The ICT authority (ICTA) through its Cloud computing standard technical committee has developed Cloud Computing Standards to ensure coherence and unified approach to acquisition, deployment, management and operation of ICTs in the public service, as well as state corporations, in order to promote service integration, adaptability and cost savings through economies of scales in ICT investments. The committee identified a total of Nine Standards falling under six different domain areas were identified to be relevant for government ICT Standards. The identified standards were developed

through a process that took into consideration stakeholder participation as well as industry/sector best practices, government requirements and international requirements. The Kenya Bureau of Standards format and procedure for standards development was adopted by the committee in order to bring conformity with other existing national standards. The ICTA Cloud Computing Standard came into effect on 1 October 2016 and shall be reviewed after 3 years. The standard shall provide guidelines on deployment and selection of cloud based computing products and services among government ministries, county government and state agencies. The standard has guidelines on risk assessment, cloud service selection (SaaS, IaaS and Paas), cloud deployment model selection (public, private, hybrid and community cloud) and service level agreement guidelines (ICT Authority, 2016). The table below gives a description of the Cloud Computing Standards. A summary of the ICTA Standards Description is shown in **Appendix 2**.

The government has developed data protection legislation to ensure the protection of confidentiality and integrity of citizens' information. The legislation shall cover the collection, use, retention, security and divulgence of such information, including divulgence to law enforcement agencies. The Data protection Act 2019 was developed to establish the Office of the Data Protection Commissioner; to regulate the processing of personal data; ensure the handling of personal data of a subject is guided by the principles of: lawful processing; minimization of collection; restriction to further processing; data quality; and security safeguards. To establish legal and institutional mechanism to protect personal data. It also provides for the rights of data subjects and

obligations of data controllers and processors; and for connected purposes (Kenya Gazette, 2019).

All data controllers and processors must be registered with the Data commissioner providing a description of the personal data to be processed, the purpose for which the data is to be processed, any country the data may be transferred to directly or indirectly and a description of the risks, safeguards, security measures and mechanisms to ensure the protection of the data. The Data Commissioner may periodically carry out audits of the data controllers and processors systems to ensure adherence with the Act. The Act also highlights that health data of subject may only be processed by a professional or by a person subject to the obligation of professional secrecy. The health data can only be processed for preventive or occupational medicine; assessment of the working capacity of an employee; medical diagnosis; provision of health or social care; treatment or management of health. The bill stipulates that data controllers and processors need to ensure that at least one serving copy of personal data is stored on a server of data center located in Kenya while cross-border processing of sensitive personal data is prohibited. The bill allows for transfer of personal data to another country where proof has been given on the appropriate safeguards as concerns the security and protection of the data or the subject has given explicit consent to the proposed transfer (Kenya Gazette, 2019).

Cloud computing transcends into the realm of architecture and data models and does not address specific problems but provides multiple hard and soft benefits (Macvittie, 2014). Consequently, organizations justify implementations based on the benefits they deem most applicable to their business and operational needs. Cloud computing involves different infrastructure and deployment models that pose challenges to

traditional performance, security and regulatory guidelines. Policy frameworks that encompass all devices and systems and the multiple concerns that arise from adopting cloud computing would bolster cloud computing adoption and use. Cloud computing uses shared computing environment and relies on public internet for transmitting information raising concerns on privacy and personal data protection as well as interoperability between cloud service and lack of data standards. Service disruptions will reduce as technology matures, however 100% reliability is not guaranteed who the bears the risk? Fixed or obscure contract terms may also limit liability and service guarantee thereby infringing on client rights (Davies, 2016). Cloud computing being largely dependent on a reliable internet platform, are cloud providers cushioned against the telecommunications sector in terms of pricing and distribution structures (Jarno, 2015).

Despite the government formulating legislation and policy frameworks to guide and support deployment and use of emerging ICTs in the country, pertinent questions still remain. Are healthcare personnel aware of existing legislation and policy frameworks regarding cloud computing? Does existing legislation and policy frameworks effectively address the depth and breadth of cloud computing? Is there effective implementation of the developed policy frameworks and does the government enforce adherence to laid down procedures and guidelines to cloud computing adoption and use? Does the policy framework support dynamic adjustments or variability in the use of cloud computing in the country? This study sought to addresses these questions and how they influence the adoption of cloud computing for health service delivery by public health facilities in Kisumu County.

Firm size is a major factor affecting adoption of new technology and it acts as resilience for environmental shocks. (Jeyaraj, Rottman & Lacity, 2008). Bigger enterprises have extra resources that motivate the adoption of technological innovations. The uptake of internet and its infrastructures in business is slower in smaller than in larger firms indicating that financial constraints, lack of professional expertise and short term management perspectives are characteristics of small business (United Nations Conference on Trade and Development, 2008), all these are hindrances to adoption of cloud computing. Large firms tend to adopt more innovations, majorly due to their ability to take risk and greater flexibility (Asli, 2010). Firm size is therefore an important predictor of cloud computing adoption and warrants investigation in our healthcare sector. Some researchers have found firm size to be a predictor of cloud computing adoption (Low et al., 2011; Borgman *et al.*, 2013; Espanadal & Oliveira, 2012). However, there is a conflict with regards to the relationship between firm size and the likelihood to adopt cloud computing and further research was needed to establish the influence of firm size on cloud computing adoption for health service delivery in this setting (Bergvall-Kareborn & Nielsen, 2014; El-Gazzar, 2014).

The adoption of cloud computing is largely dependent on the individual difference factors of the decision makers. The Idiosyncrasy of an organization is dependent on the decision maker's cognitive assumptions concerning the future, alternatives and the consequences of these alternatives (Rosenburg, 2011). The strategic and tactical focus of an organization is shaped by the peculiarity of the decision makers' minds. Individual factors are very important in determining if adopting an innovation would be successful (Jha & Bose, 2016). The individual difference factors can be measured by the education,

experience, age and gender. Favorable experience regarding an innovation influences adoption of similar ones due to stimulus generalization (Lai, 2017). Prior experience about cloud computing would enhance individual's ability to simplify complexities and improve perceived usefulness. Education influences personal innovativeness, belief systems, risk-taking, cognitive preferences, and receptivity of an innovation (Jacques & Elma, 2019). The decision maker's age and gender influence the aptness to try out novelty. Early adopters in technology-led markets are commonly young and male (Lu *et al.*, 2008). Research of individual factors on cloud computing adoption at the organisational level is limited (Ogunlulo, 2017) and investigating the influence of individual difference factors on the adoption of cloud computing for health service delivery by public health facilities in Kisumu County was worthwhile.

2.5 Behavioural factors influencing cloud computing adoption

Behavioural factors refers to psychological factors like emotional, cognitive, personal and social processes that drive human behavior (American Psychological Association, 2018). It refers to psychological factors that determine the decision to adopt or not to adopt a given technology. Behavioural context can be discussed in terms of Perceived usefulness, Perceived ease of use, trust and social influence.

Perceived usefulness is the user's subjective belief that using a new technology will improve operations. The probability of adopting new technology increases when a firm perceives a relative advantage in that innovation. Cloud computing offers a pay-for-use platform that is scalable, flexible, offers great processing power on demand and allows for collaboration between stakeholders (Avram, 2014). Customization, ease of data

analysis, reduction of deployment time and ubiquitous access have also been highlighted as possible benefits (Hsu, Ray & Hseih, 2014). This study looked at Perceived usefulness through the sub-indicators of improved efficiency and accomplishing tasks quickly. Some studies have found Perceived usefulness to be among the influential factors in cloud computing adoption by organizations (Gangwar, Date & Ramasway, 2015; Gupta, Seetharaman & Raj, 2013; Low et .al, 2011). On the contrary, other studies have found no relation between perceived usefulness and adoption (Hassan & Nasir, 2017; Gutierrez, Boukrami & Lumsden, 2015; Alhammadi, Stainer & Eardley, 2015). However cloud computing adoption being sector-specific, the study sought to establish if the influence of perceived usefulness on adoption of cloud computing by public health facilities in Kisumu County.

Perceived ease of use (PEOU) as described in the technology acceptance model refers to prospective user's assessment of mental capacity required to use the new technology (Davis, 2003). Technologies that require less mental effort to use attract more adoption behaviour. Perceived complexities in user interface and learning curve in new technologies hinder adoption (Otieno, 2015). Difficulty in comprehending and applying a new technology increases associated risk (Richardson, 2011), resulting in resistance, fear of failure and slower recognition of the technology's value (Gupta *et al.*, 2011). PEOU is a proven determinant of user's intention to accept IT and there is a positive relationship between ease of use and attitude towards adoption (Davis, 2003). Some adoption studies have found PEOU to be a significant factor in cloud computing adoption (Lee, Lee, Olson & Chung, 2010; Changchit, 2014; Yuvaraj, 2016). Contrarily, other studies did not find a significant relation between PEOU and adoption

(Low ET .al, 2011; Tehrani & Shirazi, 2014). The sector-specific nature of cloud computing adoption therefore warranted establishing the influence of PEOU on cloud computing adoption by public health facilities in Kisumu County.

Cloud computing offers cost reduction and flexibility but it also affects traditional security, trust and privacy mechanisms. Privacy refers to the ability to determine what personal information to be shared to third parties in a computer system, Security refers to preservation of confidentiality, integrity and availability of information while trust refers to the intention to accept the vulnerabilities based on the positive expectations of the intentions. Trust is broader than security as it includes subjective criteria and experience. People often find it harder to trust on-line services than off-line services because of absence of physical cues and there may not be established centralized authorities in the digital world (United Nations Conference on Trade and Development, 2019). The risks of cloud computing are not fully understood and public risk perceptions of cloud computing will be crucial for the realization of technological advances (Catteddu, 2011). Security concerns was identified by Chief Information Officers as the top reason for not aggressively embracing public cloud in UK (Cloud industry forum, 2011). Data subjects, consumer advocates and regulators have added to the growing concern of the impact on personal data protection. The cloud aggravates the strain on traditional frameworks for privacy, for example, Location matter from a legal standpoint but in the cloud information can be in multiple places, managed by different entities. Privacy arises as an issue if the cloud handles personal information and is dependent on the cloud deployment model. Traditional security perimeter like firewalls become blurred in public and hybrid clouds as confidential information is processed

outside trusted areas since computing environments have fuzzy boundaries. Overall, there is a paradigm shift with the cloud that increases security and privacy concerns which ultimately affects trust of users. Some researchers have found trust to be a predictor of cloud computing adoption (Hashemmi, 2013; Moqbel, Bartelt & Cicala, 2014). The paradigm shift occasioned by cloud causes issues of trust and it is necessitated understanding the influence of trust on adoption of cloud computing for health service delivery by public health facilities in Kisumu County.

Social influences moves from functional to psychological motives of behaviour as they define other peoples' opinions, superior influences and peer group opinions. The Theory of Reasoned Action (Azjen & Fishbein, 1980) posits that attitudes towards doing a behavior are positively related with intentions to perform that behavior and predict actual behavior; attitudes are influenced by social influence (Dinev, Goo, Hu & Nam, 2008). It is an important determinant of intention and sociologists believe that often group member's exhibit cohesiveness even against their own feelings in order to show commitment to group norms. Peers as well as those in authority also affect social influence (Venkatesh & Morris, 2000). Some researchers have found social influence to be a predictor of cloud computing adoption (Moqbel, Bartelt & Al-Suqri, 2014; Lian, 2015; Amponsah, Panford & Acquah, 2016). Because of the differential adoption of cloud computing across sectors establishing the effect of social influence on cloud computing adoption for health service delivery by public health facilities in Kisumu County was important.

Healthcare organizations leveraging cloud-based computing and cloud services experience an array of benefits in comparison to in-house client-server systems;

including economic, operational and functional advantages. These benefits are likely to drive the behavior of healthcare organizations.

