A FRAMEWORK FOR INTEGRATING RADIOLOGY WITH HOSPITAL MANAGEMENT INFORMATION SYSTEMS IN SELECTED PUBLIC HOSPITALS IN UASIN GISHU COUNTY

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DECLARATION AND APPROVAL

This thesis is my original work and it has not been presented for a degree in any institution of higher learning.

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DEDICATION

I dedicate this work to my parents, Mr. Gajetan Mulomi and Felistas Ondigo for their immense support and understanding.

ABSTRACT

The main aim of integrating health information systems is more like transformation in business organizations, which is to streamline, interconnect, and compress the value chain or process. The aim of the study was to develop a framework for integrating a Radiology and Hospital Management Information System. The study had the following objective; To assess the status of the design framework of the Radiology and Hospital Management Information System in the selected public hospitals in Uasin Gishu County, to identify organizational factors that should be considered while integrating Radiology and Hospital Management Information System, to determine the capabilities of the existing infrastructure to support the integration of Radiology and Hospital Management Information System, and lastly to develop a framework for integrating Radiology and Hospital Management Information System. The study was carried out at selected public hospitals in Uasin Gishu County. The selected hospitals are Ziwa Sub County Hospital, Burn Forest Sub-County Hospital, Moi Teaching and Referral Hospital. The study aimed at developing a framework for the integration of Radiology and Hospital Management Information System**.** The study carried out an all-inclusive participatory investigation into ways of integrating Radiology and Hospital Management Information System in the selected public hospitals in Uasin Gishu County by administering questionnaires. Data from the questionnaires were analyzed using a statistical package for social sciences (SPSS v 20) and the findings presented as follows: On the design framework of the Radiology and Hospital Management information system used in the selected public hospital in Uasin Gishu county, the result showed that both Radiology and Hospital Management Information Systems used in selected hospital exist independent systems that do not exchange data; The results also showed that the Infrastructure framework in the selected hospitals contains poor communication channels, lacked proper data centers and the network infrastructure was also not up to the standards required for integration; On organizational factors to be considered in the integration framework, the study found that there was poor budgetary allocation to critical departments especially the Information Communication Technology section. The study recommended a complete overhaul of the network infrastructure in the selected hospitals, and evaluation of both the Radiology and Hospital Management Information System, and finally appropriate budgetary allocation.

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ACRONYMS AND ABBREVIATIONS

CT - Computerized Tomography

DICOM - Digital Imaging and Communication in Medicine

EAHRC - East African Health and Research Commission

EMR - Electronic Medical Record

EHR - Electronic Health Record

FHIR - Fast Health Integrated Resource.

HIS - Hospital Information System

HITECH - Health Information Technology for Economic and Clinical Health

HL7 - Health Level Seven

HMIS - Hospital Management Information System

HMN - Health Metrics Network

ICT - Information and Communications Technology

IHE - Integrating the Healthcare Enterprise

ISO - International Organization for Standardization

KeHP - Kenya eHealth Policy

MTRH - Moi Teaching and Referral Hospital Eldoret

MRI - Magnetic Resonance Imaging

OSI - Open Systems Interconnection

PACS - Picture Archiving and Communication System.

RESTful - Representational State Transfer

RIS - Radiology Information System

RSNA - Radiological Society of North America

SIIM - Society of Imaging Informatics in Medicine

SPSS -Statistical Package for Social Sciences

USA - United States of America

VA - Veterinary Affairs

WHO - World Health Organization

CHAPTER ONE

INTRODUCTION AND BACKGROUND INFORMATION

1.1 Background of the study

An information system is defined as the socio-technical subsystem of an institution, which comprises of all information processing as well as the associated human or technical actors in their respective information processing roles (Boell & Cecez-Kecmanovic, 2015). On the other hand, a health information system is composed of all organizations, institutions, resources, and people whose primary purpose is to improve health. This contains efforts to control determinants of health as well as more direct health-improvement activities. Health information provides the foundation for all the decisions in a healthcare organization. These decisions could be clinical, at the bedside, or a national government level (Hovenga & Grain, 2013).

A health management information system (HMIS) consists of two subsystems that define it namely; a hospital management information system and a patient management information system. The patient information management system deals with issues relating to the patient which include; patient data, patient billing, patient treatments, and prescriptions. Hospital management information system on the other hand deals with clinical information concerning financing, administration, operations, and logistics services such as accounting, record keeping, assets management, Human Resource Management, and stock management (Macharia & Maroa, 2014).

The WHO has a framework that outlines the health system in terms of six core components or "building blocks" namely; Services delivery, health workforce, health information system, access to essential medicines, financing, and leadership/ governance. These building blocks are interdependent and must interact synergistically

to produce a positive impact on health outcomes. They also contribute towards the improvement of health systems in different ways. Some for instance leadership/governance and health information systems acts as a basis for the overall policy and regulation of the other health system blocks. Others such as medical products and technologies and service delivery reflect the immediate outputs of the health system, i.e. the availability and distribution of care.

Human resources for health or the health workforce is also a key building block according to the WHO. They are defined as the stock of all people engaged in actions whose primary intent is to enhance health. An adequate, productive, and equitably distributed pool of accessible health workers is necessary for the effective delivery of healthcare (World Health Organization, 2015). The Kenya health service is categorized as;

National Referral services; Comprises of all tertiary also known as level 6 referral hospitals, National reference laboratories, and services, Government-owned entities, Blood transfusion services, Research, and training institutions that provide highly specialized services. These include (1) General specialization (2) Discipline specialization, and (3) Geographical/regional specialization. The main focus of national referable services is usually on highly specialized healthcare, for area/region of specialization, training, and research services on issues of cross-county importance. Moi Teaching and Referral in Eldoret and the Kenyatta National hospital are the two national hospitals that fall into this category.

County Referral Health Services; Comprises of level 4 and level 5 hospitals, sometimes also referred to as primary and secondary hospitals. They mainly provide health services at the county level together with those managed by non-state actors.

They provide comprehensive in-patient diagnostic, medical, surgical, and rehabilitative care, including reproductive health services. They are also mandated to provide specialized outpatient services, facilitate, and manage referrals from lower levels, and other referrals. Also, they provide other services such as management of cemeteries, funeral parlors, and crematoria.

Primary Care Services; Comprises of all dispensaries and health centers. They are also referred to level 3 and 3 hospitals, including those managed by non-state actors. Their functions include Disease prevention and health promotion services; Basic outpatient diagnostic, medical-surgical & rehabilitative services; -Ambulatory services -Inpatient services for emergency clients awaiting referral, clients for observation, and normal delivery services; -Facilitate referral of clients from communities and to referral facilities.

Community Health Services; Comprise community units (level 1) in the County. Those that are constitutionally defined, and in community health strategy, including; Facilitate individuals, households and communities to embrace appropriate healthy behaviors; Provide agreed health service; Recognize signs and symptoms of conditions requiring referral; Facilitate community diagnosis, management, and referral (Ministry of Health Kenya, 2016).

The 2010 Constitution also provides a legal framework that guarantees an inclusive rights-based approach to health service delivery to all Kenyans. It provides that Kenyans are entitled to the highest attainable standards of health, which includes the right to healthcare services including reproductive health care (Article 43). Article 53, provides for the right of every child to basic nutrition, shelter, and healthcare. Article 53 provides for the right of every child to basic nutrition, shelter, and healthcare. In

Article 56, the constitution provides that the state shall put in place affirmative action designed to ensure that minorities and marginalized groups have reasonable access to water, health services, and infrastructure (GOK, 2010).

To actualize the health-related rights, the constitution has divided the healthcare responsibilities between the County and national government. The Fourth Schedule of the constitution provides specific guidance on which services the county or national governments are to provide. The delivery of essential health services is assigned to county governments while the national government deals with health policy, technical assistance to counties, and management of national referral health facilities (Kimathi, 2017).

To support the devolution of healthcare services, the Government of Kenya initiated the Managed Equipment Service project (MES) in 2016. The project refers to a flexible, long-term contractual arrangement that involves outsourcing the provision of specialized, modern medical technology and equipment to private sector service providers. It comprises a 7-year contract between the Ministry of Health and various contractors for the supply of equipment to 98 hospitals comprising of two health facilities in each of the 47 Counties as well as four health facilities under the management of the National Government. The equipment supplied included; Radiology equipment, Theatre, Laboratory, ICU, and Renal equipment. The Radiology Equipment includes a digital x-ray machine supported by a Radiology Information system for managing patient data and the subsequent images (Olotch, 2017).

In most radiology departments, there is at least five separate information system in use. The most commonly used are the Picture archiving and Communication System (PACS), Radiology Information System (RIS), a Hospital Information System (HIS)

(Honeyman, 1999). RIS facilitates patient radiology examination scheduling, assists in tracking patient data and information, and permits online radiology diagnostic reporting, whilst HIS supports hospital administrative tasks such as patient registration, discharge, and billing. PACS on the other hand is a system that specializes in the acquisition, storage, processing, and distribution of radiographic image data. Patient radiographic images are obtained via the use of imaging modalities (Mohd-Nor, 2011).

Over several years, certain standards have been developed for radiology departments to support the equipment using digital technology. Some of the radiology equipment using digital technology includes MRI, CT, Ultrasound, General X-ray, and Mammography. Magnetic resonance imaging (MRI) uses a strong magnetic field and radio waves to create detailed images of the organs and tissues within the body. The scanner itself typically resembles a large tube with a table in the middle, allowing the patient to slide in. A computerized tomography (CT) scan combines a series of X-ray images taken from different angles around your body and uses computer processing to create cross-sectional images (slices) of the bones, blood vessels, and soft tissues inside your body (Power, 2016). On the other hand, An ultrasound scan also referred to as Sonography is a medical test that uses high-frequency sound waves to capture live images from the inside of your body. It combines the ability for very good spatial resolution with deep penetration into soft tissues, except those involving underlying bones or gas (Klibanov & Hossack, 2015).

Data interchange and message standards used for the integration of Radiology services in a healthcare Enterprise are the Digital Imaging and Communication in Medicine (DICOM), the Health Level Seven (HL7), and Fast Health Integration Resource (FHIR). DICOM is the international standard for medical images and related information. Implemented in almost every radiology imaging device, it defines the

formats for medical images that can be exchanged with the data and qualities necessary for clinical use (Noumeir & Pambrun, 2012). The DICOM standard makes it possible for images from different imaging modalities to be distributed over an internet network to distant viewing workstations and a central archive almost seamlessly (Robertson & Saveraid, 2008). The HL7 refers to a set of international standards for the transfer of clinical and administrative data between software applications used by various healthcare providers. The Standard is produced by the Health Level Seven International and recognized by other standardization bodies like the American National Standards Institute and the International Organization for Standardization (HL7 International, 2016). Level Seven in this case refers to the highest level of the International Standards Organization (ISO) communication model for Open Systems Interconnection (OSI). It provides a common language for information exchange and electronic patient records both externally and internally (Abdulla, Al-mejibli, & Ahmed, 2017)

FHIR is the most current interoperability standard developed by the HL7 organization. It's an open standard that allows external software to quickly search for and access clinical information from the EMR. This is done in a developer-friendly method, using the current internet technology standards. FHIR uses the representational state transfer (RESTful) architecture which standardizes methods to search for, update and delete, which is similar to what organizations such as Facebook or Twitter use (Kamel & Nagy, 2018).

Globally, the Integrated Healthcare Enterprise (IHE) forum, established in 1998 by the Healthcare Information and Management Systems Society (HIMSS) and Radiological Society of North America (RSNA) provides the technical framework that allows the seamless passing of vital information from the application to application, system to system using DICOM and HL7 standards. Healthcare organizations across the world

that have followed IHE guidelines have achieved effective system integration and facilitated the appropriate sharing of medical information within and across their enterprise (Kohn, 2004).IHE is an initiative where professionals in the healthcare setup and industry providers work together to improve the way computer systems in hospitals share information to achieve a high level of integration. IHE enables healthcare providers to identify the integration needs, while manufacturers implement solutions by providing systems that communicate better, are easier to deploy, and less expensive to maintain (Drew, 2013).

In the United States, as early as 1969 when the internet was being invented, the Agency for Healthcare Research and Quality funded its first project in Medical informatics. The idea was to use the available information technology tools to improve health care (Medicare, Drug, & Act, 2004). Demographic changes such as an aging population with increased chronic illness and a more mobile population created the need for large volumes of health information. This also increased the demand for readily available healthcare information that is easily transferrable. The increased concerns about bioterrorism after September 11 attacks focused attention on the need for public health information infrastructure with capabilities of providing aggregate information on a real-time basis (Harris, 2003).

The use of health information technology, especially the use of electronic health records (EHR) in the USA hospitals has had an impact on improving the efficiency and effectiveness of healthcare providers. The American Recovery and Investment Act of 2009 made the promotion of a national, interoperable health information system a priority. The act also included the enactment of the Health Information Technology for Economic and Clinical Health Act (HITECH). Under the HITECH Act, the United

States Department of Health and Human Services is spending $25.9 billion to promote and expand the adoption of health information technology (Jha, 2009).

At the onset of E-health adoption in the US, referring clinicians used to receive radiology reports via fax and emails. This has changed with the advent of digital modalities which led to the implementation of RIS Radiology departments. RIS was adopted rapidly because it provided a centralized platform that enabled increased scheduling efficiency and reliability through enforced specific workflows. Meaningful use of regulations has resulted in the widespread implementation of EHR by hospitals and clinicians, resulting in the integration with Radiology information system (Kohli, Dreyer, & Geis, 2015). One of the first hospitals to integrated RIS and HMIS in the US was the Veterinary Affairs Medical Centers (VA). The VA's HMIS is an integrated system that is installed in 164 VA medical Centers (Dayhoff, Maloney, Kuzmak, & Shepard, 1991).

Regionally there has been a realization that many problems with existing HIS originate from the practice of installing specific, narrow information subsystems, and often covering limited information needs. Without a clear strategy, these subsystems evolve into an inefficient system leading to less use of information for health improvement. This has led to several international organizations that specifically address these challenges with new strategies. The Health Metrics Network (HMN, established in 2005) was created to strengthen HIS in developing countries and information use, by integrating the subsystem and data sources. Other international donors many of whom were initially the source of fragmented systems have adopted a strategy to improve the integrated HMIS systems (Sæbø, Kossi, Titlestad, Tohouri, & Braa, 2011).

The East African Community is undertaking positive steps to use digital technology to transform the health sector in this region as well as achieving the Sustainable Development Goals. In its 2016-2021 Strategic Plan, the East African Health Research Commission (EAHRC) has mandated the use of digital technology in the health sector. To achieve this mandate, EAHRC hopes to bring together governments in the East African Community, development partners, and the private sector to build on rather than replace the national health programs and strategies. The Commission on Health Research for Development (1990) identified a need for research on the development of practical health information systems to guide policy and management decisions. HIS improvements were identified a critical in countries such as Tanzania, this has made international organizations mobile funds for the improvement of HIS (Gladwin, Dixon & Wilson, 2003).

In Kenya, the Ministry of Health Services through the Division of Health Information System (HIS) recognized the importance of the use of ICT in improving health services. Under Strategic Objective Five of the HIS Strategic Plan 2009-2014, the HIS aim is to strengthen the use and application of ICT in data management. It's from this objective that the Ministry of Health saw the need to standardize and interoperable ICT applications in the health system. Through the HIS, the Ministry of Health started the standardization of EMRs in Kenya. The standardization aimed to aid in system development and implementation which would result in the integration of health information systems for better service delivery.

The Kenya Constitution (2010) (GOK, 2010) and Vision 2030 (The Ministry of Planning and Devolution, 2007) development blueprint requires the country to provide the highest attainable standard of healthcare. To achieve this mandate, the Ministry of Health developed the Kenya Health Policy (2014 – 2030), an improved version of the

HIS policy 2009-2014. One of the revised objectives is to plan, design, and install information and Communication Technology (ICT) infrastructure and software for the management and delivery of essential healthcare (Kenya Health Policy, 2014-2030).

Kenya, just like other developing countries faces numerous healthcare system challenges which include the demand for high quality and equitable distribution. To overcome these challenges, the government and healthcare providers had to focus their energies on developing an eHealth policy. These efforts lead to the development of the Kenya eHealth Policy (2016-2030) (KeHP) as a subset of the sector-wide Kenya Health Policy to strengthen and accelerate the integration of ICT into the healthcare system (Ministry of Health Kenya, 2016). Policy objective 3 of the KeHP is to enhance the electronic exchange of health data and information. The following are priority strategies under this policy objective; ensure standardization of stored data to improve the interoperability of the eHealth system; continuous improvement of infrastructure and resources to support the cost-effective implementation of telehealth applications; and ensure prompt and convenient access to the patient's demographic and clinical data to privileged healthcare providers.

1.2 Statement of the Problem

Integrating RIS with the HMIS will ensure patient information is accurately matched with the imaging data. When an order is entered into a RIS, the patient information is automatically available at the Radiological machine. This greatly increases the accuracy of the data entered during each examination. Billing accuracy is also improved and historical study information is made available to the physicians in the wards for future examinations (Nance, Meenan, & Nagy, 2013). The main aim of integrating health information systems is more like transformation in business organizations, which is to streamline, interconnect, and compress the value chain or process. Largely independent

and poorly coordinated work processes are integrated to eliminate redundancy operations, sort out ambiguity, and cut back on secondary or administrative overheads (Monteiro, 2003).

However, most hospitals in Kenya use different information systems in a different care setting, making it difficult to safely communicate information. These independent systems also maintain their own vertical and uncoordinated reporting system making it impossible to even trace a patient healthcare journey (Njeri & Matende, 2014). If systems are not integrated in a healthcare set up, then the results are duplicate data entry tasks, inconsistency, and inadequate functionality. Inaccurate data entry makes it difficult to find historical studies. It also makes it almost impossible to match a report with its associated study (Dlodlo & Systems, 2017)

In response to the problems mentioned above that result from not integrating RIS and HMIS, the study assessed the design framework RIS and HMIS in the selected public hospitals in Uasin Gishu County, identified critical factors to be considered while integrating the two systems before developing a comprehensive framework to integrate them.

1.3 Purpose of the Study

The purpose of the study was to develop a framework for integrating the Radiology Information System with the Hospital Management Information System in selected public hospitals in Uasin Gishu County.

1.4 Objectives

The objectives of the study were;

i. To assess the status of the design framework of the Radiology and Hospital Management Information Systems in the selected public hospitals in Uasin Gishu County.

ii. To identify the organizational factors that should be considered while integrating Radiology and Hospital Management Information Systems in the selected public hospitals in Uasin Gishu County.

iii. To determine the capabilities of the existing infrastructure framework to support the integration of Radiology and Hospital Management Information Systems in the selected public hospitals in Uasin Gishu County

iv. To develop a framework for integrating Radiology and Hospital Management Information Systems in the selected public hospitals in Uasin Gishu County.

1.5 Research Questions

i. What is the status of the design framework of the Radiology and Hospital Management Information Systems in the selected hospital in Uasin Gishu County?

ii. What are the organizational factors that should be considered while integrating Radiology and Hospital Management Information Systems in the selected public hospitals in Uasin Gishu County?

iii. What are the capabilities of the existing infrastructure to support the integration of Radiology and Hospital Management Information Systems design in the selected public hospitals in Uasin Gishu County?

iv. What kind of framework will be developed to integrate Radiology and Hospital Management Information Systems in the selected public hospitals in Uasin Gishu County?

1.6 Scope of the Study

The subject area of the study was the integration of the Radiology and Hospital Management Information System in selected public hospitals in Uasin Gishu County.

1.7 Justification of the Study

Integrating RIS and HMIS supports clinical operations, business, and administrative functions in a hospital. It also improves hospital services which include workflow reduction that reduces the time for a patient to be treated for radiology and physicians to diagnose them. The integration of these two systems also eliminates the need to print films and the worry of losing them (Sibarani, 2012). Information Systems and service delivery are important pillars of a health system and therefore this study will contribute significantly to the establishment of an efficient health system (WHO, 2015).

1.8 Significance of the Study

The findings and recommendations of this study will provide the needed information on the importance of integrating RIS and HMIS to all stakeholders in the health sector. It will assist the policymakers, including government officials in decision making, policy formulation, and strategic planning regarding health information systems. Managers of the health institutions will now be more knowledgeable when they engage Information system vendors.

Vendors and system developers of RIS and HMIS will also find this study useful. It should be able to guide them during the design and implementation of an information system. They will see the need of engaging other stakeholders in the health sector during the development and implementation of any health information system.

1.9 Limitation of the Study

This study was limited to time and finances. Some of the research participants had a busy schedule or worked in shifts and therefore this posed a challenge to the researcher.

The study involved traveling during the data collection process, this required some finances.

1.10 Definition of Operational Terms

Information systems: is the study of complementary networks of hardware and software that people and organizations use to collect, filter, and process, create, and distribute data (Boell & Cecez-Kecmanovic, 2015).

Hospital Information systems: It's a specialized information system designed to manage the administrative, financial, and clinical aspects of hospitals and healthcare facilities. They are considered one of the most important focal points on which the delivery of healthcare within hospitals and different types of medical institutions depends (Khalifa & Alswailem, 2015).

Hospital Management Information Systems: HMIS is a system for patient care and hospital management. If functions include: keeping patient information; general billing; maintenance of hospital equipment and recording information related to patient's diagnosis among other functions (Abdulla et al., 2017).

Radiology Information System: is an information system where patients are registered, examinations are scheduled and radiologists' reports are recorded, stored, and distributed. The RIS can also provide management information and may hold information that is important for revenue generation (Ratib, Swiernik, & McCoy, 2003).

Picture Archiving and Communication System: is a medical imaging technology that provides economical storage and convenient access to images from multiple modalities (source machine types). Electronic images and reports are transmitted digitally via PACS; this eliminates the need to manually file, retrieve, or transport film

jackets, the folders used to store and protect X-ray film. The universal format for PACS image storage and transfer is DICOM (Huang & Demiris, 2005).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the literature available on health information system integration based of on the study objectives. It also describes a conceptual framework as well the theories used in the study. Staff shortages, continuing cost inflation, and service demand have intensified the call for more effective and efficient use of scarce resources through integrated service delivery models (Fleury, 2006). Integrated health systems as a result of effective communication and standardized protocols are widely considered to provide superior performance in terms of quality and safety, although these outcomes have not been fully demonstrated.

Despite the growing enthusiasm for integration, information related to implementing and evaluating integration-related initiatives is dispersed and not easily accessible. There is little guidance for planners and decision-makers on how to plan and implement integrated health systems. With evidence-informed decision-making as an expectation in healthcare management and policy, there is a need to seek out and apply current knowledge on health systems integration to advance effective service delivery. Systematic reviews can serve as a tool for evidence-based decision-making for health planners and policymakers (Suter, Oelke Adair, & Armitage, 2009). According to Hasselbring (2000), there are several forms of information system integration, with the aim of being able to support several organizational processes. They include:

Enterprise Application Integration; the aim, in this case, is to integrated independent resource planning systems at their layer. It involves some exchange of information using a messaging service. At this layer, an application needs to interpret and

understand data provided by another application. This is achieved by standardization of the message format and information shared among the applications.

Middleware integration: At this layer, the ideas for creating computerized information systems with complicated infrastructures such as CORBA, database gateways, and transaction monitors, are employed. Middleware integration addresses the syntactical level ("plumbing" and "wiring") while Enterprise Application Integration also addresses a semantic level. The borderline between Enterprise Application and middleware integration cannot always be pinpointed precisely. For instance, the Object Management Architecture of the OMG defines the Object Request Broker, which can be deployed for middleware integration, and also high-level services.

The challenge facing the medical industry is that many automated solutions have been implemented departmentally. Most facilities live with the legacy of disparate systems that now need to communicate with each other if digital workflow throughout the medical enterprise is to be realized. One piece of the puzzle that must be in place is the integration of the hospital information system (HIS), the radiology information system (RIS), and the picture archiving and communication system (PACS) (Nance, Meenan & Nagy, 2013).

A RIS, on the other hand, is an information system where patients are registered, examinations are scheduled and radiologists' reports are recorded, stored, and distributed. The RIS can also provide management information and may hold information that is important for revenue generation. Needless to say, a PACS and a RIS need to work seamlessly together. Proper integration of the RIS and PACS can provide productivity improvements in radiology departments resulting in, for instance, faster study turnaround times for patients and clinicians. The integration of medical

imaging as part of the patient record is a critical component of documentation and information that support clinical decisions. With the increase in the number of medical imaging procedures that require more accurate and specific diagnosis, integrating radiology system with HMIS is therefore important in patient management (Ratib, Swiernik & McCoy, 2003).

By definition, HMIS is a system for patient care and hospital management. If functions include: keeping patient information; general billing; maintenance of hospital equipment and recording information related to patient's diagnosis among other functions (Abdulla et al., 2017). Combining data from multiple information systems requires an organization to put in a lot of effort. The different functionality, data presentations, user interface, semantic presentation, and terminology usually pose a great challenge to system integration (Kitsiou, Manthou, & Vlachopoulou, 2006).