2.5.1 Economic status

Economic status refers to how the financial position of an organisation may change as a result of adopting cloud computing. Cloud computing is a significant shift in the business and economic models for provisioning and consuming Information technology that can lead to cost savings. Cloud computing provides for pay-for-use computing resources that supports the shift from capital-intensive technology investments to operational costs. When a cloud infrastructure is introduced in an enterprise majority of the IT tasks is shifted to providers, according to IBM IT labor costs is reduced by 50%. Energy costs for small business is also reduced by 90% (Netmetix, 2011). This cost savings can be realized through the use of significant pooling of computing resources, which is one of the characteristics of Cloud computing as defined by National Institute of Technology. Resource pooling refers to the capability of a cloud infrastructure to serve many customers employing a multi-tenant model with different physical and virtual resources dynamically assigned and reassigned guided by demand. With the maturity of the cloud paradigm, it is becoming increasingly well understood that companies and organizations of all sizes – from the smallest Small and Medium-sized Enterprises(SMEs) to the largest enterprise or public agency – can realize highly compelling economic benefits by adopting cloud computing solutions(Jacques, 2011). A Survey by Klynveld Peat Marwick Goerdeler (KPMG) found that 70 percent of businesses say that the cloud has already brought them significant efficiencies and cost

savings (Merrett, 2013). The economic benefit can be realized through: Less capital expenditure, traditional and legacy on premise systems require large upfront capital investment in terms of hardware, servers and infrastructure while cloud computing offers on-demand network access to computing resources with minimal management effort that is provisioned on a pay-per-use basis. This involves very little upfront costs. Migrating to the cloud eliminates capital expenditure and replaces these major up-front costs with predictable and manageable operating costs. This transition lowers the risk associated with strategic IT projects, thereby keeping the business agile by allowing for more experimentation and entrepreneurship (Plex, 2016; Jackson, 2011).

Fast expansion is also another aspect of the economic benefits of cloud computing. The time to deploy a new application drops significantly, as servers can be brought up and repurposed in a short time. Only the internet connection is needed to add new users and locations. New locations can be fully integrated simply by adding them to the database and connect to it via the internet. A new server can be dialed up and imaged through a self-serve control console rather than installing and networking a new hardware server (Plex, 2016; Jackson, 2011). This mechanism allows for fostering of innovation by allowing new configurations to be tried quickly and easily without having to pay for each new configuration. Lower maintenance costs also lead to economic benefits; cloud computing offers opportunity for infrastructure savings. Servers, databases, middleware, replacement costs, upgrade and maintenance of legacy systems can eat into the IT budget. Since cloud computing uses minimal physical resources, there is less hardware to be powered and maintained. Cloud computing eliminates the need for management of infrastructure, maintenance, or software versions and fixes. The economic benefit of

cloud computing is not in doubt. It is a pay-per-use approach to computing which is available at a fraction of the cost of traditional IT services, eliminates upfront capital expenditures and reduces administrative burden on IT resources.

2.5.2 Operational capability

The operational benefits of cloud computing include security; cloud computing offers an added layer of security and protection of sensitive data stored. Employees often work around laid IT rules in a bid to get easier access to their work files. This work around often don't follow security policies and they create enterprise vulnerabilities for data loss and information breaches (Becker hospital, 2015). Cloud computing offers user access to documents and files from anywhere or on any device while keeping the information secure. Cloud computing offers sophisticated security controls, including data encryption and fine-grained access controls and access logging. Cloud computing platform is usually safer, in terms of security, than traditional information systems because cloud providers like Google and Amazon can attract and retain better qualified cybersecurity personnel than many business (Maritz, 2018;). With the internet as its base network, cloud computing is free from any physical threats with data easily accessible. Cloud computing offers scalability as one of its characteristics; Capabilities can be rapidly and elastically provisioned automatically, to quickly scale out and rapidly released to quickly scale in. storage of data in the cloud offers more computational scale because organizations can store exponentially more data in the cloud than they are when storing locally. Cloud computing offers its user's collaborative platforms that enhances sharing of data and collaboration between different stakeholders.

Collaboration is vital to the healthcare industry; by allowing professionals to store and access data remotely; healthcare professionals around the world can gain access to patient data immediately and offer care immediately. In addition, cloud computing allows remote conferencing, up-to-the-second updates on healthcare developments and patient conditions which enhance collaboration and care quality (Ferkuon, 2014). Data analytics features a great potentiality to support clinical decision-making, enhance patient safety and enable continuous learning process within the healthcare delivery process. However, traditional IT network platforms may not easily fulfil the computational capabilities and flexibility it demands. Healthcare providers can turn to cloud computing for scalable storage capacity, greater processing power and timely access (COCIR, 2016). Users of cloud computing are offered 24-hour functioning which increases its accessibility; personnel are no longer tied to office hours access their files and can thus work whenever they want.

2.5.3 Functional potentiality

The Functionality of healthcare can be enhanced by cloud–based IT systems that offer the potential for broad interoperability and integration. Cloud computing services in Healthcare are internet based and usually use standard protocols, so connecting them to other systems and applications is typically straightforward. However, Electronic Medical Records (EMR) vendor contractual and technical impediments still present challenges; technical and legal agreements still make it complicated to integrate with EMR systems (Cloud council, 2017). The sharing of information easily and securely is a critical capability that is enabled by cloud computing. Cloud computing supports rapid

development and innovation, particularly for Internet of things and mobile devices, and as a results satisfies the demands placed on healthcare IT systems by new and advancing technologies. Cloud computing enables remote access to applications and data the internet using wireless and wired systems; access is granted at anytime from anywhere that internet connectivity can be established. Access to a larger ecosystem of healthcare providers, payer, life sciences and IT solution partners is offered by cloud computing. This increases the potential for a wide range of services to healthcare provider organizations.

2.6 Theoretical Framework

Theories of adoption in IS discipline are aimed at understanding, or predicting how, why and to what extent individuals, firms or organizations will adopt and agree to deploy a new technology (Choudrie & Dwivedi, 2009). Examination of IS adoption and diffusion innovation theories reveal that the role of organisational and environmental factors are not fully integrated in most adoption/diffusion theories (Parker & Castleman, 2009).

Understanding the dynamics at work in the adoption of cloud computing in healthcare would be key in fast tracking the adoption so that the healthcare sector can realize sustainable value from investing in Cloud Computing technology. Various theoretical frameworks underpin the understanding of IT adoption behavior in an organization. The technology-organization-environment (TOE) framework created by Tornatzky and Fleisher (Tornatzky & Fleisher, 1990). It describes the influence of Technological, organisational and environmental contexts on the adoption and implementation of an

innovation by an organization, while the Technology Acceptance Model (TAM) posits that perceived usefulness and perceived ease of use determine an individual's intention to use a system with intention to use serving as a mediator of actual system use (Davis, 2003). The integration of TAM and TOE constructs brings both human and non-human actors into the network and provides a richer theoretical lens for understanding cloud computing adoption behavior in healthcare (Awa, Ukoha & Emecheta, 2012).

In this study, the researcher therefore drew from the integrated TOE, TAM and Theory of Planned Behaviour (TPB) frameworks to study the adoption cloud computing by public health facilities in Kisumu, Western Kenya. Accordingly, the researcher looked at the influence of technological, organisational and behavioral contexts on the adoption of cloud computing. The TAM constructs of individual different factors, perceived trust and perceived service quality were integrated into TOE as well as social influence from TPB to provide a richer theoretical lens for understanding cloud computing adoption for health service delivery by public health facilities in Kisumu County.

2.6.1 Technological Acceptance Model (TAM)

TAM is an information system that models the acceptance and usage of a technology by users (Davis, 2003). The model was first proposed by Fred Davis and subsequently modified over the years to fit into developing technology. TAM postulates that perceived usefulness and perceived ease of use influence an individual's intention to use a system with intention to use serving as an intermediary of actual system use. Furthermore, perceived usefulness is considered to be directly influenced by perceived ease of use. Perceived usefulness is the degree to which a person believes that using a

particular system would enhance his or her job performance; people are more likely to use an information system that they believe will help them perform their job better. Perceived ease of use is the extent to which a person believes that using a particular system would require less mental effort. If a system is too difficult to use, the potentially enhanced performance benefits to be derived from the system are outweighed by the effort required to use it.

The original TAM has been modified into more advanced forms: the first modified version (Bagozzi, 2007) the final modified version (Venkatesh & Davis, 1996), TAM2 (Venkatesh & Davis, 2003), the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Davis, 2003) and TAM3 (Venkatesh, 2003). According to King and He (2006), four kinds of modifications contributed to the evolution of TAM: (1) altering external antecedents; (2) amending predictive variables; (3) manipulating moderator variables; and (4) varying consequence measures.

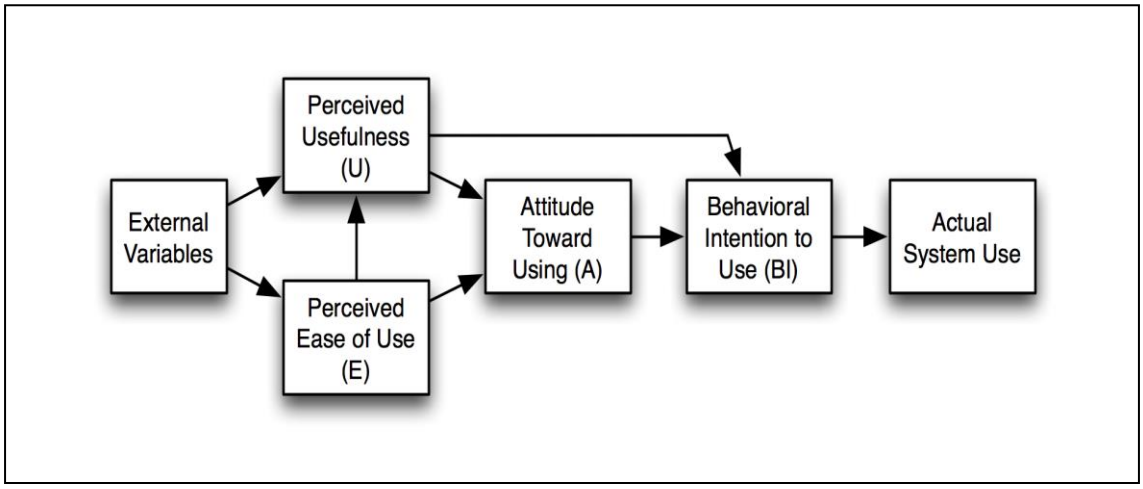

Figure 2.2 *Technological acceptance model (Davis, 2003)*

The researcher used TAM to enrich the integrated framework by incorporating perceived usefulness and perceived ease of use constructs to provide a richer theoretical lens for understanding cloud computing adoption for health service delivery. These constructs were incorporated under behavioral factors in the conceptual framework to gain a better understanding of the influence of behavioural context on the adoption of cloud computing for health service delivery.

2.6.2 Technology-Organization-Environment (TOE) Framework Theory

DE Pietro proposed the technology-organization-environment (TOE) theory in 1990 to analyze the adoption of technological innovations by firms and organizations. The TOE framework posits that adoption of IT technology by firms and organizations is influenced by three different context groups: technological, organisational, and environmental contexts (Melville & Ramirez, 2008).

The researcher drew from TOE to enrich the integrated framework by incorporating constructs of technological and organisational contexts to provide a richer theoretical lens for understanding cloud computing adoption for health service delivery. The indicators of technological and organisational factors in the conceptual framework were incorporated from the TOE framework to help understand the influence of technological and organisational contexts in the adoption of cloud computing for health service delivery.

2.6.3 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior was developed as an improvement on the predictive power of theory of reasoned action by adding the perceived behavior control construct

(Ajzen, 1991). TPB links one's perspectives and behavior, and has been applied to studies of the relations among beliefs, attitudes, behavioural intentions and behaviors in various fields like public relations and healthcare. It predicates that attitude regarding behavior, subjective norms, and perceived behavioural control, model an individual's behavioural intentions and behaviors.

TPB postulates that individual behavior is driven by behavioural intentions; behavioural intentions are a function of attitude toward the behavior, the subjective norms surrounding the performance of the behavior and the individual's cognizance of the ease required to execute the behavior.

The researcher used TPB to enrich the integrated framework by incorporating the construct social influence to provide a richer theoretical lens for understanding cloud computing adoption for health service delivery. Social Influence were incorporated under behavioral factors in the conceptual framework to help understand the influence of behavioral factors on cloud computing adoption for health service delivery.