According to Lopez and Blobel (2009) for highly distributed systems in a healthcare domain to communicate in a consensus, interoperability needs to happen in the following levels;

- Technical interoperability refers to technical aspects of interconnecting computer systems. It covers key issues such as interconnection services, communications technologies, middleware, data exchange, security services, data presentation, technical architecture styles, technical infrastructures, and accessibility services. This perspective should support the interoperable solutions at the technical layer.
- Semantic interoperability is the ability to exchange information between information systems. To achieve this compatibility at the transport and application layers of the communications protocols is necessary. The agreement

with the messaging protocols and encoding data formats is also required. It is a necessary precondition for further interoperability.

- Structural interoperability provides a commonly agreed model of clinical or other domain concepts. This model clinically is a meaningful entity that can be shared by multiple independent information systems components

2.2 HMIS and RIS Design Framework

According to Ngafeeson (2014), Hospital Management Information Systems (HMIS) is a comprehensive and integrated information system designed to manage the administrative, financial and clinical aspects of a hospital and it encompasses paper-based information processing as well as data processing and storage equipment. He further adds that HMIS comprises hardware, software, and people who handle the systems. HMIS automates management reporting to support administrative and patient care applications and to reduce the time and effort spent on the part of health knowledge workers such as doctors, pharmacists, and nurses.

Le Pape, Suarez, Mhayi, Haazen and Ozaltin (2017) define HMIS as a socio-technical subsystem of a hospital that comprises all information processing actions, human and technical actors in their respective roles within the system. HMIS automates routine management reporting to support administrative and patient care applications; designs health office systems and processes to reduce time and effort expenditure on the part of health knowledge workers such as doctors, pharmacists, and nurses. (Macharia & Maroa, 2014)states that HMIS is used for the master index, patient management, billing, insurance management, pharmacy, radiology, accounts management, order entry, operation theatre, depending on the specific hospital and further says that their functionalities may increase.

Macharia and Maroa (2014) continues to state that by definition, HMIS can be on County, District, or national level at the Ministry headquarters and consist of data for both strategy and policy. The main goal of HMIS is to provide accurate and timely information that can lead to improved health care planning, diagnosis, and improve patients' access to health services. According to Sibarani (2012), to integrate RIS and HMIS, one needs look at the following technical design component; system architecture and data standards and interoperability.

2.2.1 System Architecture

Information system architectures are grouped are as follow: Hardware architecture; Software architecture and Enterprise architecture. Software architecture refers to the basic elements of a software system. It's the backbone of Information system architecture as it's concerned with how programs and application components are internally built. Hardware architecture refers to the identification of the system's physical components and how their interrelationships. It's an important component of information system architecture as it provides software designers with relevant information needed for software development and integration. Enterprise architecture on the other hand applies principles and guidelines that help organizations in business, information processing, and technological changes necessary to execute strategies (Vasconcelos, Sousa & Tribolet, 2003).

Vasconcelos et al., (2003) go further to state that Information System Architectures are usually distinguished by three aspects or sub-architectures that define the ISA functions. They are; Informational Architecture or data architecture which represents main data types that support an organization. Application Architecture defines applications needed for data management and business support, and finally, Technological Architecture that represents the main technologies utilized in application

implementation and the technological infrastructure that provides an environment for Information system development.

According to Abdulla et al., (2017), the architectural design of HMIS is classified according to the number of functions that can be supported by it. HMIS systems suitable for small to medium level hospital consist of only one database that stores all patients' related data. The network architecture of such systems is client-server with a centralized database. They include one mainframe server connected to multiple terminals or workstations. In this kind of architecture, application components: patient registration; Accounting and Finance; Billing; Radiology; Pharmacy; Stores are on the framework to be accessed by the terminals.

On the other hand, HMIS systems with many heterogeneous application components are suitable for large hospitals and those that are distributed over a large geographical area. The network architecture is therefore distributed database architecture which means several application components store data about certain entity types persistently and contain the own database. The central server and interconnected to each other through network protocols (Abdulla et al., 2017).

2.2.2 Data Standards and Interoperability

To use and share data within multiple systems, the data must be built upon common words, structure, and organization. The common words in which data is built upon are data elements and terminology. This requirement is what is referred to as interoperability (Brooks, Health, Healthcare, & Standards, 2010).

According to Cain and Mittman (2002) to be able to share health information, interoperability across the software from multiple vendors is critical. Without interoperability, access to data becomes difficult which in turn leads to inefficiencies,

increased cost, and poor quality (Stiell, Forster, Stiell, & Van Walraven, 2003). An essential building block of interoperability is the adoption and use of terminology and messaging standards that are agreed upon (Brooks, 2010). Terminology standards provides an unambiguous, machine-readable meaning of specific terms and messaging standards permitting the electronic exchange of information consistently (Dlodlo & Systems, 2017). Together, they will allow the interoperable use and exchange of healthcare information. Miller and Sim (2004) stated that even with the wide adoption of HMIS true healthcare transformation will not occur without the standardization and improved interoperability of healthcare systems.

Lack of shared standards for data collection in a health institution means that the same data are often collected and reported many times among departments. At the same time, there are gaps where important data do not get reported. This inconsistency in definition and procedure creates inefficiency (Van Panhuis et al., 2014).

According to Adebesin, Foster, Kotze and Van Greunen (2013), there exit interoperability framework and architectures that advise the development of integrated health information systems by effectively using enterprise architecture approaches to ensure the system can share information across organizations. They include;

Identifier standards: Are those that deal with the unique identification of various entities, such as, patients, healthcare providers, and health-care institutions.

Messaging standards: These specify the structure and format of messages to aid secure transfer and receipt of information across health institutions. They go as far as specifying the acknowledgments that should be sent by the recipient of a ‘message’, as well as the warnings that should be generated when the ‘message’ has not to be delivered or if it is declined. An example is the HL7 standard.

Structure and Content standards: These provide speciation's for the structure of the data element in discharge summaries, referral letters, and electronic patient records. The standards also specify the data types, field lengths, and content of the data elements. This ensures data is presented systematically by the software applications.

Clinical Terminology and Coding standards; This type of standard supports the description of medical conditions, symptoms, diagnosis, and treatment using common language to prevent difficulties in the interpretation of healthcare information that is transmitted electronically.

Electronic Health Record standards: They are standards that describe the architecture of computerized medical records e.g. EHRs and EMR.

System function Models: They describe the range of functionalities that should be supported by EHR systems in different health-care settings. For instance, inpatient or outpatient setting. This standard gives a framework on which a specification for a particular EHR system implementation can be based and assessed.

Security and access control standards: They ensure secure transfer and delivery of healthcare information to ensure patient data is secure from unauthorized access. An example is the ISO privilege management and access control (ISO/TS 22600).

Regardless of the technology, for integration between systems to happen application component has to communicate. There must be an agreement about the syntax and semantics of data and messages that are to be exchanged. The common standard used in the integration of RIS and HMIS is HL7 and DICOM (Abdulla et al., 2017).

Digital Imaging and Communication in Medicine (DICOM): DICOM is the international standard for medical images and related information. Implemented in

almost every radiology imaging device, it defines the formats for medical images that can be exchanged with the data and qualities necessary for clinical use (Noumeir & Pambrun, 2012). The DICOM standard makes it possible for images from different imaging modalities to be distributed over an internet network to distant viewing workstations and a central archive almost seamlessly (Robertson & Saveraid, 2008).

DICOM data formats groups information into data sets, with data objects consisting of attributes such as name, patient ID, and imaging pixel data. A single DICOM object can only contain one attribute containing pixel data. A DICOM file contains both a header; which stores information about the patient name, the type of scan, image dimensions, etc a well as all the image data (Bairagi, Memorial, View, Dwt & Bairagi, 2014).

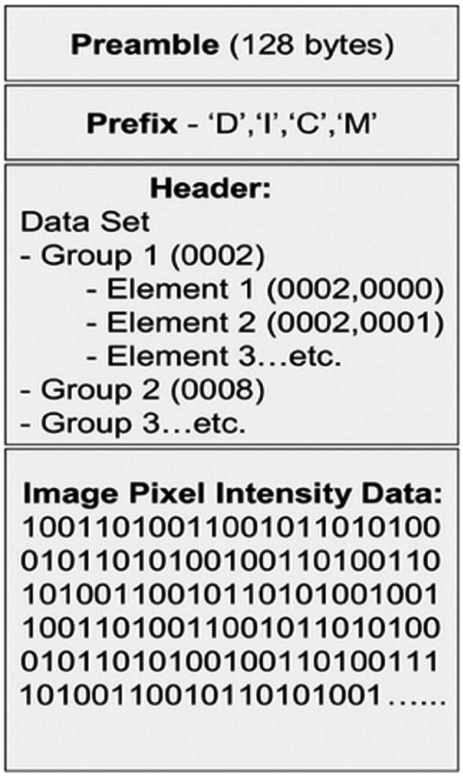

Figure 2.1 Structures of a Dico Image File

Source: Bairagi, Memorial, View, Dwt and Bairagi (2014)

The DICOM Standard is an object-oriented language in which the DICOM image contains both information and the functions (print, save, etc) that this information must undergo. Information processing in the case consists of matching a DICOM object (Information Object) to a specific function (Service Class). This kind of combination is referred to as an SOP (Service/Object Pair) (Farahat et al., 2020).

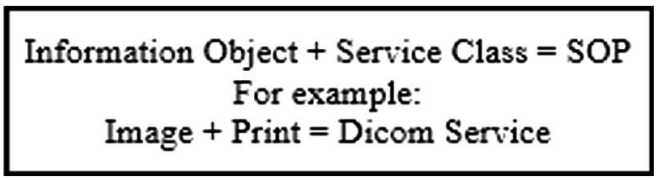

Figure 2.2 Combination SOP of DICOM file
Source: Farahat et al., (2020).

DICOM has services used for communication of imaging information with a device and for the device to perform a specific function for instance to store or display an image. A DICOM service is built on top of a set of DICOM message service elements (DIMSEs). These DIMSES are computer software written to perform a specific function (Huang & Demiris, 2005)

The DIMSEs are categorized into Normalized and Composite objects. Normalized commands are more specific whereas Composite is generalized. Examples of the objects and functions are shown below (Bairagi et al., 2014).

Table 2.1 Normalized DICOM Message Service Elements (DIMSE)

Command	Function
N-EVENT-REPORT	Notification of information object-related event
N-GET	Retrieval of information object attribute value
N-SET	Specification of information object attribute value
N-ACTION	Specification of information object-related action
N-CREATE	Creation of an information object
N-DELETE	Deletion of an information object

Source: Bairagi et al., (2014)

Table 2.2 Composite DICOM Message Service Element (DIMSE)

Command	Function
C-ECHO	Verification of connection
C-STORE	Transmission of an information object instance
C-FIND	Inquiries about information object instances
C-GET	Transmission of an information object instance via third-party application processes
C-MOVE	Similar to GET, but end receiver is usually not the command initiator

Source: Bairagi et al., (2014)

DICOM utilizes the existing network communication standards based on the Open Systems Interconnection Model (OSI) for imaging information transmission. When imaging information objects are transmitted between layers in the same device, the process is called a service. When information objects are sent between devices, the process is called a protocol. In a DICOM protocol, several steps are invoked between

the two devices in what is referred to as an Association. An illustration of the association between an Image Acquisition device and a Workstation is shown below.

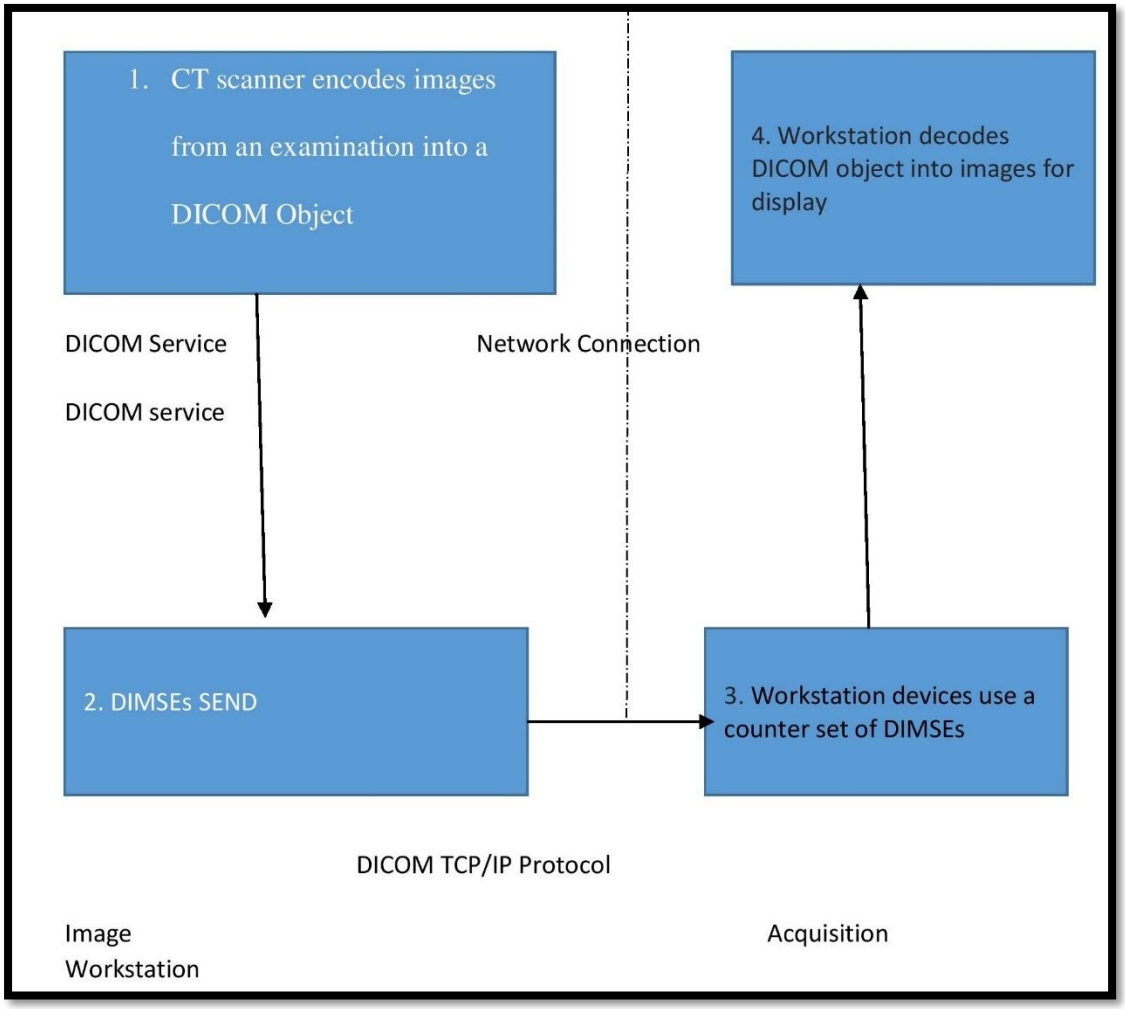

Figure 2.3 Data Flow of a Set of CT Images

Source : Abdulla et al., (2017).

In the above figure, the numeral represents the following steps;

1. CT scanner encodes all images into the DICOM object.
2. Scanner invokes a set of DIMSEs commands to move the image from a certain level down to the physical layer of the ISO model.
3. Workstation devices use a counter set of DIMSEs to receive the image object through the physical layer and move it up to a certain level.
4. Workstation decodes the DICOM image object.

2.2.3 Health Level Seven

The HL7 refers to a set of international standards for the transfer of clinical and administrative data between software applications used by various healthcare providers. The Standard is produced by the Health Level Seven International and recognized by other standardization bodies like the American National Standards Institute and the International Organization for Standardization (HL7 International, 2016). Level Seven in this case refers to the highest level of the International Standards Organization (ISO) communication model for Open Systems Interconnection (OSI). It provides a common language for information exchange and electronic patient records both externally and internally (Abdulla et al., 2017).

According to Huang and Demiris (2005) the HL7 standard, the basic data unit is a message. Each message consists of multiple segments in a defined sequence. A segment contains multiple data fields and is identified by a unique, predefined three-character code. The first segment usually is the message header with a three-letter code MSH. It defines the intent, source, destination, and other relevant information which includes the time stamp and message control identification. An example of an HL7 message on patient admission would contain the following segments;

MSH—Message header segment

EVN—Event type segment

PID—Patient identification segment

NK1—Next of kin segment

PV1—Patient visit segment

Data communication between the HMIS and RIS is event-driven, according to (Le Pape et al., 2017). When an HL7 Admit Discharge Transfer (ADT) event occurs, the HMIS would automatically send a broadcast message, conformed to HL7 format, to the RIS. The RIS would then pass this message and insert, update, and organize patient demographic data in its database according to the event, otherwise, a rejected message would be sent instead(Huang & Demiris, 2005). According to Noumeir (2019), a typical HL7 transaction of a patient admitted for surgery would look as illustrated below;

Table 2.3 HL7 Message

1) Message header segment MSH||STORE|HOLLYWOOD|MIME|VERMONT|200305181007|security| ADT|MSG00201|||<CR> (2) Event type segment EVN|01|200305181005||<CR> (3) Patient identification segment PID|||PATID1234567||DoeΛJohnΛBΛII||19470701|M||C| 3976 Sunset BlvdΛLos Angeles ΛCAΛ90027||323-681-2888|||||||<CR> (4) Next of kin segment NK1|DoeΛLindaΛE||wife|<CR> (5) Patient visit segment PV1|1|I|100Λ345Λ01||||00135ΛSMITHΛWILLIAMΛK|||SUR|ADM| <CR>

Source : Noumeir (2019).

This segment would be translated as follow; “Patient John B. Doe, II, male, Caucasian, born on July 1, 1947, lives in Los Angeles, was admitted on May 18, 2003, at 10:05 a.m. by Doctor William K. Smith (#00135) for surgery. The patient has been assigned to Room 345, bed 01 on nursing unit 100. The next of kin is Linda E. Doe, wife. The ADT (admission, discharge, and transfer) message 201 was sent from system STORE at the Hollywood site to system MIME at the Vermont site on the same date two minutes after the admit.”

The Open Systems Interconnection Model (OSI)

The OSI is a model reference tool for understanding data communications between any two networked systems. The communication process is divided into seven layers, with each layer performing specific functions to support the layers above it and offer services to the layers below it. The three lowest layers focus on passing traffic through the network to an end system. The top four layers come into play in the end system to complete the process (Simoneau, 2006).

The physical layer is the lowest layer of the OSI model that provides an electrical and mechanical interface to the network medium. It defines connectors and interfaces specifications and their requirements. This layer comprises the actual network cables, network cards interfaces, fibers, switches, and other electrical components that are attached to a network. Other components include; Connectors, Hub, Reapers, Patch panel specifications, Wireless system equipment's and Small computer system interfaces. It's in this layer that digital data is transformed into signal and transmitted via a medium channel. In most cases, the signals are always electrical with an exception of fiber connections where they can be non-electrical. The main function of this layer is to provide a framework for data to be sent and received (Chinmay, 2015).

The data link layer is the layer responsible for repackaging data sent from the physical layer. It's the second layer on the OSI model and consists of two parts, Logic Link Control, and Medium Access Control. The data link layer handles physical transfer, flow, and error control functions as well as the assembly of data into a unit or block. This layer unpacks raw data that comes from the physical layer as well as transforming information that originates from the upper layers into raw data to be sent on the physical layer (Suresh, 2016).

The Network layer is the endpoint where the inbound and outbound data is set. It's on this layer where data is guided to its destination. This is done by attaching an address header on the information being sent through the layers. The network layer is also responsible for determining the shortest data set destination. It's here where networking equipment such as routers ensure that data is correctly addressed or re-addressed before passing it to the next layer (Chinmay, 2015).

Transport Layer is one responsible for sending or transmitting data across the network. At this stage, data is looked not as individual packets but in form of a conversation. This can only be achieved when a set of network protocols are defined. They are sometimes referred to as "rules of communication". The set of communication rules look at the complete transmission of packets while checking for conversation errors, recognizing successful transmission, and retransfer if any errors are detected. The transport layer works hand in hand with the networking layer just like a letter posting system. The network layer allocates an address to the data while the transport layer sorts through the data, grouping those that are similar before transmitting (Mehta et al., 2016).

The Session Layer is the fifth layer of the OSI model that sets up communication channels between components. It's where connections are started, maintained, and ended. As the transport layer deals with the actual flow of data, the session layer on the other hand makes sure that the programs and applications understand that their request is being worked on. In a technical concept, the session layer synchronizes data transmission. Other functions of this layer include; Virtual connection between application entities, Creation of dialog units, Connection parameter negotiations, partitioning of services into functional groups, Acknowledgements of data received

during a session, retransmission of data if it is not received by a device (Chinmay, 2015).

The presentation layer is the sixth layer of the OSI model where data received is turned into a format that an application can understand. This layer usually received data in an encrypted form, so usually it has to decrypt the data into a form that the requesting application will understand. Here data is converted for the generic form to a readable for the application to understand. Some of the functions of the presentation layer are; Coding and decoding of a message for security purpose, Change in size of a message so that the message becomes efficient, Graphics configuration, and data translation (Madan & Tuteja, 2014).

The Application Layer acts as an interface between the user and the presentation layer. This layer coordinates network access to the program running on a given computer or device. Some of the function of this layer is; To support file transfer over a given network, allow the ability to print through a given network, the use of electronic mail and electronic message, finally the ability for an application to allow the user to browse over the world wide web (Madan & Tuteja, 2014).

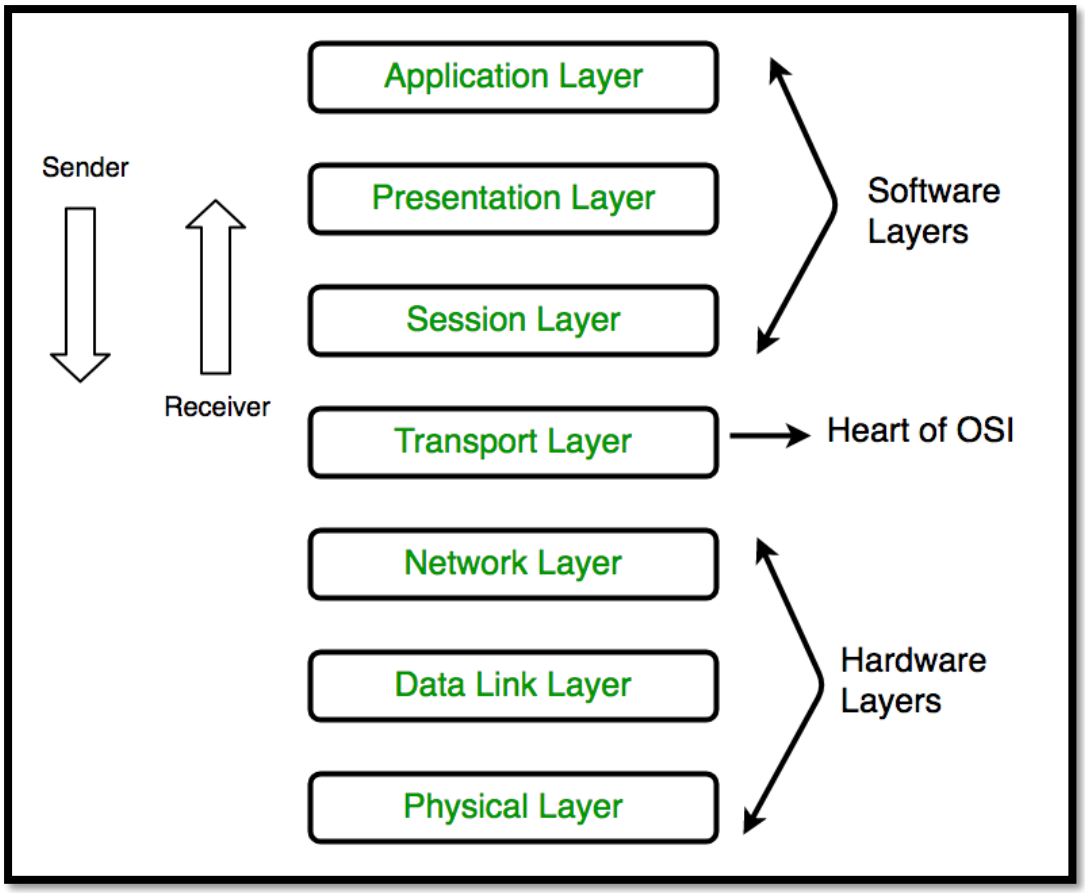

Figure 2.4 OSI Reference Model

Source: Simoneau (2006)

Within the HL7, there is a standard for the representation of clinical documents such as discharge summaries and progress reports. These document standards are what constitute the HL7 Clinical Document Architecture (CDA). The CDA is a document markup standard that specifies the structure and semantics of "clinical documents. A CDA document is a defined and complete information object that can include text, images, sounds, and other multimedia content. The document can be transferred inside an HL7 message or can exist independently outside a transferring message (Dolin et al., 2001).

A typical CDA document has a header and body. The header conveys the context in which the document was created, and the body contains the informational (factual)

statements that make up the actual content of the document. The header enables clinical documents to exchange within and across health institutions, it facilitates clinical document management as well as a compilation of individual patient's clinical information into a lifetime electronic health record (Dolin et al., 2001).