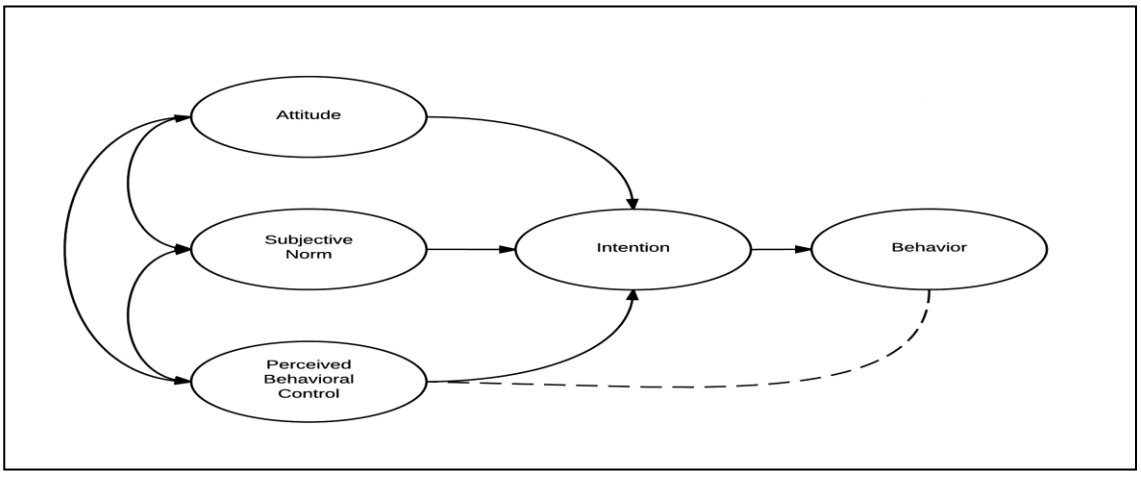

Figure 2.3 *Theory of Planned Behavior (Orzanna, 2015)*

2.7 Knowledge Gap

Cloud computing adoption is sector-specific because of the different security levels and features. While there has been research on cloud computing adoption factors in other sectors (Insurance, banking and tertiary learning institutions), there is limited research on Cloud computing adoption in the Kenyan healthcare sector. The extent of cloud computing adoption in Kisumu County has not been evaluated. Furthermore, the influence of technological, organisational and behavioral contexts on the adoption of cloud computing for health service delivery in the County has not been addressed. Health service delivery in the county still has challenges (human errors, practice inefficiencies, poor clinical outcomes, lack of collaboration and budgetary constraints) and cloud computing because of its inherent characteristics and benefits would help to address some of these challenges if adopted by public health facilities. The study remained critical in establishing the technological, organisational and behavioural factors of cloud computing adoption influencing health service delivery in Kisumu County.

2.8 Conceptual Framework

A conceptual framework is a hypothesized model for identifying concepts under study and an existing relationship. In this study, the dependent variable was health service delivery and was looked at in terms of economic status, operational capability and functional potentiality. Cloud computing adoption was an intermediate variable. The independent variables were technological (technical competency, technological

infrastructure, security, privacy, timeliness and expert scarcity), organisational (budgetary allocation for IT, working environment, policy, firm size and individual difference factors) and behavioral (perceived usefulness, perceived ease of use, trust and social influence) factors. The constructs for technological and organisational factors were drawn from TOE framework while constructs for behavioural factors were drawn from TAM and TPB.

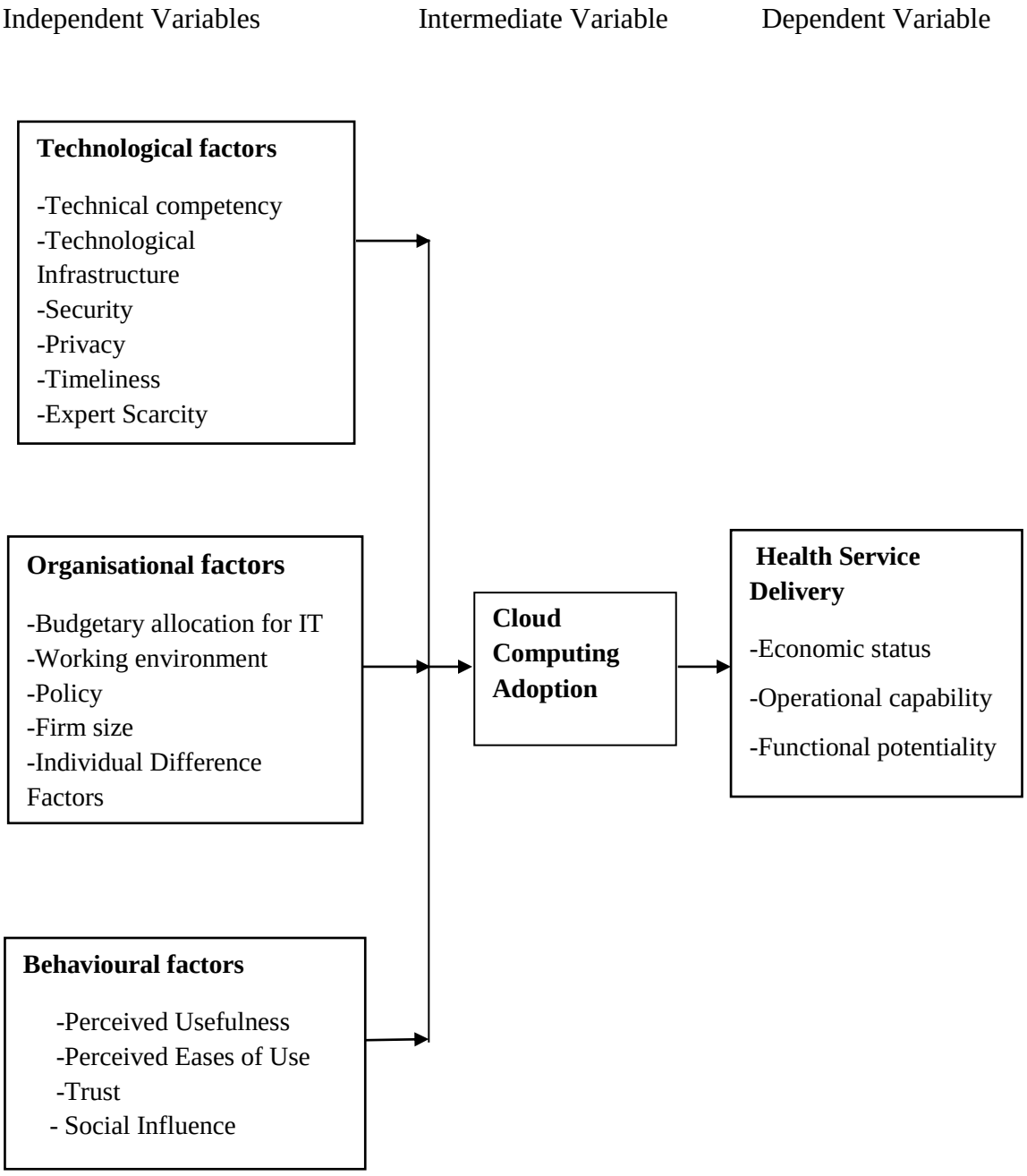

Figure 2.4 *Conceptual Framework*

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This study sought to establish the determinants of cloud computing adoption for health service delivery by public health facilities in Kisumu County, Western Kenya. This section highlights the study design, the target population, the sampling procedure, instrumentation, the methods used in data collection, the methods that were employed in the analysis of data and finally how the results were presented.

3.2 Research Design

This study used a quantitative approach. The quantitative approach involved a cross-sectional study design that entailed a one time collection of data from sampled healthcare personnel in public health facilities in Kisumu County using questionnaire. Cross-sectional study was used as it involves the measuring of outcome and exposures in a population of interest at a given point in time without changing or modifying the indicators under examination. The researcher employed this design to determine the influence of technological, organisational and behavioural contexts, on cloud computing adoption for health service delivery by public health facilities.

3.3 Study Site and Target Population

This study was conducted in Kisumu County located in Western Kenya by the shores of Lake Victoria and it has under its jurisdiction 57 public health facilities: Level 3-34; Level 4-22; Level 5-1 (**Appendix 3**). The study focused on public health facilities as they have lower health care costs compared to private hospitals and most of the populace seek care in public health facilities.

The target population refers to the entire group of individuals for which any study intends to examine and draw conclusions from (Barnsbee, Barnett, Halton & Nghiem, 2018). The target population for this study was 114 healthcare personnel from 57 public health facilities (Kenya Master Health Facility List, 2018). They were facility in-charges and health records information officers in Level 3 to Level 5 public health facilities in Kisumu County, Kenya. Facility in-charges were considered for inclusion in this study because they are the decision-makers in the day to day running of the health facilities and would therefore have a say in the adoption of cloud computing. Health records information officers were included in this study because they are the end-users of most health information management systems. In most facilities they also doubled up as the IT personnel providing user support and maintenance of systems, they would therefore offer great technical insight.

In determining technological factors influencing cloud computing adoption, facility in-charges and health records were considered to give both a technical and non-technical perspective on technical competency, security, privacy, timeliness and expert scarcity. While for organisational factors both of them were involved to give a management perspective and non-management perspective on budgetary allocation for IT, working environment and policy from both personnel who had an influence on the decision to adopt cloud computing by public health facilities. Lastly, for behavioural factors both were involved to give a comprehensive understanding of the psychological motives of behaviour namely perceived usefulness, perceived ease of use, trust and social influence.

3.4 Inclusion criteria

Inclusion criteria define who can be incorporated from the study sample: inclusion criteria identify the study population in a consistent, reliable, uniform and objective manner (Garg, 2016). Healthcare personnel (Facility in-charge and health records officer) in any public health facility in Level 3 to Level 5 were included in the study. Level 1 (Community) and Level 2 (Dispensaries) health facilities were not included in this study because they lacked the requisite technological infrastructure upon which cloud computing can be deployed. All facility in-charges and health records officer in these facilities were included the study. The most senior health records officer was considered in facilities that had more than 1 health records officers.

3.5 Exclusion criteria

Exclusion criteria encompasses characteristics that make the recruited population ineligible for the study (Garg, 2016). The exclusion criteria for this study involved excluding public health facilities (Level 3-Level 5) that did not have a health records information officer posted in the facility. They were excluded as the health records information officers were the end users of most health information management systems and they also double up as IT personnel in the facilities therefore technical insight would be lacking and such facilities would rely on the sub-county health records information officer to offer the required services to them remotely.

3.6 Sampling procedure and Sample Size

The study used stratified random sampling method to draw the sample from the sampling frame based on the level of facilities as shown in **Table 3.1**. Stratified random

sampling enables one to obtain a sample population that best represents the entire population of interest by dividing the population into homogenous groups thereby providing greater precision. It ensures that each subgroup of the entire population is represented within the sampled population (Adam, 2020).

Table 3.1 *Tabulation of Sampling Frame and Sample Size*

Hospital Level	Target population	Proportion for Stratified Sampling*	Sample Size
Level3	68	0.77	**52**
Level4	44	0.77	**34**
Level5	2	0.77	**2**
Total	114		**88**

*sampling proportion (0.77) obtained by dividing the sample size by target population

The samples size was calculated using Yamane formula for finite populations developed in 1967: a simplified formula for sample size calculation with the assumption of a 95% confidence level and P=0.05 as shown below (Yamane, 1967; Singh & Masuku, 2014).

$$n = \frac{N}{1 + N(e)^2}$$

Where the sample size is given by n, N represents the population size, and e stands for the level of precision.

N=114

e=0.05

n=N/ (1+N (e) ^2)

n=114/ (1+114(0.05) ^2)

n=114/1.285

n=88.71

n=88 healthcare personnel

The sample size for this study was 88 healthcare personnel: 44 facility in-charges and 44 health records information officers. The facility in-charges and health records information officers were targeted per facility.

3.7 Instrumentation

3.7.1 Pre-testing

Questionnaires were the main data collection tool. The questionnaire was designed using Teleforms Verity Software (**Appendix 4**). Questionnaires were used in the study because they are economical in terms of time, energy and resources. Data collected through questionnaires are also easy to code and analyze as they are in immediate usable form.

Pre-testing was conducted to test whether the questionnaire was valid, to check for potential errors in the tool and correct them before data collection. Pre-testing was carried out in Lwak clinic which is a surveillance site for infectious diseases run by Kenya Medical research Institute. The pre-test achieved 10 respondents and the pre-test results were used by the researcher to evaluate the compatibility and the consistency of the instrument with the study requirements, and editing was done in the areas requiring improvement in order to come up with a reliable instrument.