FHIR is the most current interoperability standard developed by the HL7 organization. It's an open standard that allows external software to quickly search for and access clinical information from the EMR. This is done in a developer-friendly method, using the current internet technology standards. FHIR uses the representational state transfer (RESTful) architecture which standardizes methods to search for, update and delete, which is similar to what organizations such as Facebook or Twitter use (Kamel & Nagy, 2018).

Kitsiou et al., (2006) indicates that other than DICOM and HL7 there are other dominant industry health informatics standards, legislative standards, and European Research and Development project standards. Legislative and industry standards differ in that the legislative standards take more years to build and certify. Industry standards on the other hand are easily developed and ratified.

CORBA/CORBAmed (Common Object Request Broker Architecture) is another industry standard that aims to provide a common framework architecture model using object-oriented technology. This, therefore, permits the development of scalable and reusable software components that can develop gradually on their own without having to depend on common operating systems and hardware platforms. CORBAmed on the other hand was established by a special task force to define standardized object-oriented interfaces between healthcare-specific middleware services and components to provide a high degree of interoperability. Some of the most common CORBAmed for healthcare

services are *PIDS*- Patient Identification Service; *CIAS*- Clinical Image Access Service; *COAS*- Clinical Observation Access Services(Kitsiou et al., 2006).

Rajabifard (2010) claimed that many issues are hindering effective data integration from both technical and non-technical perspectives. To effectively integrate spatial data, standards and specifications are required to deal with technical inconsistencies including metadata, quality, attribution, and logical inconsistency. If not standardized, any attempt to integrate data is confined to the framework of single initiatives. Integration at the attribute level is required for some levels of analysis which is based on joint queries and non-spatial analysis, hence, inconsistencies of attributes including inconsistencies in attribute type, attribute specification, and content need to be addressed. However, this task can be done at logical data modeling, but still needs attention if practitioners are reluctant to get their hands dirty with data modeling.

An issue with data standards was prompted by a palpable maturation among Health Information Technology standards in clinical practice and biomedical research in just the last decade. There has been remarkable cooperation among HIT standards development organizations, including the new agreement to harmonize and coordinate overlapping content in Systematized Nomenclature of Medicine—Clinical Terms (SNOMED CT) and Logical Observation Identifiers Names and Codes (LOINC), and the historic cooperation between the SNOMED CT and ICD developers to create ICD11 on the semantic foundation of SNOMED CT (Rajabifard, 2010). In parallel, there have also been unprecedented consolidation and harmonization of standards into an emerging suite of specifications for health and biomedical observations such as the ONC Meaningful Use and the National Institute of Health (NIH) Common Data Element efforts within the United States (Richesson & Chute, 2015).

2.3 Information Systems Infrastructure

The emergence of distributed component architecture, which has seen the most significant shift in the corporate computing environment since the move from monolithic enterprise systems. In particular, the shift towards componentized, packaged applications that combine component-based software with highly integrated functionality has revolutionized a new era in the design, implementation, maintenance, and upgrade of corporate information systems. The highly configurable application systems that match the distributed functionality of real-world business processes more closely than any previous architecture did. At the heart of this technology is the connectivity amongst application servers, database servers, and all other computing and communication hardware (Eriksson, n.d.)

Information system infrastructure is so much important that it's considered as a backbone of e-health that’s why it is a step just before implementation. It includes equipment, installation, maintenance, and ongoing support (Tahseen & Kamran, 2014). In most organizations, the Information and Telecommunication infrastructure is the basic technological platform for other system processes and activities. It’s an enabling foundation that the organization's business activities depend on. In most cases, the advancement of IT affects the organization's IT infrastructure (Sirkemaa, 2015). Embeddedness which entails that the IT infrastructure is part of other technologies, organizational and social structures; Learned as part of the membership which means its specific to each organization; Transparency meaning it’s not supposed to be separately modified on reinvented; Becomes visible upon breakdown as in the transparency of the infrastructure disappears when it fails to deliver as expected; Reach and scope- It extends beyond a single place, process or even; Role of standards- Standards are a vital part of the infrastructure and give room to interoperability; Built

on an installed base- Its growth is gradual. It's built and based on existing infrastructure; based on conventional practice – Information Technology infrastructure shapes organization.

Information technology infrastructure is also a concept that can be further divided into technical IT infrastructure and human IT infrastructure. Technical include components and devices that are connected to computers and systems. Human on the other hand includes individual, organization skills, expertise, and competence (Palanisamy & Sushil, 2003).

The adoption of information technology in healthcare organizations is being viewed as a tool to help bring improvements in the quality of healthcare services and achieve patient satisfaction(Alotaibi & Federico, 2017). The non-integrated IT infrastructure in healthcare organizations has caused the problem of providing high-quality medical care and achieving higher patient satisfaction. Patient satisfaction is, therefore, a factor for the strategic use of IT in healthcare organizations and the integration of healthcare information systems(Haas et al., 2000). The use of digital computers, fast communication channels, and the internet has been able to change the way information is managed in organizations. However, it’s a worrying fact the adoption of information technology in the healthcare sector is very low compared to other sectors. This is so mainly because of budget cuts (Khalifa & Alswailem, 2015)

For an Integrated HIS to run it requires technology infrastructure such as hardware, software, and network. It’s also important the infrastructure is ideal in terms of right-sizing, the servers and PC’s, with good bandwidth network connectivity and supply of power (Harris et al., 2003). Delivery of care especially in the highly fragmented delivery system requires both the clinicians and patient to have access to patient

information. The communication between clinicians, decision support system tools should be effective. The Internet and the World Wide Web have provided patients with unprecedented access to health information and made possible more continuous, asynchronous communication between patients and their care providers (Pipek & Wulf, 2009).

Five technical factors are important in planning for the implementation of communication networks: (1) bandwidth requirements and availability; (2) latency in transmission throughout the network; (3) continuous availability of the network; (4) confidentiality and security of data; and (5) ubiquity of access to the network (Mukwa, 2016).

2.4 Organizational Factors in the Integration of RIS and HMIS

Romi (2016) stated that organization culture is the values, expectations, underlying assumptions, definition, and ideologies presented in an organization. It relays some form of identity to the employees of an organization. In most cases, organization culture is like some sort of unwritten guidelines that everyone in the organization needs to adhere to. They are unspoken rules that enhance stability in an organization. Romi (2016) added that organizational culture has a particularly very strong impact on health information system development and implementation. In cases where there is an understanding of meanings, norms, and powers in an organization, the development and implementation of the health information system is usually a success story. The contextualization of an organization's culture also plays a big role in the adoption of information technology in most organizations. The main function of organization culture includes;

- Providing unspoken guidelines for how to cope with each other in the organization, and increases the stability of the social system in the organization.
- Allows individuals in the organization to deal successfully with problems of external adaptation and internal integration.
- Permits the distinction between in-group and out-group people.

When looking at the impact of organizational culture on information system adoption and implementation. Remi (2016) process the use of the General Model. The model establishes a relationship between the information system as a dependent variable and the organization culture as an independent variable.

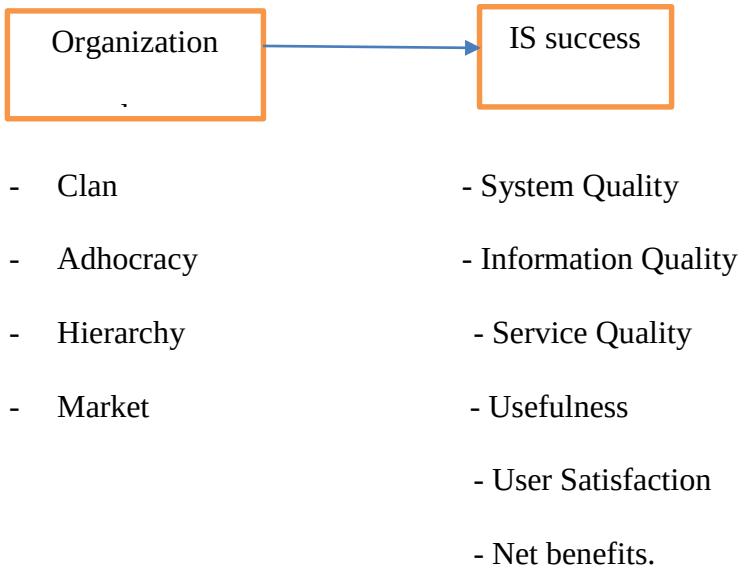

Figure 2.5 General Model
Source: Romi (2016)

Information success factors are integrated computer-based system that uses computer hardware, software, users, procedures, models, and database which interact to produce a positive outcome for the organizational activities. This kind of relationship also has some benefit to the information system which include; System Quality, Information

Quality, Service Quality, System Usefulness, User satisfaction, and net benefits (Romi, 2016).

System Quality: Are Information related constructs determine the quality of the system. They are system reliability, ease of use, relevance, response time, timeliness, the accuracy of the information, and system productivity.

Information Quality: It's the level at which information presents the required benefits. The information should present the following characteristics; - Accessibility, appropriateness, believability, completeness, free from errors, interpretability, objectivity, relevancy, reputation, and security.

Service Quality: Are set of attributes related to the services produced by an information system to its customers. These attributes include; system reliability, assurance, empathy, timeliness, and security.

System Usability: It's the utilization of the information system output by the beneficiary of the information system. System utilization should be indicated by learnability, flexibility, and robustness.

User satisfaction: This refers to the response by the information system used to the output. It's associated with the following information system attributes; system availability, accuracy, completeness, consistency, robustness, flexibility.

Net benefits: It's an evaluation of the positive and negative effects on the information system users. These benefits can be highlighted by the following set of constructs; cost savings, expanded markets, incremental additional sales, reduced search costs, and time savings

According to Mahdzur and Salim (2015), Integrated information systems can improve work processes, data utilization, staff efficiency, and knowledge value creation in an organization. According to Christenson *et al*., (2000), cultural and organizational factors that have contributed to a rigid division of labor in many areas of health care often begin with the introduction and use of tools, technologies, and other innovations that could improve quality and productivity in health care. Benefits offered by many of these tools and technologies can only be realized if management has the authority and capacity to convince health care providers to change their work practices and organization.

Romi (2016) indicated that organizational culture is an important aspect of any information system's success. An organization culture that encourages innovation improves information technology management practices and organizational practices. When looking into organizational factors that should be considered in any information system integration strategy, a key area that should be clearly defined in the discussion are; Management support, Human capacity and training, and cost implications.

2.4.1 Management Support

Management support on information systems implementation and integration implies the degree to which the management understands the significance of the information system functions and are involved in its activities. Shamsuddin (2011) stated that in a case where the management allocates most of the organization resources to support Information technology, they tend to promote the greater use of information systems within the organization. When senior management supports the use of information systems, they tend to offer some sort of reward for the use of it. In most cases, this promotes its use hence creating a culture that supports the use of information technology.

Implementation and operation of an integrated health system require leadership with vision as well as an organizational culture that is in line with the vision of the organization. Suter et al., (2009) argues that clashing cultures, such as differences between providers of medical services and long-term care services or between physicians and other service providers are one of the reasons named for failed integration efforts. Health professionals in management feel that to offer supervision to support staff with the HIS system will take up time for their primary duties. In this is case support and adaptability from the top management of health institutions remains a major challenge to integrate HMIS (Kyalo et al., 2018).

There is a tendency of managers to be concerned about the cost, return on investment, and interest of external stakeholders. The direct and indirect cost of an Integrated HMIS remains a major concern of many healthcare institutions. It's because of the high initial investment and low perceived return on investment (Asangansi, 2012).

2.4.2 Human Capacity and Training

In developing countries, there is a lack of knowledgeable personnel with the capabilities of integrating and implementing HIS in-health institutions. Because of complexities associated with the integration of HIS, it requires trained IT personnel to provide technical support (Tossy, 2014). Training boost awareness and confidence level as users can overcome technophobia while relating usage to expected benefits (Jabbari, Yalda & Azarfam, 2012).

Optimal use of IT towards the transformation of health care requires IT knowledge in the medical communities. The clinicians must also understand their benefits and how they will impact routine and business processes in hospitals, a challenge that can be overcome by including ICT in the curriculum of medical courses offered in developing

countries (Nzuki & Mugo, 2014). Routine information system users need to have good knowledge and information technology skills to effectively use and sustain the system (Gacheri, 2015).

Due to the lack of proper guidelines especially in the developing countries' health personnel deployment the distribution of workforce has tended to give priority to areas that have high socioeconomic development, leaving marginalized and hard-to-reach areas at a disadvantage. Poor areas have fewer health facilities and are not preferred by health workers, while other regions report surpluses in staff (WHO, 2015).