3.7.2 Validity

Validity is the ability of an instrument to adequately capture what it is intended to measure. It alludes to the extent to which an empirical measure sufficiently captures the real meaning of the concept under consideration (Bolarinwa, 2016). Validity is done to ensure the research investigation is providing answers to the research questions for which it was undertaken and if so, is it providing the answers using appropriate methods and procedures. Convergent validity tests that constructs that are expected to be related do, indeed, have a relationship while divergent validity tests that constructs that should have no relationship are, indeed, unrelated (Trochim, 2020). To determine the convergent validity of independent measures a correlation coefficient of ≥ 0.50 are considered acceptable (Carlson & Herdman 2012). The researcher developed a questionnaire based on intensive literature review and different technology adoption models studied to guarantee validity of results. Validity was affirmed by performing a pretest. From the pre-test results, for convergent validity 36 out of 39 items in the questionnaire (92%) had a correlation coefficient with the score of their own dimension greater than 0.50 while for divergent validity 38 out of 39 items in the questionnaire (97%) had a correlation coefficient with the score of their own dimension greater than those computed with other scores (**Appendix 5**). After discussions with the supervisors the researcher identified questions with ambiguities and those that needed editing.

3.7.3 Reliability

Reliability is the ability of an instrument to create reproducible result (Datt & Chetty, 2016). The reliability of this study was ascertained through pre-testing of the research

tool using a sample group similar to the actual sample. The researcher evaluated the compatibility and the consistency of the instrument with the study requirements using the pre-test results, and editing was be done in the areas requiring improvement in order to come up with a reliable instrument. Cronbach alpha was used to assess the reliability coefficient of the research instrument. The values of all indicators or dimensional scales 0.7 or higher are acceptable (Tavakol & Dennick, 2011). **Table 3.2** represents the Cronbach alpha coefficients for the independent and dependent variables. All the coefficients are good as they are ≥ 0.7.

Table 3.2 *Cronbach's Alpha Reliability coefficients for Independent and Dependent Variables*

Variable	No. of Items	Cronbach's alpha
Technological Factor	9	0.7300
Organizational context	10	0.7247
Behavioral Factor	9	0.7141
Health service delivery	11	0.7001

3.8 Data Collection Procedure

The cross-sectional study employed involved a onetime collection of data from 88 respondents, which constituted 44 facility in-charges and 44 health records officers drawn from Level 3-Level 5 public health facilities within Kisumu County. The data was collected over a period of one month and questionnaires were administered to respondents in their respective facilities. The researcher administered informed consents (**Appendix 6**) to the respondents and also introduced the study to the respondents, explained the intentions of the study and clarified any arising issues. Participants were

made aware on the information type needed from them, the reason for seeking the information and the purpose as well as the direct and indirect effects of the research on them. The questionnaire was physically administered to the respondents by the researcher and then the completed questionnaire was scanned using the teleforms platform which converts digital images to data that is then stored in a database. The data stored in the database was then pulled into Stata 14.0 for analysis using a data import procedure (code). Confidentiality was also of great concern and to ensure information shared by respondents was not improperly divulged, the researcher did not collect unique personal identifiers of the respondents. In addition, the completed questionnaires were kept in a lockable cabinet only accessible to the researcher while the scanned images and database containing the data were kept in a password protected computer.

3.9 Methods of Data Analysis and Presentation

Data analysis refers to the process of systematically applying statistical techniques to describe, summarize and evaluate data (Office of Research Integrity, 2020). Data analysis was done using Stata 14.0 and employed both descriptive and inferential statistics. The data was screened for missing data, normality, and multicollinearity. Normality refers to the normal distribution; a symmetric distribution where most of the observations cluster around the central peak and the probabilities for values further away from the mean taper off equally in both directions. Multicollinearity refers to the occurrence of high intercorrelations between two or more independent variables (Hayes, 2020).

Descriptive statistics were used to provide summaries about the sample and measures; the research used frequencies and proportions to show distribution of the indicators of the independent variables in our study. Inferential statistics were used determine the magnitude and nature of the relationship between the dependent variable and the independent variable and the researcher used logistic regression to analyze the data to predict the probability of an outcome variable (cloud computing adoption for health service delivery) from predictor factors with the results of the analysis in the form of odds ratios. The logistic model is utilized to approximate the probability of a binary response based on the predictor variables. The dependent variable was recoded into a binary variable for analysis: 1 if at least one benefit was reported or 0 if no benefit was reported. Logistic regression deals with normality problem by using a logarithmic transformation on the outcome variable, which allow us to model a nonlinear association in a linear way. Logistic regression was used because of its ability to calculate the probability of success over the probability of failure while also providing knowledge of the relationships and strengths among the variables (Burns, 2008). Statistical significance was indicated by a p-value less than 0.05. In addition, an odds ratio greater than 1 indicates a positive relationship between the independent and dependent variables while an odds ratio less than 1 indicates a negative relationship between the independent and dependent variables. The confidence interval gives the level of uncertainty around the Odds ratio; precision of the effect estimate. 95% confidence interval (95%CI). If the 95% confidence interval (95%CI) crosses 1 (e.g. 0.9-1.1) this implies that there is no statistically significant difference.The results of this study were presented through tables, pie charts, bar graphs and prose.

The first objective of this study was to establish the level of cloud computing adoption. Descriptive statistics were employed with frequencies and proportions used to show the prevalence of cloud computing, level of cloud computing awareness and the cloud computing service models among public health facilities in Kisumu County. Frequencies were used because variables under consideration were discrete and proportions included to better understand them and for generalization.

The second objective was to determine technological factors of cloud computing adoption influencing health service delivery by public health facilities in Kisumu County and the indicators under this objective were technical competency, technological infrastructure, security, privacy, timeliness and expert scarcity. For descriptive statistics, frequencies and percentages were used to show the distribution of these indicators among those who had adopted cloud computing and those who had not adopted. For inferential statistics, Logistic regression was used determine the association of these indicators and health service delivery.

The third objective was to establish the influence of organisational factors of cloud computing adoption influencing health service delivery by public health facilities in Kisumu County and the indicators were budgetary allocation for IT, working environment, policy, firm size and individual difference factors. Frequencies and percentages were used to show the distribution of these indicators among those who had adopted cloud computing and those who had not adopted. While logistic regression was used determine the association between these indicators and health service delivery.

The last objective of the study was to evaluate the behavioural factors of cloud computing adoption influencing health service delivery by public health facilities in

Kisumu County and the indicators were perceived usefulness, perceived ease of use, trust and social influence. Frequencies and percentages were used to show the distribution of these indicators among those who had adopted cloud computing and those who had not adopted. While logistic regression was used determine the association of these indicators and health service delivery.

3.10 Ethical Consideration

The researcher sought a research permit from National Commission for Science, Technology and Innovation (**Appendix 7**). The researcher also sought approval from the Kisumu County Department of Health to be able to conduct this study in public health facilities in Kisumu County and was issued with an approval letter by the director of health. Participation in the study was voluntary and the researcher explained to the respondents the scope of this study, the procedures involved, the potential benefits and to guarantee them of the confidentiality of provided information. Informed consents were then sought from all respondents. Confidentiality was assured to the respondents as indicators like technical competency and budgetary allocation if revealed alongside the names of the respondents could lead to stigmatisation. The researcher also observed scientific integrity by adhering to professional values and practices when conducting the research and reporting the results of this study to ensure objectivity, clarity and reproducibility.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results on cloud computing adoption by public health facilities in Kisumu County, Western Kenya. Questionnaires designed using Teleforms Verity Software were used in the data collection and Stata 14.0 used in data analysis. The objectives of this study was to assess the level of loud computing adoption and determine the influence of technological, organisational and behavioural factors of cloud computing adoption on health service delivery by public health facilities.

4.1.1 Response rate

The study targeted facility in-charges and health records and information officers from 57 public health facilities in Kisumu County. Out of the sampled 88 healthcare personnel, 80 respondents successfully completed questionnaires giving a response rate of 91%, this was achieved through mobilisation using sub-county health records officers. The remaining 8 participants were not found in the facility after 3 attempts.

4.2 Extent of cloud computing adoption

The first objective of this study was to assess the extent of cloud computing adoption. This was looked at by the prevalence of cloud computing, the level of cloud computing awareness and the cloud service models.

Out of the 80 respondents who completed the questionnaire, 69 (86%) were aware of cloud computing while 11 (14%) had not heard of cloud computing (**Figure 4.1**). Those who had not heard cloud computing were more likely to be facility in-charges than

health records officers (11out of 40 [28%] compared to 0 out of 40 [0%)], p=0.003) and were also likely to have had a longer work experience: median years (10 compared to 7, p=0.0438).

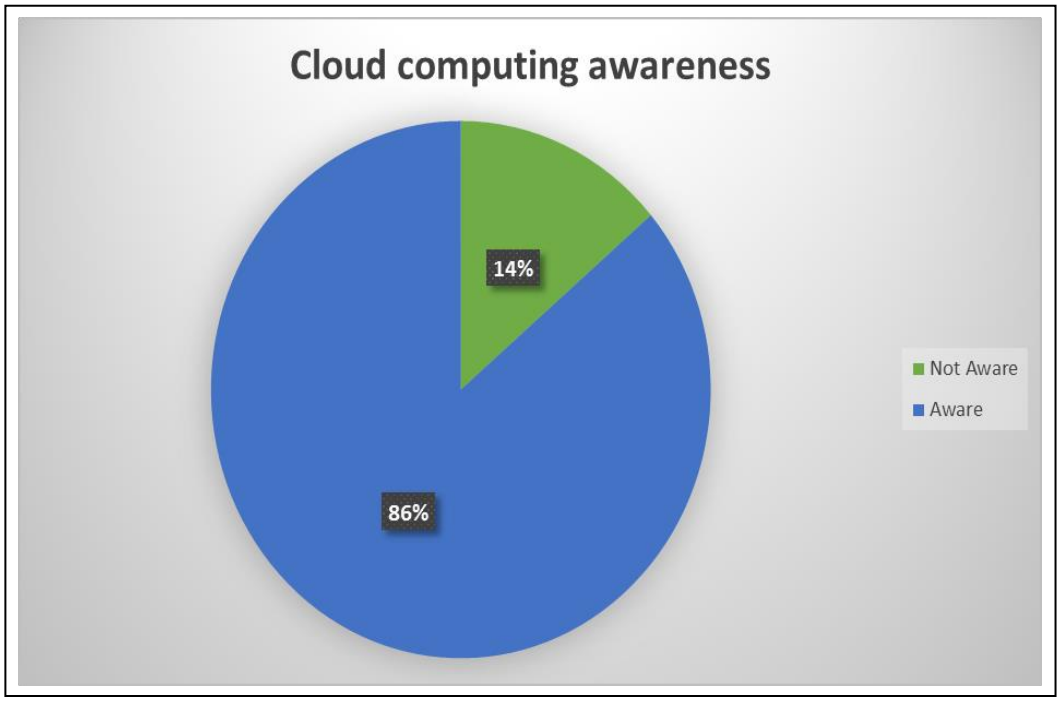

Figure 4.1 *Cloud computing awareness among respondents*

The adoption of cloud computing in the county was at 53%. Among the 80 respondents, 42 (53%) worked in public health facilities that had adopted cloud computing as shown in **Figure 4.2**. Those who had adopted cloud computing were 7 times more likely to realize improved health service delivery compared to those who had not (odds ratio (OR) =7.14, 95% confidence interval (95%CI) [1.45-35.14], p=0.016). The p-value is < 0.05 and the 95%CI does not go below 1 indicating this association is statistically significant.

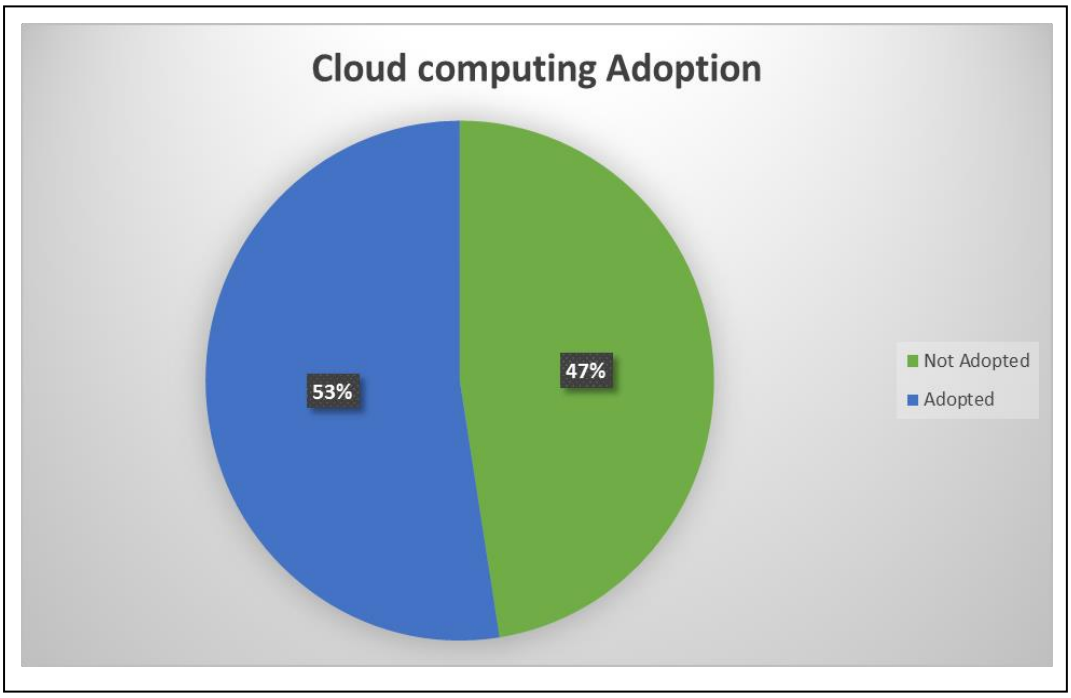

Figure 4.2 *Cloud computing adoption by public health facilities in Kisumu County*

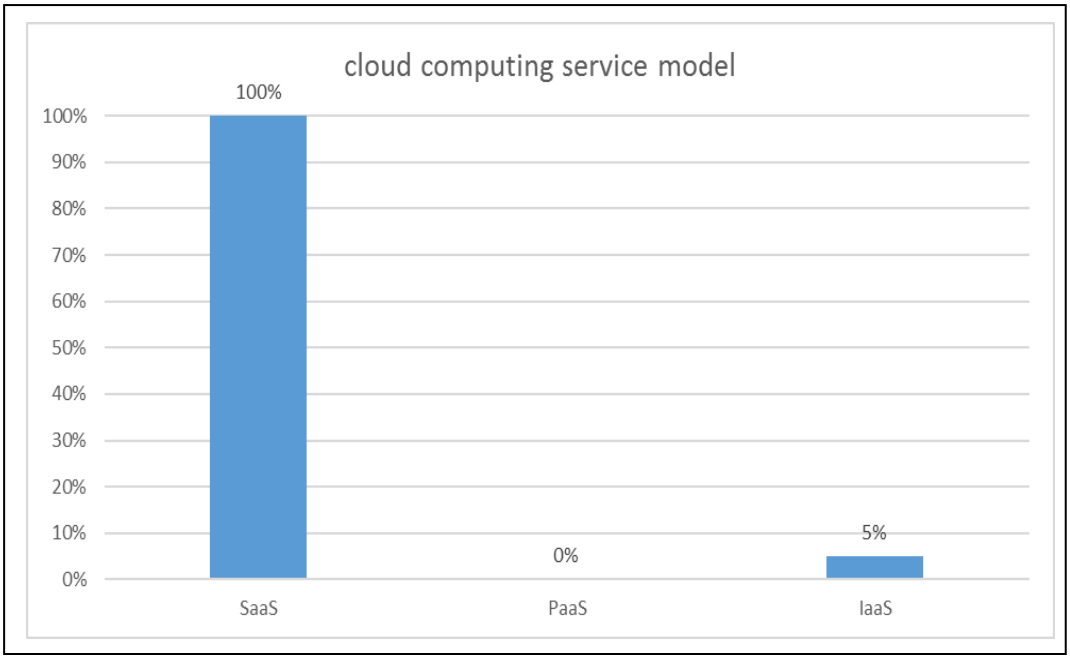

Figure 4.3 *Cloud computing service models implemented by public health facilities*

The cloud computing service models implemented by public health facilities that have adopted cloud computing are shown in **Figure 4.3**. Software-as-a-Service was the most common cloud computing service model at 100% followed by Infrastructure-as-a-Service at 5% while none of the health facilities had Platform-as-a-Service as a service model. The most prevalent SaaS implementations were national-level systems; Kenya Health Information System (KHIS) 100%, Health Facility Equipment Assessment Application (HEAA) 100%. KMFL (Kenya Master Facility List) and iHRIS (Health Workforce Information Systems) were used at the sub-county and county levels. In terms of deployment models, the cloud implementations were deployed as hybrid clouds as they had sections that were open to the public while other sections were restricted to healthcare personnel with accreditation.

The study found out that the prevalence of cloud computing in public health facilities was 53% shown in **Figure 4.2**. This is an improvement compared to 35.6% that was reported previously among public sector institutions (CA and KNBS, 2017). This increase can be attributed to a high ratio of internet users connecting with mobile devices compared to traditional fixed point connections (Cisco, 2018). Those who had adopted cloud computing were more likely to realize improved health service delivery compared to those who had not. This can be explained by the fact that cloud computing is a technological paradigm that reduces costs of IT, enhances collaboration while improving productivity. In terms of cloud services models, most public health facilities implemented SaaS (100%) while very few adopted IaaS (5%) and none had PaaS (0%) as shown in Figure 4.3. This is consistent with the findings from Medium and High tech industries in Nairobi, Kenya (Wanjiku & Moturi, 2016). This differential in

implementation of cloud service models could be attributed to high cost implications (the cost of cloud computing reduces the higher up the cloud stack you go; SaaS is cheaper than PaaS and PaaS is Cheaper than IaaS) and the level of skills required to implement and maintain services associated with PaaS and IaaS (Low et al., 2011, Omwansa, Waema & Omwenga, 2014). Lack of implementation of PaaS service model can be explained by the fact that most public health facilities rely on nation-level systems that are developed and maintained by the Ministry of Health. Furthermore, health facilities that have adopted other digital health systems in addition to the nation-level systems normally outsource the development and testing of such systems or rely on partner institutions. The implementation of SaaS being largely driven by nation-level systems and the low implementation of IaaS service model highlight the great potential that still exists for public health facilities to fully embrace cloud computing and realize the benefits which would translate to improved health service delivery.

4.3 Technological factors influencing cloud computing adoption for health service delivery

The second objective of the study was to determine technological factors of cloud computing adoption influencing health service delivery. There were six indicators under technological factor: Technical competency, technological infrastructure, security, privacy, timeliness and expert scarcity. The results of the logistic regression determining technological factors of cloud computing adoption influencing health service delivery are shown in **Table 4.1**, statistical significance was indicated by a p-value less than 0.05.

Table 4.1 *Logistic regression determining technological factors of cloud computing adoption influencing health service delivery*

Characteristics	**Service delivery Improved (n=42)**	**Service delivery not Improved (n=38)**	**Odds Ratio [95%CI]**	**p-Value**
	n (%)	n (%)		
Technological Readiness				
Technical Competency				
No	7 (16.7)	27 (71.1)	**Ref**	
Yes	35 (83.3)	11 (28.9)	**12.27(4.20-35.87)**	**<0.0001**
Technological Infrastructure				
No	6 (14.3)	24 (63.2)	**Ref**	
Yes	36 (85.7)	14 (36.8)	**10.29(3.47-30.50)**	**<0.0001**
Service Quality				
Secure services				
No	5 (11.9)	19 (50.0)	**Ref**	
Yes	37 (88.1)	19 (50.0)	**7.40(2.40-22.90)**	**0.0010**
Privacy of Data				
No	3 (7.1)	18 (47.4)	**Ref**	
Yes	39 (92.9)	20 (52.6)	**11.70(3.08-44.50)**	**<0.0001**
Timeliness				
No	1 (2.4)	6 (15.8)	Ref	
Yes	41 (97.6)	32 (84.2)	7.69(0.88-67.12)	0.0650
Expert Scarcity				
Cloud experts available				
No	13 (31.0)	26 (68.4)	**Ref**	
Yes	29 (69.0)	12 (31.6)	**4.83(1.88-12.45)**	**0.0010**

Technological readiness was looked at in terms of technical competency and technological infrastructure. Both technological infrastructure and technical competency and were statistically significant as shown in **Table 4.1**. Those who were technically

competent were 12 times more likely to realize improved health service delivery as a result of adopting cloud computing compared to those who were not (35 [83%] compared to 7 [17%], odds ratio (OR) =12.27, 95% confidence interval (95%CI) [4.20-35.87], p=<0.0001), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association had statistical significance. 71% of respondents who had not realized improved health service delivery in their facilities were not technically competent in using cloud computing in this setting. Those who had adequate technological infrastructure were 10 times more likely to realize improved health service delivery from adopting cloud computing compared to their counterparts who did not (36 [86%] compared to 6 [14%], OR=10.29, 95%CI [3.47-30.50], p=<0.0001), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association was statistical significant. 63% of respondents who had not realized improved health service delivery in their facilities had inadequate technical infrastructure in the facilities where they worked

Service quality was looked at in terms of security, privacy of data and timeliness. From the results, shown in **Table 4.1**, only security and privacy had a statistically significant effect on health service delivery as a result of cloud computing adoption.

Those who believed that cloud computing offered secure services were more likely to realize improved health service delivery from adopting cloud computing compared to those who did not believe cloud services were secure (37 [88%] compared to 5 [12%], OR=7.40, 95%CI [2.40-22.90], p=0.0010). Furthermore, those who believed cloud computing upheld the privacy of data were more likely to realize improved health service delivery from adopting cloud computing compared to those who did not believe

that the privacy of data was upheld (39 [93%] compared to 3 [7%], OR=11.70, 95%CI [3.08-44.50], p<0.0001). The results of the study, shown in **Table 4.1**, indicated that those who believed cloud services were offered in a timely manner were more likely to realize improved health service delivery from adopting cloud computing compared to those who did not, however this difference was not statistically significant (41 [98%] compared to 1 [2%], OR=7.69, 95%CI [0.88-67.12], p=<0.0650). The p-value is > 0.05 and the 95% confidence interval goes below 1 indicating that this association was not statistically significant.

The study found expert scarcity to have a significant effect on health service delivery as a result of cloud computing adoption (29 [69%] compared to 13 [31%], OR=4.83, 95%CI [1.88-12.45], 0.0010) as shown in **Table 4.1**.

The study found five indicators of technological factors of cloud computing adoption to have a significant effect (p<0.05) on health service delivery as shown in **Table 4.1**: Technical competency, technological infrastructure, security, privacy and expert scarcity. Timeliness, however did not have a significant effect on health service delivery.

Technological readiness through its sub-indicators, technical competency and technological infrastructure, were found to positively affect health service delivery as shown in **Table 4.1**. This is consistent with results from previous studies (Zhu et al., 2008; Cegielski et al., 2012; Tweel, 2012). This finding can be explained by the fact that health facilities with existing technological infrastructure (installed network technologies and enterprise systems) that support cloud computing would not incur any additional cost apart from operational cost compared to those who do not have an

existing infrastructure, who would have to incur the costs of installing network technologies, internet costs and operational costs. These facilities would be better placed to improve health service delivery as they are more inclined to adopt cloud computing. Additionally, health facilities having staff with the technical competence to handle cloud computing would realize improved health service delivery since those who are technically competent would readily embrace cloud computing due to positive attitude and minimal resistance.