The sluggish internet use among doctors in Pakistan was due to the unavailability of proper technology and lack of computer training (Qureshi & Khan, 2014). Those health care professionals who lack the ICT skills of processing the online health data end up spending too much time on the same (Alotaibi & Federico, 2017). Without adequate ICT skills, user involvement in the selection and development of ICTs becomes difficult and if it happens, it is only to rubberstamp the expert's decisions. This might lead to having eHealth technologies that are not widely accepted or used adequately (Nzuki & Mugo, 2014). For a successful implementation of e-healthcare in the world, computer skills to all healthcare professionals and staff involved in the process are a must (Qureshi & Khan, 2014).

When a system is integrated, there is a usual need for staff in an organization to be trained in the development, user support, and how to use the system. However, in most organizations, there is a tendency of high staff turnover which creates a need for new staff to be trained to replace those that have moved on (Dlodlo & Systems, 2017).

According to Sirkemaa (2015), the human component is an important piece of information technology infrastructure in the Information system. The human

component consists of individual and organizational skills, expertise, abilities, and dedication. African countries, in general, tend to have few experts who can participate and developed a standard for integration. The adoption of health informatics standards by an organization in Africa requires a great deal of localization to meet the specification required by the country. Inadequate technical expertise in most cases makes integration extremely difficult. To cope with the above shortfall, adequate training and education programs should be developed to come up with a workforce that can design, build, and operate an interoperable information system. With the help of technical experts, they should be able to localize international standards to meet their local requirements (Adebesin et al., 2013).

2.4.3 Capital Intensity

HIS systems are very expensive to set up and require trained personnel to make use of them. Most health institutions do not see the importance of the IT department and only allocate about 2 to 3 percent of the total budget to IT operations (Hung, Chen, & Wang, 2014). Integrating new systems with existing ones makes make implementation complex and, in most cases, increases the costs. Health institutions may not have enough resources to implement affordable and easy to use integrated HIS.

For successful integration to occur, enough financial resources should be made available for the purchase of physical infrastructures such as computer hardware and network communication medium that can allow secure exchange of healthcare information. The funding of the health information system should be aligned to the interoperability goal of a particular organization (Adebesin et al., 2013).

Financial management including cost controls was among the main incentives of integrated health systems in the United States. It was believed that integrated health

information systems would result in economic benefits because of cost reductions and economies of scale associated with its implementation (Suter et al., 2009)

In most developing countries, there seems to be very little investment in ICT for health. The result is that of fragmentation, with many different types of information systems being acquired from donors. Financial sustainability is also important when considering the integration of an information system in an organization, especially in public hospitals in developing countries. The ability to support the system financially in the long term is an important factor to consider. Capital investment and costs should identify upfront (Gacheri, 2015).

Investment in Information technology by health organizations must be measured over time and the time from which the technology was introduced should also be considered. Investment in IT should be followed up with clinical and administrative staff practices within the hospital to produce a return on investment. This always means a change in hospital process because of the use of information technology methods (Parente and Van Horn, 2007).

2.5 Theoretical Framework

The study adopted two theories, Delone and Mclean's Information System Success Model and the Level of Conceptual Interoperability Model.

2.5.1 DeLone and Mclean's Information System Success Model.

It's an information system theory that was developed in 1992 by William H. DeLone and Ephraim R. McLean based on empirical and theoretical Information System research done in the 1970s and 1980s. The theory seeks to provide comprehensive knowledge of the IS success by identifying, describing, and explaining the relationships

among six of the most important dimensions of success along which information systems are examined (DeLone & McLean, 2003).

The study identified six major categories of IS success which are; System Quality, Information Quality, Use, User Satisfaction, Individual Impact, and Organization Impact.IS success model implies that System quality and information quality impact both the use and user satisfaction. The amount of information system use can affect user satisfaction positively or negatively. Use and user satisfaction will therefore have an impact on an individual hence affecting the organization as a whole (Halawi & Mccarthy, 2006).

In the D&M IS success model, system quality measures technical success, information quality measures semantic success whereas use, user satisfaction, individual impacts, and organizational impacts measure the effectiveness of the information system (DeLone & McLean, 2003).

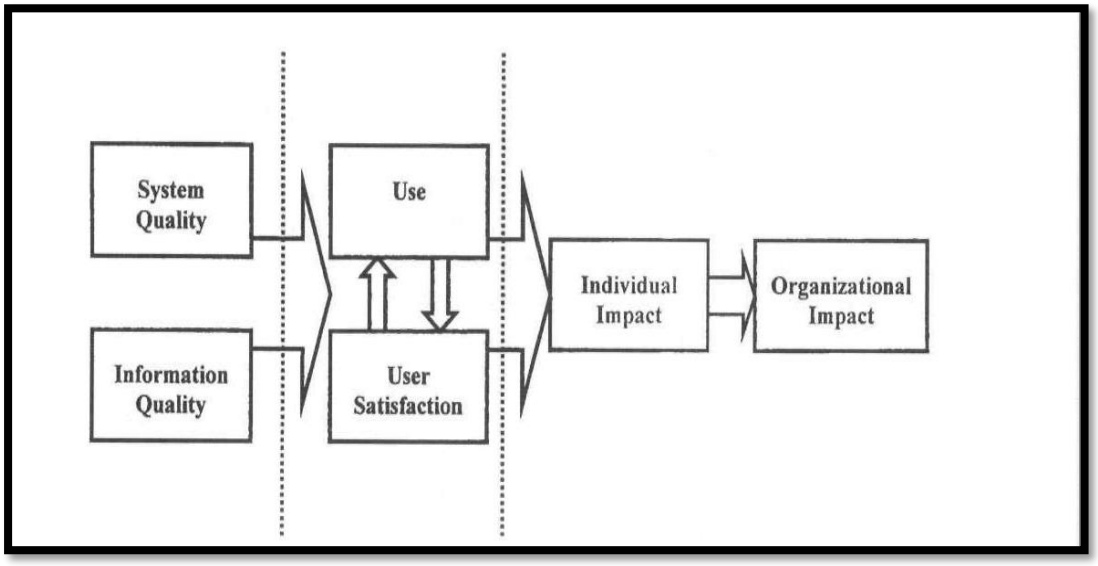

Figure 2.6 D&M IS Success Model

Source : DeLone and McLean (2003).

2.5.2 Levels of Conceptual Interoperability Model

The level of Conceptual Interoperability Model was original proposed by Tolk and Muguira to deal with conceptual interoperability issues beyond technical interoperability. The LCIM divides conceptual interoperability into Seven layers, from non-interoperability to conceptual interoperability as shown below (Wang, Tolk, & Wang, 2009).

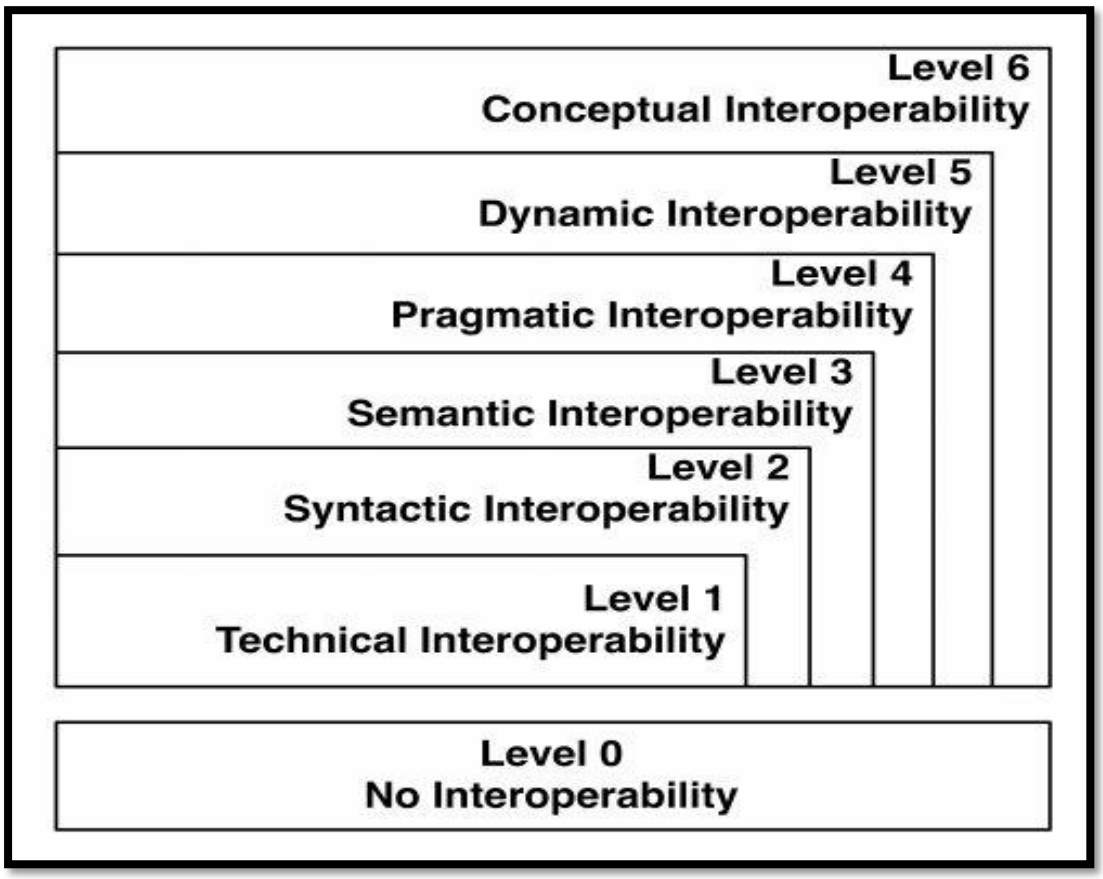

Figure 2.7 Levels of Conceptual Interoperability Model

Source: Wang, Tolk and Wang (2009).

2.6 Empirical Review

Sebetci and Aksel (2016) sought to survey the use of health information technology in the healthcare systems in Turkey. The study sought demonstrated how heavy investment in Information technology in the healthcare setup has had an impact on

patient care. It concluded that integration of health information system is very critical concerning speed, cost control, patient information accuracy, and safety for the public of private health insurance organizations covering health insurance with HIS.

Sabooniha, Toohey and Lee (2012) found that Information systems in the healthcare domain have been developed in different platforms, computer languages, and data structures, they are not deployed as heterogeneous and autonomous systems and so the capability of the healthcare organization to provide quality and shared patient care delivery is impeded. The integration of these heterogeneous systems is seen as a solution to this, and many different integration approaches have been developed. The study also found that there is no single approach that satisfies all integration requirements. Identification and combination of integration solution is essential for Inter and intra-organizational integration to select the most suitable set of technologies, standards, and approaches for a given set of integration requirements.

Kitsiou et al., (2006) aimed at presenting challenges as well as alternative approaches for integrating heterogeneous healthcare information systems. The study also proposed an evaluation framework for healthcare decision-makers and system integrators with a clear perspective regarding the assessment of available technology on integration approaches

2.7 Knowledge Gap

A number of studies have been conducted as shown by the reviewed literature. The studies reviewed have revealed how heavy investment in Information technology in the healthcare setup has had an impact on patient care. Information systems in the healthcare domain have been developed in different platforms, computer languages, and data structures, they are not deployed as heterogeneous and autonomous systems

and so the capability of the healthcare organization to provide quality and shared patient care delivery is impeded. However, from the reviewed literature, it is evident that no comparative study has been done on the integration of RIS and HMIS between public and private hospitals.

2.8 Conceptual Framework

Figure 2.8 is a schematic diagram of a framework for Integrating RIS and HMIS in the selected public hospitals in Uasin Gishu County. It includes independent, intervening, and dependent variables with indicators.

Independent Variables include:

- Design framework of the current RIS and HMIS; - Information Systems Standards and Interoperability
- Infrastructure framework; - Networking Equipment, Computer Hardware, and Radiology Machine
- Critical factors in the integration framework of RIS and HMIS; - Management Support, Staff Training, Cost implication.

Intervening Variables

Intervening variables included;

- Health Level Seven and DICOM standards for Information Standards and Interoperability
- Fiber optic cable, high capacity servers and computer workstations, Digital Radiology Machines for Infrastructure framework.
- Budgetary Allocation or Financial planning and Computer training for Critical factors in the design framework of RIS and HMIS.