Security and privacy which are indicators of service quality were found to be predictors of health service delivery as shown in **Table 4.1**. This was in concurrence with the findings from other studies (Amini, 2014; Salah, Bin, & Salah, 2015; Zadok, 2018; Sadoughi, Ali & Erfannia, 2019). Similarly, the findings of this study on privacy is consistent with existing literature (Salah et al., 2015; Gao & Sunyaev, 2019). Data security and privacy is more complicated in cloud computing than in traditional information systems as cloud computing transcends into the realm of architecture and data models. Cloud computing offers improved security due to its sophisticated security controls, including data encryption and fine-grained access controls and access logging as well as having highly qualified security experts to secure their platforms. Therefore providing a trustworthy environment in terms of security and privacy is a prerequisite that wins confidence of users to adopt cloud computing (Sun, Zhang, Xiong and Zhu, 2014). Security and privacy associated with the cloud platform would affect health service delivery by ensuring services are offered in line with pre-established quality of standards.

Timeliness was not found to be a predictor of health service delivery as shown in **Table 4.1**. This is contrary to findings from other studies (Alsanea & Barth, 2014; Tsai & Hung, 2014; Alkhater, Walters & Wills, 2018). Despite Kenya having an internet speed of 21.3 megabits per second (Speedtest, 2020), remote areas still suffer from poor connectivity and low internet speeds. This would lower expectations of clients as regards timeliness of cloud services as they are dependent upon internet connectivity. Also, experiences of delayed access to cloud-based platforms like Kenya Health Information System (KHIS) during end-month reporting period when users overwhelm the system further reduces the expectations of clients as concerns timeliness of cloud services. However, as the telecommunications industry in the country matures, uniformity in internet connectivity is likely to be achieved over time. Also, Cloud platforms should be designed to anticipate and tolerate unexpected overload situations. This would bolster the timeliness of cloud services.

Lastly, expert scarcity (availability of deployment, integration and security experts) was found to significantly influence health service delivery as shown in Table 4.1. This was in agreement with previous studies: Hameurlin et al., (2017) and Almabhouh (2015). Organizations need IT professionals to help them articulate their cloud computing plans, determine what and how to move into the cloud and guide them on how to manage integration with on-site systems. This finding could be explained by the fact that adequate technical support guarantees smooth and seamless transition to the cloud and institutions who believed this experts are readily available would be predisposed to adopt cloud computing. The availability of cloud experts would result in increased adoption of cloud computing as well as improved operations due to integration and

security of the cloud platform. And this would translate to improved efficiency in service delivery. However, scarcity of IT professionals in the area of cloud computing has been reported (Hudson, 2013; Mishra, 2017; Hameurlin et al., 2017) and this shortfall is projected to hit 5 million globally within the next decade, if nothing is done to mitigate it (Hudson, 2013). To alleviate this shortage Ministry of Health IT personnel could be trained in cloud related skills (deployment, integration and securing of cloud infrastructure) thereby providing technical support and maintenance of cloud systems.

4.4 Organisational factors influencing cloud computing adoption for health service delivery

The third objective of the study was to establish the effect of organisational factors of cloud computing adoption on health service delivery. There were five indicators under organisational factors: Top management support (Budgetary allocation for IT and working environment), Policy, Firm size and individual difference factors. The results of the logistic regression determining organisational factors of cloud computing adoption influencing health service delivery are shown in **Table 4.2**, statistical significance was indicated by a p-value less than 0.05.

Table 4.2 *Logistic regression determining organisational factors of cloud computing adoption influencing health service delivery*

Characteristics	**Service delivery Improved (n=42)**	**Service delivery not Improved (n=38)**	**Odds Ratio [95%CI]**	**p-Value**
	n (%)	n (%)		
Top Management Support				
Budgetary allocation for IT				
No	27 (64.3)	32 (84.2)	**Ref**	
Yes	15 (35.7)	6 (15.8)	**2.96(1.01-8.69)**	**0.0480**
Working environment				
Not enabling	4 (9.5)	7 (18.4)	Ref	
Enabling	38 (90.5)	31 (81.6)	2.15(0.57-8.01)	0.2560
Policy				
Aware of Policy				
No	30 (71.4)	32 (84.2)	Ref	
Yes	12 (28.6)	6 (15.8)	2.13(0.71-6.40)	0.1770
Firm Size				
0-15 beds	19 (45.2)	36 (94.7)	**Ref**	
>= 15 beds	23 (54.8)	2 (5.3)	**21.79(4.63-102.46)**	**<0.0001**
Individual Difference Factors				
Age Category				
24-30 years	19 (45.2)	10 (26.3)	Ref	
>30 years	23 (54.8)	28 (73.7)	0.43(0.17-1.11)	0.0820
Work experience				
1-10 years	30 (71.4)	27 (71.1)	Ref	
>10 years	12 (28.6)	11 (28.9)	0.98(0.37-2.59)	0.9700
Education				
Diploma	26 (63.4)	35 (92.1)	Ref	-
Certificate	1 (2.5)	0 (0)	-	
Bachelors	11 (26.8)	3 (7.9)	3.47(0.85-14.09)	0.0710
Masters	3 (7.3)	0 (0)	-	-

The researcher looked at top management support in terms of budgetary allocation for IT and working environment. The results, shown in **Table 4.2**, illustrates that only

budgetary allocation for IT had a statistically significant effect on health service delivery. Those who had adequate budgetary allocation for IT were 3 times more likely to realize improved health service delivery from adopting cloud computing compared to those who did not have adequate allocation (OR=2.96, 95%CI [1.01-8.69], p=0.048), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association had statistical significance. However, only 74% of the respondents reported inadequate budgetary allocation for IT. The study also found out that, shown in **Table 4.2**, health facilities where the top management provided an enabling work environment were 2 times more likely to realize improved health service delivery from adopting cloud computing compared to those who did not, this difference was however not significant (38 [91%] compared to 4 [9%], OR=2.15, 95%CI [0.57-8.01], p=0.256), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association was statistical significant. Overall, 86% of respondents reported having an enabling working environment.

From the study findings shown in **Table 4.2**, although those who were aware of policy/legislation regarding cloud computing were 2 times more likely to realize improved health service delivery from adopting cloud computing compared to those who were not aware, the difference was not statistically significant (OR=2.13, 95%CI [0.71-6.41], p=0.177), the p-value is >0.05 and the 95%CI goes below 1 indicating that this association lacked statistical significance. Overall, only 22% of the respondents were aware of existing policy/legislation regarding cloud computing.

The researcher looked at firm size in terms of the bed capacity. Firm size had a statistically significant effect on health service delivery based on cloud computing

adoption as shown in **Table 4.2**. Health facilities that had a bed capacity greater than or equal to 15 beds were more likely to realize improved health service delivery from adopting cloud computing compared to health facilities with a bed capacity of 0-15 beds (23 [55%] compared to 19 [45%], OR=21.79, 95%CI [4.63-102.46], p<0.0001), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association had statistical significance.

Individual different factors had three sub-indicators: age of respondent, work experience of the respondent and level of education. All the three sub-indicators under individual different factors did not have a statistically significant effect on health service delivery as shown in **Table 4.2**.

The study found only budgetary allocation for IT and firm size constructs of organisational factors to be predictors (p<0.05) of health service delivery based on cloud computing adoption shown in **Table 4.2**. Top management support under the sub-indicator of budgetary allocation for IT was found to influence adoption. This is concurrent with existing literature on cloud computing adoption (Ramdani & Kawalek, 2007; Borgman et al., 2013; Yigitbasioglu, 2015). This can be explained by the fact that cloud computing comes with additional costs as it is a pay-per-use platform and it also heavily relies on the internet, institutions with adequate budgetary allocation for IT would therefore be more inclined to adopt cloud computing and realize the benefits compared to those with inadequate allocations. However, only 26% of respondents reported having adequate budgetary allocation for IT compared to 86% who reported that the top management provided an enabling environment for cloud computing adoption. This differential in the proportion of those who had adequate budgetary

allocation for IT and those who had an enabling work environment indicates that top management was supportive of cloud computing and not lack of interest in cloud computing but rather budgetary constraints by public health facilities as the possible reason for inadequate budgetary allocations for IT. This brings to the front the need for implementation of the Abuja declaration on health budget (WHO, 2011) by the national and county governments which would in turn translate to improved allocations to the county health office and consequently the health facilities and IT departments.

Firm size was also found to be a predictor of health service delivery as shown in **Table 4.2**. This is consistent with findings from previous studies (Low et al., 2011; Espanadal & Oliveira, 2012; Borgman et al., 2013). Health facilities with a higher bed capacity are more likely to have a bigger budget than those with lower bed capacity and in return be more likely to adopt cloud computing and realize improved health service delivery than their counter parts from health facilities with a smaller bed capacity. Additionally, the uptake of internet and its infrastructures in health facilities is slower among smaller facilities than in large ones.

Policy was not a predictor of health service delivery from the findings of the study as shown in **Table 4.2**. This is consistent with results from previous adoption studies (Borgman et al., 2013; Oliveira et al., 2014). This could possibly be explained by the fact that despite deliberate government policy to promote new computing technologies, their advancement is largely due to corporate focus on technology (Jha, 2015).

4.5 Behavioural factors influencing cloud computing adoption for health service delivery

The fourth and final objective of the study was to evaluate the influence of behavioural factors of cloud computing adoption on health service delivery. Behavioural factors was looked at in terms of Perceived usefulness, Perceived ease of use, Trust and Social influence. The results of the logistic regression determining behavioural factors of cloud computing adoption influencing health service delivery are shown in **Table 4.3**, statistical significance was indicated by a p-value less than 0.05.

Table 4.3 *Logistic regression determining behavioural factors of cloud computing adoption influencing health service delivery*

Characteristics	**Service delivery Improved (n=42)**	**Service delivery not Improved (n=38)**	**Odds Ratio [95%CI]**	**p-Value**
	n (%)	n (%)		
Perceived Usefulness				
No	6 (14.3)	24 (63.2)	**Ref**	
Yes	36 (85.7)	14 (36.8)	**10.29(3.46-30.50)**	**<0.0001**
Perceived Ease of Use				
No	3 (7.1)	15 (39.5)	**Ref**	
Yes	39 (92.9)	23 (60.5)	**8.48(2.21-32.46)**	**0.0020**
Trust				
No	10 (23.8)	10 (26.3)	Ref	
Yes	32 (76.2)	28 (73.7)	1.14(0.42-3.15)	0.7960
Social influence				
Other health facilities are adopting				
No	8 (19.1)	17 (44.7)	**Ref**	
Yes	34 (80.9)	21 (55.3)	**3.44(1.26-9.36)**	**0.0160**

Perceived usefulness had a statistically significant effect on health service delivery based on cloud computing adoption as shown in **Table 4.3**. Those who believed that cloud computing would improve operations in the facility were 10 times more likely to realize improved health service delivery from adopting cloud computing compared to those who did not (36 [86%] compared to 6 [14%], OR=10.29, 95%CI [3.46-30.50], p<0.0001), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association had statistical significance. 63% of respondents who realized improved health service delivery in their facilities did not believe cloud computing would improve their operations. The study also found Perceived ease of use to be a predictor of health service delivery based on cloud computing adoption as shown in **Table 4.3**. Those who believed cloud computing required less mental effort were 8 times more likely to realize improved health service delivery from adopting cloud computing compared to those who thought otherwise (39 [93%] compared to 3 [7%], OR=8.48, 95%CI [2.21-32.46], p=0.0020), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association had statistical significance. 40% of respondents who did not realize improved health service delivery in their facilities believed cloud computing required much mental effort to use.

Social influence was also found to have a significant effect on health service delivery based on cloud computing adoption as shown **Table 4.3**. Those who believed other health facilities were adopting cloud computing and they were benefitting from it were 3 times more likely to to realize improved health service delivery from adopting cloud computing compared to those who did not (34 [81%] compared to 8 [19%], OR=3.44,

95%CI [1.26-9.36], p=0.016), the p-value is <0.05 and the 95%CI does not go below 1 indicating that this association had statistical significance.

Those who had trust in cloud computing were more likely to realize improved health service delivery from adopting cloud computing compared to those who did not, but this difference was not statistically significant (32 [76%] compared to 28 [74%], OR=1.14, 95%CI [0.42-3.15], p=0.796) as shown in **Table 4.3**, the p-value is >0.05 and the 95%CI goes below 1 indicating that this association lacked statistical significance.

The study found three indicators under behavioural factor to be predictors (p<0.05) of health service delivery as shown in **Table 4.3**: perceived usefulness, perceived ease and social influence. Trust did have a significant effect on health service delivery.