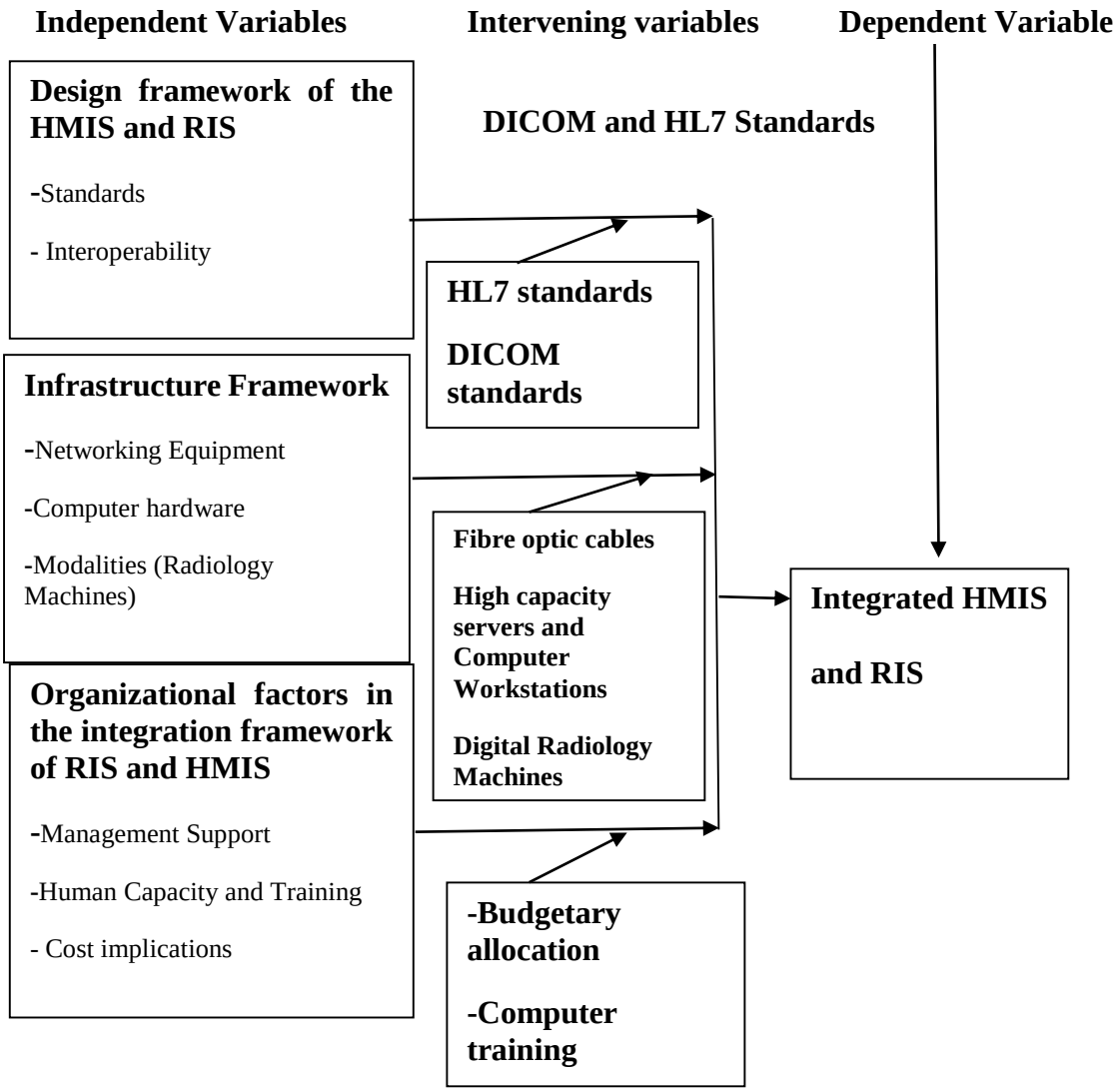

Figure 2.8 Conceptual Framework

Source: Author (2020)

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter discusses the methodology used in the study including the research design, study location, target population, sampling procedures and sample size, research instruments, data collection procedures, data analysis and ethical considerations.

3.2 Research Design

This study adopted a descriptive research design using a survey method. The survey was carried out in three selected hospitals. Descriptive-survey research uses surveys to acquire statistics approximately various topics. The statistic pursuits to apprehend the quantity to which fantastic situations can be received amongst the topics selected. A descriptive survey attempts to set up the variety and distribution of some social traits, at the side of education or schooling, career, and location, and to find out how these traits may be related to positive behavior styles or attitudes (Schneider & Wagemann, 2010).

3.3 Study Location

The study was carried out at selected public hospitals in Uasin Gishu County. These hospitals were Ziwa Sub-County Hospital, Burn Forest Sub-County Hospital, Moi Teaching, and Referral Hospital. The hospitals are beneficiaries of the Medical Equipment Services program by the national government.

3.4 Target Population

The study targeted Staff in the selected hospital in Uasin Gishu County. The Target population was 195 staff members from Ziwa Sub County Hospital, Burn Forest Sub County Hospital, and Moi Teaching and Referral Hospital.

Table 3.1 Target Population

Target Group	MTRH	Ziwa	Burnt Forest	Total
Hospital Administrators	10	4	6	20
Radiologists	8	4	3	15
Radiology Registrars	12	4	4	20
Referring Physicians	10	5	5	20
Nurses	15	7	8	30
Radiographers	12	4	4	20
Health Record officers	20	10	10	40
ICT technician's	10	10	10	30
TOTAL				195

Source: Human Resource Office Data, MTRH, Ziwa sub-county hospital, Burnt-Forest Sub-county hospital (2019)

3.5 Sampling Procedure and Sample Size

The study used random sampling approaches. This was because random sampling gave respondents an equal chance of being represented in a sample. To get a representative sample, the study calculated using the 30% formula of Mugenda Mugenda(Mugenda & Mugenda, 2003).

Table 3.2 Sample Size

Category	Procedure	Sample
Hospital Administrators	20x 0.3	6
Radiologist	15 x 0.3	5
Radiology Registrars	20 x 0.3	6
Referring Physicians	20 x 0.3	6
Nurses	30 x 0.3	9
Radiographers	20 x 0.3	6
Health Record officers	40 x 0.3	12
ICT technicians	30 x 0.3	9
Total		**59**

Source: (Mugenda & Mugenda, 2003)

3.6 Research Instruments

Data was collected through objectively structured questionnaires. This is because the responses are gathered in a standardized way, so questionnaires are more objective, and generally, it was relatively quick to collect information using a questionnaire.

3.6.1 Pilot Study

According to Nixon (2002), pre-testing is the main chance for researchers to gauge the meaning attributed to survey questions before it is too late. Pilot study was carried out to test validly and reliability of research questionnaires. In this study, a pilot study was conducted in Moi Teaching and Referral Hospital with ten responses to measure the validity of the study

3.6.2 Validity

Kothari (2004) defines validity as the degree to which an instrument measures what it is supposed to measure. Validity explains how well the collected data covers the actual area of investigation. Validity is not a property of the tool itself, but rather of the interpretation or specific purpose of the assessment tool with particular settings and learners. The validity of the study was tested by administering questionnaires to a small group of respondents who do not form part of the study to validate the information collected. The questionnaire for this study was carefully prepared to ensure it covers all the research objectives and address all the issues under investigation

3.6.3 Reliability

Tabachnick and Fidell (2007) defines reliability as the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable. The reliability of the tools of data collection was conducted during the pilot study to determine where the results produced are achievable and consistent. After the pilot study, the data collected were subjected to Cronbach's coefficient alpha to test the reliability of the research instruments. The pilot study results were as presented in Table 3.3

Table 3.3 Reliability Results

Objective	Alpha Coefficient	Number of Items
Status of the design framework	0.712	8
Organizational factors	0.811	6
Capabilities of the existing infrastructure framework	0.754	4
Framework for integrating radiology and Hospital Management Information Systems	0.703	3

From the pilot study results, it is evident that all the study variables had a coefficient alpha greater than 0.70 hence they were treated as reliable and valid for analysis.

3.7 Data Collection Procedures

An introductory letter was sought from Rongo University to carry out the study. The researcher visited the selected hospitals during the data collection process and made arrangements for data collection. The researcher administered questionnaires to the designated respondents and collected them after they were filled. The respondents were enlightened on the intention of the research and given a data sheet, which was on the first page of the data collection tool. They read the information leaflet and decide whether to take part in the study.

3.8 Data Analysis

Data collected was first cleaned, classified and coded to facilitate analysis. Secondly, data solicited was analyzed using descriptive statistics. Analysis of data was done with the help of SPSS (Version 20.0). The study mainly collected quantitative data. Descriptive (frequencies, percentages, mean and standard deviation) were adopted to analyse the data. Data analyzed were presented using frequency tables and charts.

3.9 Ethical Considerations

The researchers whose subjects are people or animals must consider the conduct of their research, and give attention to the ethical issues associated with carrying out their research (Kombo & Tromp, 2006). This study dealt with people as respondents. Therefore, the researcher assured the respondents of confidentiality. The researcher considered the fact that participation in research is voluntary. This is why the researcher took the time to explain to the respondents the importance of the study and therefore requested the respondents to participate in the study by giving information relevant to the study. To establish a good working relationship with the participants, the researcher endeavored to develop a rapport with them. The researcher sought and obtained ethical clearance from Moi University/Moi Teaching and Referral Hospital Institutional Research and Ethics Committee (IREC) and the National Commission for Science Technology and Innovation (NACOSTI)

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, AND INTERPRETATION

4.1 Introduction

This chapter discusses the data analysis and findings from 59 questionnaires completed by respondents. The study targeted 59 respondents, 35 from MTRH, and 12 each from Ziwa and Burnt Forest hospitals. The study used questionnaires on 59 respondents of which all of them were responded to and returned. The response rate for the study was (100%) which was more than adequate.

Table 4.1 Response Rate of Respondent

Hospital	Distributed	Returned	Percentage
MTRH	35	35	100.0%
Ziwa	12	12	100.0%
Burnt Forest	12	12	100.0%

The chapter, therefore, presents data collected from primary sources based on the objectives and research questions of this research study. The data from the questionnaires were first coded using Microsoft Excel 2010 and then analyzed using Statistical Package for the Social Sciences software (SPSS) version 20. The findings are discussed according to the three sections of the questionnaire namely: Design framework of the RIS and HMIS in the selected public hospital; Capability of the existing infrastructure framework; Organizational factors to be considered in the integration of RIS and HMIS.

4.2 Design Framework of the RIS and HMIS

The study sought to assess the status of the design framework of the RIS and HMIS in the selected public hospitals in Uasin Gishu County. The purpose of the questions was

to establish if the design framework of the current RIS and HMIS used in the selected hospitals can support information system integration.

From the findings, (45.8%) strongly agreed that there exists an HMIS in the hospital where they work, while (54.2%) agreed on the same. The results also show that (57.6%) agreed to the presence of RIS in the hospital, (35.6%) strongly agreed while (6.8%) were undecided. A small number of the participants, about (10.2%)were undecided on whether the RIS system is used only in the radiology department.

Participants of the study were also asked to indicate whether the existing HMIS is used in all sections of the hospital where they work. From the findings, (10.2%) of the respondents strongly agreed with that statement, (15.3%) agreed while (10%) were not sure if indeed the HMIS is used in all the sections of the hospital. The majority of the respondents disagreed with the statements, representing (55.9%) of the participants.

To further evaluate the interoperability of the existing RIS and HMIS, participants were also asked to indicate if they think the two systems are compliant with the international standards for hospital systems integration, which is DICOM for RIS and HL7 for HMIS. The results show that (25.4%) strongly agree that the RIS is a DICOM compliant, whereas (33.9%) agree with the same. The majority of the respondents (37.2%) are not sure if indeed the RIS meets the required standard for integration while (3.4%) disagree. Regarding the HMIS, (3.4%) strongly agree that it meets the required standard for system integration, whereas (15.3%) agree that indeed its HL7 complaint. Again, just as with the RIS design framework, the Majority of the respondents are not sure or are undecided on whether the existing HMIS is HL7 complaint representing (72.9%) of the participants. Participants were also asked to indicate if any other systems within the hospital are connected to the HMIS. The majority of the respondent

Disagreed (57.6%), whereas (25.4%) of them were undecided. Some participants, (8.5%) strongly agreed that indeed other systems are connected to the HMIS while the same percentage of respondents agreed with the statement.

The result shows the both RIS and HMIS used in the selected hospitals exist as independent systems that do not share or interchange information. This could be because of several reasons, one of them being that they do conform to the required standards for data interchange as indicated by the results. The results, therefore, show that even though the two system exits in the selected hospital, they just do not meet the required data standards for integration. The respondents agreed to the existence of the systems, but they pointed out that the system to do not communicate.

Regardless of the technology, for integration between systems to happen application components have to communicate. The design framework of the systems must be in agreement with the syntax and semantics of data and messages that are to be exchanged. The common standard used in the integration of RIS and HMIS is HL7 and DICOM (Abdulla et al., 2017).