Perceived usefulness was found to influence health service delivery as shown in **Table 4.3**. This is consistent with existing literature (Low et al., 2011; Gupta et al., 2013; Gangwar et al., 2015). This could be explained by the fact that adoption of new technology increases when a firm perceives a relative advantage in that innovation. When health facilities believe cloud computing will improve their operations, they will be more predisposed to adopt and realize improved health service delivery as a result.

Perceived ease of use was found to be a predictor of health service delivery as shown in **Table 4.3**. This finding is in agreement with results from previous studies (Lee, Lee, Olson & Chung, 2010; Changchit, 2014; Yuvaraj, 2016). This can be explained by the proliferation of cloud computing services that can be accessed by mobile devices. Services like email and storage (google drive and drop box) have reduced complexities in user interface and learning curve thereby bolstering the belief of users that cloud computing requires less mental effort to learn and use. Perceived ease of use gives

personnel confidence in using cloud computing to execute their tasks and this would translate to improved health service delivery.

The study did not find trust to be a significant factor in health service delivery as shown in **Table 4.3**. This is contrary to results from previous studies (Hashemmi, 2013; Moqbel et al., 2014) that found trust to be a predictor. This can be explained by the fact that every platform (traditional or cloud computing) has its inherent vulnerability and it's upon users to follow best practices as concerns selection and securing of the platform. Also, most cloud platforms now offer offline versions that are available temporarily when the online versions are not available. This would guarantee consistency of service and alley the fears of clients thereby increasing their trust. Furthermore as knowledge of cloud computing increases and perception of its value is discerned, clients are more likely to have confidence in it.

Lastly, social influence was found to have a significant effect on health service delivery as shown in **Table 4.3**. This is in concurrence with existing literature (Moqbel et al. 2014; Lian, 2015; Amponsah et al., 2016). This finding can be explained by the need for non-adopter health facilities to conform to the current trends in the healthcare sector. Sociologists believe that often group member's exhibit cohesiveness even against their own feelings in order to show commitment to group norms (Venkatesh & Morris, 2000).

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study was motivated by the desire to see the healthcare sector compete favorably with other industries in adoption of cloud computing and consequently realize the operational, financial and functional benefits thereby improving health service delivery and remaining relevant in a dynamic business environment.

The study showed that there was an improvement in cloud computing awareness to what was reported in earlier studies in the country. The prevalence of cloud computing among public health facilities in Kisumu County was also higher than what had been reported in the public sector by previous studies. Furthermore, those who had adopted cloud computing realized improved health service delivery. In terms of cloud computing service models, Software-as-a-Service was the most implemented, while very few had implemented Infrastructure-as-a-Service and none had Platform-as-a-Service as a service model. Most Software-as-a-Service implementations were however national-level systems implemented by facilities at the county level indicating the great potential that still exists for public health facilities in cloud adoption which would enable to realize more substantial benefits culminating to improved health service delivery

The study results showed that health service delivery was influenced by technological factors of cloud computing adoption: technological readiness (technical competency and technological infrastructure), service quality (security and privacy) and expert scarcity were statistically significant constructs of health service delivery. Most respondents who had not realized improved health service delivery in their facilities reported having

inadequate technological infrastructure and were not technically competent in using cloud computing Lastly, timeliness of cloud services was not a predictor of health service delivery in this setting.

The study illustrated that organisational factors of cloud computing adoption were crucial in health service delivery: top management support (budgetary allocation for IT) and firm size were statistically significant constructs of health service delivery. Most respondents reported inadequate budgetary allocation for IT in their facilities. Contrarily, awareness of policy and individual difference factors did not have a significant effect on health service delivery.

Lastly, the study revealed that behavioural factors of cloud computing adoption equally influenced health service delivery: perceived usefulness, perceived ease of use and social influence were all significant constructs. Most respondents who realized improved health service delivery in their facilities believed cloud computing would not improve their operations and that it also required much mental effort to use. Contrarily, trust was not found to influence health service delivery in this setting.

5.2 Recommendation

In light of the findings of the study, the researcher proposes a number of recommendations for consideration by the Ministry of Health in conjunction with the county governments. These recommendations if implemented would bolster cloud computing adoption in the healthcare sector and enable healthcare institutions realize the expected business value of cloud computing and would translate to improved health service delivery.

5.2.1 Extent of cloud computing adoption

All Software-as-a-Service implementations were all national- level systems. The researcher, therefore recommends that public health facilities in conjunction with the county health office to acquire bottom-up systems (Software-as-a-Service) that are unique to their needs in in addition to the national-level systems as well as increased implementation of Infrastructure-as-a-Service models, this would enable them to realize even greater benefits from cloud computing translating to improved health service delivery.

5.2.2 Technological Factors

Technological infrastructure was found to a predictor of health service delivery but also most hospitals with inadequate infrastructure had not adopted cloud computing. In line with this, the researcher recommends that public health facilities and the county health office procure computers and install network technologies in all Level 3-Level 5 public health facilities to bolster adoption cloud adoption that would result in improved health service delivery.

5.2.3 Organisational Context

Budgetary allocation for IT was found to be a predictor of health service delivery but most facilities in the county reported inadequate budgetary allocations. The researcher recommends increased allocation of revenue to public health facilities by county governments through the county health office, this would enable them to overcome budgetary constraints, which in turn would increase the uptake of cloud computing and realize improved health service delivery as a result.

5.2.4 Behavioural Factor

Perceived usefulness and perceived ease of use had a significant influence on health service delivery, however most personnel in facilities that did not realize improved health service delivery believed cloud computing required much mental effort and it would not improve their operations. Consequently, the researcher recommends the national health office in collaboration with cloud providers to train healthcare personnel on the cloud paradigm and the benefits that come with it leading to increased confidence in the use of cloud computing and its benefits to their operations.

5.3 Suggested Areas for Future Research

This study established cloud computing adoption determinants for health service delivery from technological, organisational and environmental contexts. There are several areas future studies can examine to improve the current work. Future studies should look at the influence of environmental context in cloud computing adoption for health service delivery by investigating indicators like competitive pressure and trading partner pressure to gain a comprehensive understanding of determinants of cloud computing adoption for health service delivery. In order to gain a better understanding of the use and acceptance of cloud computing by public health facilities, future research should diversify the target population to include other healthcare personnel (clinical officers, nurses and laboratory technicians) as they are also critical users of health management information systems.

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APPENDICES

Appendix 1: Questionnaire

Cloud computing Adoption Survey in Healthcare Kisumu County, Kenya

Date of Interview (dd/mm/yyyy):_____

Hospital Code:_____

Designation: Facility in-charge **[ ]** Health Records Officer **[ ]**

Section1: DEMOGRAPHICS

1.1) Gender ☐ Male ☐ Female

1.2) Age (yrs):_____

1.3) How long have you worked in the healthcare sector (yrs)? _____

1.4) How long have you worked in this hospital (yrs)? _____

1.4) what is your level of education?

Certificate **[ ]** Diploma **[ ]** Bachelors **[ ]** Masters **[ ]** PhD **[ ]**

1.5) Do you have internet connectivity in the hospital? ☐ Yes ☐ No

1.6) What is the average time you spend on the internet? _____

Section 2: TECHNOLOGICAL CONTEXT

2.1) Have you heard about cloud computing?

Yes **[ ]** No **[ ]**

2.2a) Has your organization adopted Cloud Computing as a technology?

Yes **[ ]** No **[ ]**

2.2b) If Yes, What type of cloud computing service model has been adopted by your organization (*check all that apply*)?

☐ Software-as-a Service (SaaS); applications are hosted by the provider

If Yes, What type of SaaS have you adopted?

[] Kenya Health Information System (KHIS) **[]** KMFL (Master Facilities List)

[] Digital Health Atlas **[]** iHRIS (Health Workforce Information Systems)

[] HEAA (Health Facility Equipment Assessment Application)

[] Other:

_____

☐ Platform-as-a-Service (PaaS); Tools and services for developing and testing applications

If Yes, please specify_____

☐ Infrastructure-as-a-Service (IaaS); Rent hardware, OS, storage and network capacity

If Yes, please specify_____

2.2c) What are your reasons for adopting cloud computing, specify?

……

……

……

2.2d) To what extent have you achieved the benefits stated above?

……
……
……
……

2.3a) Do you think adopting cloud computing has financial benefits, ?

Yes **[ ]** No **[ ]**

2.3b) If Yes, specify(probe)?

☐ Less capital expenditure on IT

……
……
……

☐ Reduced IT labour costs

……
……
……....

☐Lower maintenance costs

……
……
……

☐Energy savings

.....
.....
.....

2.3c) What are the operational advantages of adopting cloud computing (*probe*)?

☐ Improved security of data

……

……

.....

☐ Enhances collaboration with partners

……

……

……

☐ Unlimited computing resources

……

……

……

☐ 24-hour platform

.....

.....

.....

2.3d) What are the functional benefits of cloud computing (*Probe*)?

☐ Easy to integrate with existing systems

……

……

……...

☐ Wider variety of services for healthcare organizations

.....

.....

.....

2.4a) If Yes in 2.1 above, are you skilled in using cloud computing?

Yes **[ ]** No **[ ]**

2.4b) Does the existing technological infrastructure favour cloud computing adoption?

Yes **[ ]** No **[ ]**

2.5a) Do you think Cloud computing will offer secure services?

Yes **[ ]** No **[ ]**

2.5b) Do you think services offered through cloud computing uphold privacy of data?

Yes **[ ]** No **[ ]**

2.5c) Do you think Cloud computing providers will offer timely services?

Yes **[ ]** No **[ ]**

2.5d) Do you think Cloud computing providers will offer personalized care?

Yes **[ ]** No **[ ]**

2.6a) Do you think IT professionals that guide deployment into the cloud are readily available?

Yes **[ ]** No **[ ]**

2.6b) Do you think IT professionals that manage integration with on-site systems are there in sufficient numbers?

Yes **[ ]** No **[ ]**

2.6c) Are there adequate numbers of IT professionals necessary for securing the entire cloud eco-system?

Yes **[ ]** No **[ ]**

SECTION 3: ORGANISATIONAL CONTEXT

3.1a) Does the top management provide adequate budgetary allocation for IT?

Yes **[ ]** No **[ ]**

3.1b) Does the top management provide adequate budgetary allocation for cloud computing?

Yes **[ ]** No **[ ]**

3.1c) Does the top management provide an enabling environment for cloud computing adoption?

Yes **[ ]** No **[ ]**

3.2a) Are you familiar with existing policy/legislation regarding cloud computing at the National level ?

Yes **[ ]** No **[ ]**

3.2b) If Yes, specify (probe)

☐ National ICT policy 2016

……
……
……

☐ Data protection Bill, 2018

……
……
……

☐ ICTA cloud computing standards

……
……
……

3.2c) Do you think existing policy frameworks covers the dynamic variability in the use of cloud computing in healthcare?

Yes **[ ]** No **[ ]**

3.2d) Do you think existing policy frameworks addresses the issues of data security in cloud computing?

Yes **[ ]** No **[ ]**

3.2e) If No, specify your reservations?

……
……
……

3.2f) Do you think the government is providing adequate oversight of adherence to laid down procedures and guidelines in Cloud Computing platform?

Yes **[ ]** No **[ ]**

3.2g) If No, Explain your reservations?

……
……
……

3.3a) What is the number of employees in this hospital? _____

SECTION 4: BEHAVIOURAL CONTEXT

4.1a) Do you think adopting cloud computing will help the hospital staff accomplish tasks more quickly?

Yes **[ ]** No **[ ]**

4.1b) Do you think adopting cloud computing will improve efficiency in delivery of service in the hospital?

Yes **[ ]** No **[ ]**

4.2a) Do you think hospital staff find it easy to learn how to use cloud computing?

Yes **[ ]** No **[ ]**

4.2b) Do you think hospital staff will find it easy to use cloud computing in accomplishing their tasks?

Yes **[ ]** No **[ ]**

4.3a) Do you think cloud computing operates reliably without failing?

Yes **[ ]** No **[ ]**

4.3b) Has cloud computing demonstrated the functionality to execute required tasks?

Yes **[ ]** No **[ ]**

4.3c) Do you think cloud computing providers offer help when needed?

Yes **[ ]** No **[ ]**

4.4a) Are many of your peers currently adopting cloud computing?

Yes **[ ]** No **[ ]**

4.4b) Are your peers that adopt cloud computing benefiting greatly?

Yes **[ ]** No **[ ]**

4.4c) Do you think your peers that adopt cloud computing are viewed differently by their patients and other industry stakeholders?

Yes **[ ]** No **[ ]**

Appendix 2: ICTA Standards Description (ICT Authority, 2016)

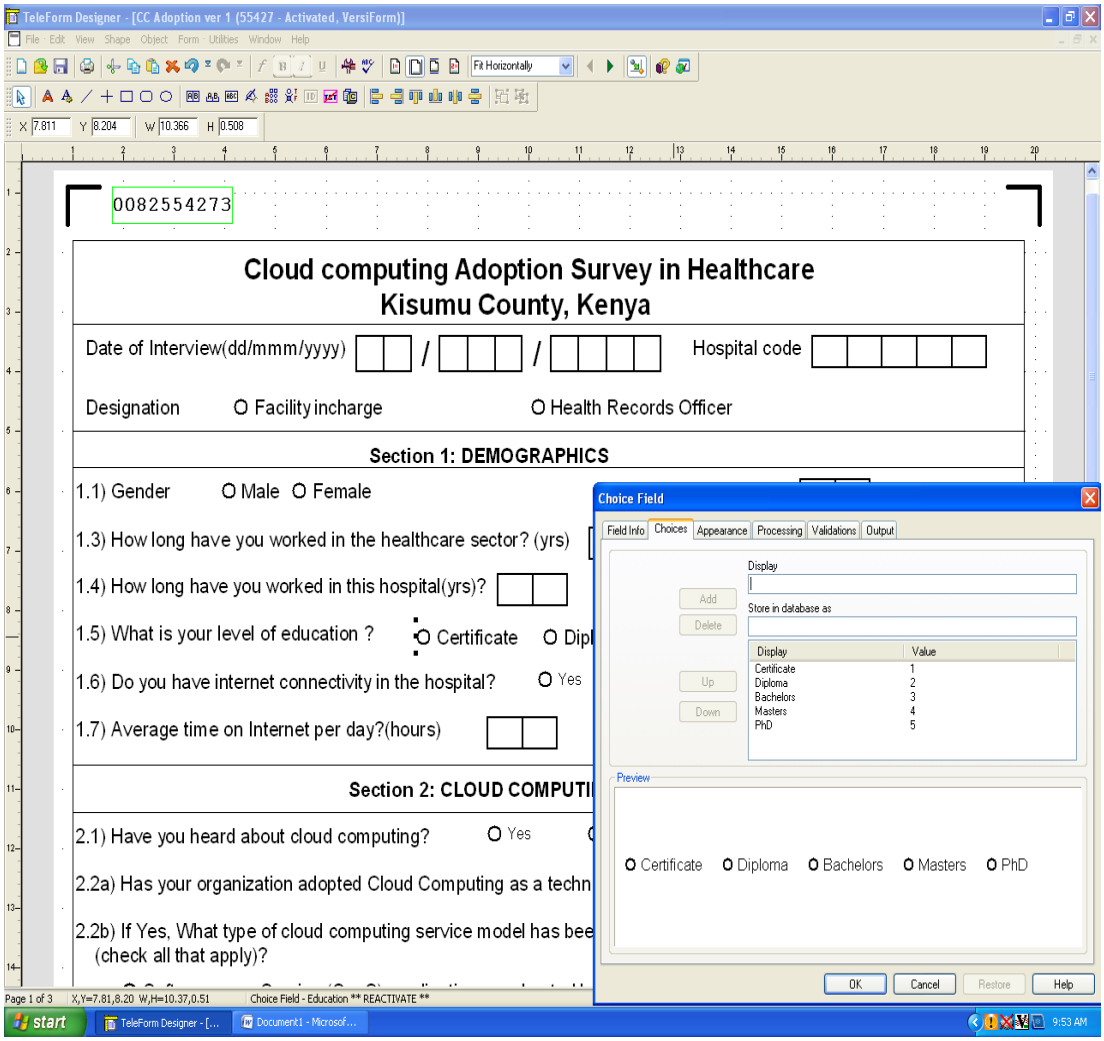
S/No	Thematic Area	Standards	Brief Description
1	Infrastructure	ICTA-2.001:2016 Network Standard	Provides compliant requirements for design, installations and management of all categories of IT Networks to be deployed in government.
		ICTA-2.001:2016 Data Center Standard	Provides compliant requirements for design, installations and management of government data centers
		ICTA-2.001:2016 Cloud Computing Standard	Provides compliant requirements for design, installations and management of cloud computing infrastructures for government
		ICTA-2.001:2016 End-User Equipment Standards	Provides the minimum specifications for all computing devices being deployed in government
2	Systems & Applications	ICTA-6.001:2016 Systems & Applications Standard	Provides compliant requirements for design, installations and management of all government Software and applications Systems.
3	IT Security	ICTA-3.001:2016 Information Security Standard	Provides compliant requirements for design, installations and management of Information Technology Security in government.
4	Electronic records management	ICTA-4.001: 2016 Electronic records and Data Management Standard	Provides compliant requirements for management of government electronic records and data
5	IT Governance	ICTA. 5.001: 2016 IT Governance Standard	Provides compliant requirements for IT Governance in government. This includes compliance requirements for government IT service providers and Professional Staff.
6	ICT Human Capacity	ICTA.7.001:2016 ICT Human Capital and Work force Development Standard	Provides compliant requirements for development of Human Capital capacity for deployment and support for government ICT infrastructure and services.

Appendix 3: List of Public Health Facilities in Kisumu County (Level3-Level5)

Code	Name	Keph level
23541	Aboge	Level 3
13469	Airport Health Centre	Level 3
13503	Bodi Health Centre	Level 3
22806	Dago Kokore	Level 3
13591	Got Nyabondo Health Centre	Level 3
13609	Hongo Ogosa Health Centre	Level 3
13687	Kibigori Health Centre	Level 3
13694	Kinasia Health Centre	Level 3
21671	Kochieng Health Centre	Level 3
13709	Kodiaga Prison Health Centre	Level 3
13727	Kodingo Health Centre	Level 3
21310	Komwaga Health Center	Level 3
21705	Kuoyo Health Center	Level 3
17174	Lwala Kadawa Health Centre	Level 3
18430	Magina Health Center	Level 3
21208	Mainga Health Centre	Level 3
17111	Mashambani Health Centre	Level 3
20199	Mbaka Oromo Health Centre	Level 3
21487	Migere Health Centre	Level 3
20332	Milenye Health Centre	Level 3
13816	Miwani Health Centre	Level 3
13884	Nyakongo health Centre	Level 3
13887	Nyalenda Health Centre	Level 3
13890	Nyalunya Health Centre	Level 3
18800	Oren Health Centre	Level 3
14040	Ratta Health Centre	Level 3
14060	Rota Health Centre	Level 3
14066	Sango Rota Health centre	Level 3
14086	Sigoti Health Centre	Level 3
14088	Simba Opepo Health Centre	Level 3
14118	St. Mark's Lela Health Centre	Level 3
14141	Tamu Health Centre	Level 3
16664	Usoma Health Centre	Level 3
18283	Wanganga Health Centre	Level 3
13468	Ahero County Hospital	Level 4
13528	Chulaimbo County Hospital	Level 4
13647	Gita Sub County Hospital	Level 4
13657	Katito Sub County Hospital	Level 4
13704	Kisumu County Hospital	Level 4

13714	Kombewa County Referral Hospital	Level 4
13738	Lumumba Sub County Hospital	Level 4
13770	Manyuanda Sub county Hospital	Level 4
13785	Masogo Sub County Hospital	Level 4
13807	Migosi Sub County Hospital	Level 4
13810	Miranga Sub County Hospital	Level 4
13831	Muhoroni County Hospital	Level 4
13880	Nyahera Sub County Hospital	Level 4
13921	Nyakach County Hospital	Level 4
13899	Nyamarimba Sub County Hospital	Level 4
13923	Nyangande Sub County Hospital	Level 4
13928	Nyang'oma Sub county Hospital	Level 4
13954	Ober Kamoth Sub County Hospital	Level 4
13971	Ojola Sub County Hospital	Level 4
14020	Rabuor Sub county Hospital	Level 4
14096	Sondu Sub County Hospital	Level 4
17376	Victoria Sub District Hospital	Level 4
13939	Jaramogi Oginga Odinga Teaching & Referral Hospital	Level 5

Appendix 4: Questionnaire Design with Teleforms



Appendix 5. Correlation matrix for Convergent and Divergent Validity

	Technological	Organisational	Behavioural	Cloud Adoption for Health service delivery
tech_readiness1	0.501	-0.169	0.329	0.42
tech_readiness2	0.589	-0.099	0.239	0.468
service_quality1	0.564	0.032	0.289	0.404
service_quality2	0.647	0.054	0.323	0.442
service_quality3	0.532	0.146	-0.028	-0.034
service_quality4	0.589	0.035	0.127	-0.1
expert_scarcity1	0.668	-0.033	0.418	0.266
expert_scarcity2	0.553	-0.168	0.355	0.32
expert_scarcity3	0.525	-0.099	0.371	0.284
IT_budget	0.307	0.531	0.303	0.202
TMS1	0.307	0.569	0.303	0.202
TMS2	0.091	0.258	0.123	0.045
aware_policy	0.255	0.739	0.404	0.276
bed_capacity1	0.171	0.553	0.292	0.407
ageyrs	-0.112	0.853	-0.093	-0.078
experience_all	-0.173	0.872	-0.1	-0.051
relevant_experience	-0.133	0.638	0.069	0.02
Education	0.071	0.515	0.182	0.196
Designation	0.254	0.678	0.394	0.197
PU1	0.367	-0.12	0.507	0.419
PU2	0.412	-0.191	0.589	0.443
PEOU1	0.418	0.147	0.492	0.383
PEOU2	0.377	0.129	0.602	0.318
trust1	0.28	-0.206	0.578	-0.119
trust2	0.087	-0.072	0.515	-0.02
trust3	0.192	-0.024	0.327	0.035
social_influence1	0.379	0.118	0.517	0.178
social_influence2	0.239	0.217	0.622	0.158
capital_expenditure	0.308	0.168	0.159	0.534
labour_costs	0.267	0.083	0.11	0.587
maintenance_costs	0.078	-0.034	0.084	0.626
energy_savings	0.252	-0.186	0.277	0.148
improved_security	0.697	-0.008	0.436	0.569
collaboration	0.001	-0.052	-0.201	0.575
unlimited_resources	0.267	0.112	0.362	0.31
all_hours_platform	0.041	-0.129	-0.063	0.636
intergration	0.331	-0.047	0.241	0.579
service_variety	0.192	-0.12	0.292	0.521

Appendix 6: Informed Consent Form

CONSENT TO PARTICIPATE IN RESEARCH

CLOUD COMPUTING ADOPTION IN PUBLIC HOSPITALS IN KISUMU COUNTY

You are asked to participate in a research study conducted by Billy Ogwel from the School of Information, Technology and Communication at Rongo University as part of my Master of Science (health Informatics) Thesis. Your participation in this study is voluntary. Please read the information below and ask questions about anything you do not understand, before deciding whether to participate.

PURPOSE OF THE STUDY:

The purpose of this study is to understand the influence of technological, organisational, environmental and policy contexts on cloud computing adoption for health service delivery.

PROCEDURES:

If you volunteer to participate in this study, a questionnaire will be administered for purposes of
academic research and will take approximately 20 minutes:

POTENTIAL BENEFITS

This study will help healthcare organizations to better understand cloud computing and guide them in the process of adoption thereby increase their service delivery and effectiveness and help them remain relevant in a dynamic business environment.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of a password-protected drive only accessible to the researcher.

CONSENT

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I understand I may withdraw from the study at any time.

_____
Name of Participant

_____ _____
Signature of participant Date

_____ _____
Signature of Researcher Date

Appendix 7: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 157085

Date of Issue: 09/September/2019

RESEARCH LICENSE

This is to Certify that Mr.. Billy Ogwel of Rongo University, has been licensed to conduct research in Kisumu on the topic: CLOUD COMPUTING ADOPTION IN PUBLIC HOSPITALS IN KISUMU COUNTY for the period ending : 09/September/2020.

License No: NACOSTI/P/19/1429

157085

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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