Lack of shared standards for data collection in a health institution means that the same data are often collected and reported many times among departments. At the same time, there are gaps where important data do not get reported. This inconsistency in definition and procedure creates inefficiency (Van Panhuis et al., 2014). As stated by Harris *et al*, terminology standards will provide an unambiguous, machine-readable meaning of specific terms and messaging standards permitting the electronic exchange of information consistently. Together, they will allow the interoperable use and exchange of healthcare information. Even with the wide adoption of HMIS true healthcare

transformation will not occur without the standardization and improved interoperability of healthcare systems. The findings are tabulated in Table 4.2

Table 4.2 Design Framework of RIS and HMIS

Sub variable	SA	A	U	DA	SD	Total
There is an existing HMIS in the hospital	27(45.8%)	32(54.2%)	0(0.0%)	0(0.0%)	0(0.0%)	59(100%)
There is an existing RIS in the Hospital	21(35.6%)	34(57.6%	4(6.8%)	0(0.0%)	0(0.0%)	59(100%)
RIS system is only used in the Radiology Department	18(30.5%)	35(59.3%)	6(10.2%)	0(0.0%)	0(0.0%)	59(100%)
HMIS is used in all sections within the hospital	6(10.2%)	9(15.3%)	10(16.9%)	33(55.9%)	0(0.0%)	59(100%)
RIS used in the hospital is DICOM complaint	15(25.4%)	20(33.9%)	22(37.2%)	2(3.4%)	0(0.0%)	59(100%)
HMIS used in the hospital is HL7 complaint	2(3.4%)	9(15.3%)	43(72.9)	5(8.5%)	0(0.0%)	59(100%)
There are other systems in the hospital that are integrated with the HMIS	5(8.5%	5(8.5%)	15(25.4%)	34(57.6%)	0(0.0%)	59(100%)

The summary of the findings is illustrated in Figure 4.1**.**

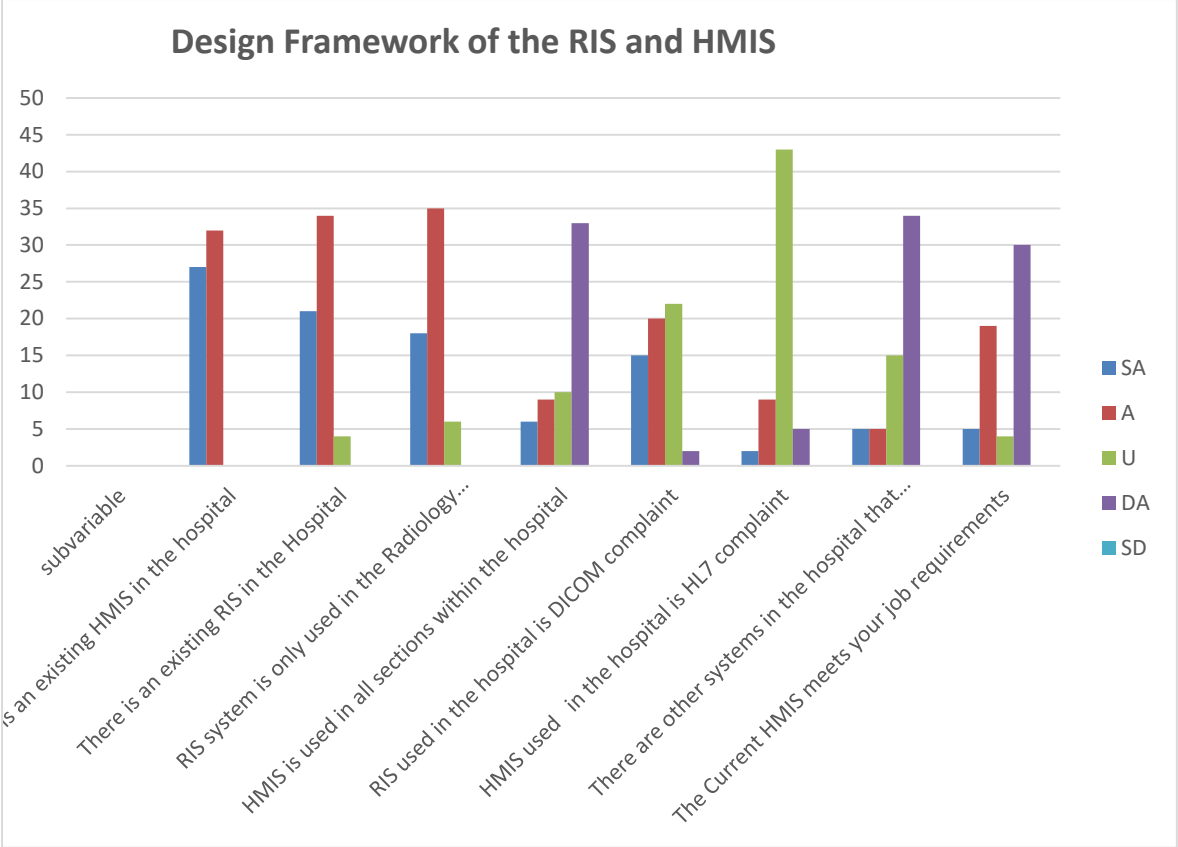

Figure 4.1 Design Framework of the RIS and HMIS

4.3 Capability of the existing Infrastructure Framework.

Respondents were asked six questions about the capabilities of the existing infrastructure framework to support the integration of RIS and HMIS in the selected public hospitals. Participants of the study were asked to indicate the availability of computers in the sections they work for their daily use. 45.8% of the respondents strongly agreed to there being computers in the sections for them to use, while (44.1%) agreed to the same. A small number of the participants, representing (1.7%) were undecided whereas (8.5%) of them disagreed with the statement.

Participants were also asked to indicate if there is an existing network connection in the hospital where they work. (61.0%) of the respondents agreed to there is a network connection, while (39.0%) strongly agreed to the same. The study also sought to establish if the computers used by the participants in their sections are connected to the

hospital's local area network. The findings show that (32.2%) of the participants strongly agreed to the statement, (50.5%) agreed while (15.3%) disagreed meaning the computers they use are not connected to the local area network. Only (1.7%) of the participants were undecided.

Regarding the network infrastructure, participants were asked to indicate if indeed if the network connection is consistent and reliable. Most of them disagreed (44.1%), those that strongly disagreed were (3.4%) whereas a good number of the participants (33.2%) agreed to indicate that the network infrastructure is good. There was also (5.1%) of the participants who strongly agreed to there being a good network infrastructure in the hospital, while (15.3%) of them were undecided. As a follow up to the network infrastructure, the study sought to find out the connection speeds to the internet and within the selected hospitals. The results show that (8.5%) of the participants strongly agreed that connection speeds are fast, whereas (30.5%) agreed to the same. On the contrary, (50.8%) of the participants disagreed, while (3.4%) strongly disagreed indicating that the connection speeds are not fast. Some of the participants (6.8%) were undecided on if the connections speeds.

Lastly, to further evaluate the capabilities of the existing infrastructure framework, the participants were asked to indicate the presence of data centers in their respective hospitals. Most respondents (39.0%) agreed, whereas (22.0%) strongly agreed. A good number of the participants (32.2%) Disagreed, (1.7%) of them strongly disagreed while some of them (5.1%) were undecided.

The result indicates that although the selected hospitals have computers that are connected to the local area network for their day to day use, the network infrastructure is not good which is also means the network speeds are very low. This is not an ideal

environment for system integration. These, therefore, indicate that the infrastructure framework in the selected hospitals is not ideal for integration. There is a lack of data servers and good network infrastructure to support information system integration. There is a need to upgrade the current data servers and the network channels to aid integration. The used fiber optic cables and high capacity servers would be ideal for the data interchange between the two systems.

Infrastructure must be ideal in terms of right-sizing, the servers, and PCs. Infrastructure is one of the most important steps in an e-health system before its implantation. It's regarded as a cornerstone of an e-health system. The non-integrated IT infrastructure in healthcare organizations has caused the problem in providing high-quality medical care and achieving higher patient satisfaction (Kim & Michelman, 1990).

The use of digital computers, fast communication channels, and the internet has been able to change the way information is managed in organizations. However, it's a worrying fact the adoption of information technology in the healthcare sector is very low compared to other sectors. This is so mainly because of budget cuts (Khalifa & Alswailem, 2015).

Five technical factors are important in planning for the implementation of communication networks: (1) bandwidth requirements and availability; (2) latency in transmission throughout the network; (3) continuous availability of the network; (4) confidentiality and security of data; and (5) ubiquity of access to the network (NRC, 2000).

The findings are tabulated in Table 4.3

Table 4.3 Capability of the Existing Infrastructure Framework

Sub-variable	SA	A	U	DA	SD	Total
There exist computers in your section for use in your daily job activities	27(45.8%)	26(44.1%)	1(1.7%)	5(8.5%)	0(0.0%)	59(100%)
There is an existing network connection in the hospital	23(39.0%)	36(61.0%)	0(0.0%)	0(0.0%)	0(0.0%)	59(100.0%)
Computers in your section are connected to the hospital network	19(32.2%)	30(50.8%)	1(1.7%)	9(15.3%)	0(0.0%)	59(100.0%)
The hospital Network infrastructure is good	3(5.1%)	19(32.2%)	9(15.3%)	26(44.1)	2(3.4%)	59(100.0%)
The connection speed to the internet and with the hospital network is fast	5(8.5%)	18(30.5)	4(6.8%)	30(50.8%)	2(3.4%)	59(100.0%)
The hospital has a data center or a server room	13(22.0%)	23(39.0%)	3(5.1%)	19(32.2%)	1(1.7%)	59(100.0.%)

The summary of the findings is illustrated in Figure 4.2.

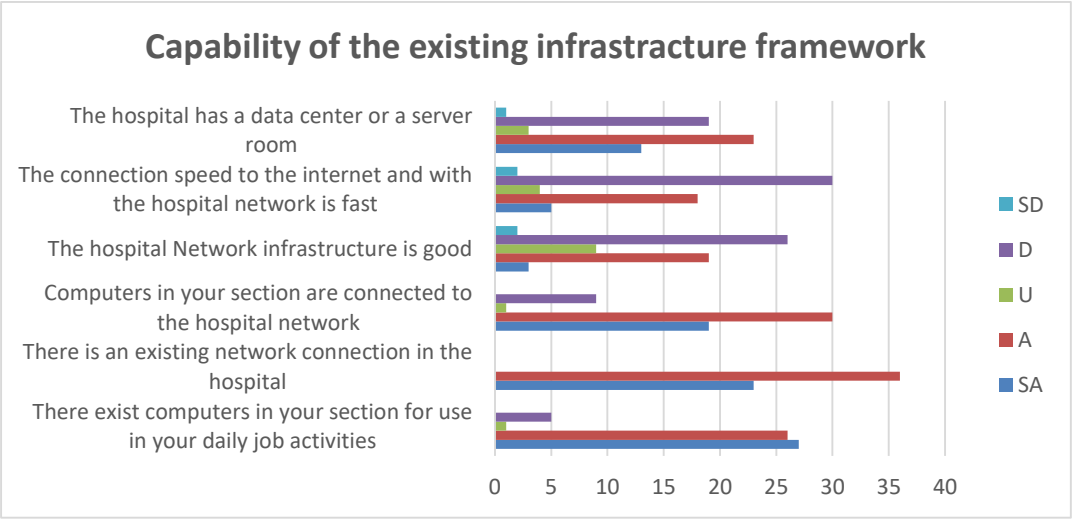

Figure 4.2 The capability of the Existing Infrastructure Framework

4.4 Organizational factors to be considered in the Integration of RIS and HMIS

The study also sought to look into some of the organizational factors that should be considered in the integration of RIS and HMIS. In this regard, respondents were asked to indicate if the hospital management supports staff in skills development. Many of the participants agreed (47.5%) that the management supports them, while (11.9%) strongly agreed. A good number of them disagreed (22.0%) whereas (18.6%) of the respondents were undecided. The study went further to know from the participants if the hospital staff receives specialized training in their area of work. Most of the respondents Disagreed (33.9%), while a good number of them agreed (30.5%). Those that strongly agreed represented (10.25), whereas (25.4%) of the participants were undecided if indeed hospital staff receive specialized training in their area of work.

Respondents were also asked if departments with the hospital that they work are allocated funds that are proportional to their needs. Many of them disagreed (57.6%), whereas a good number (23.7%) were undecided. A small number of the participants, (5.1%) strongly agreed, while (13.6%) agreed that each department allocates funds that meet their needs. To follow on budgetary allocations, respondents were also asked if the ICT department receives enough funds to cater for its activities. Majority of the respondents (52.5%) Disagreed, in which they said that the ICT department doesn't have enough funds for its activities, while a good number of them (27.1%) were undecided. Results also show (3.4%) strongly agree, whereas (6.8%) agreed.

Whereas the management of the selected hospital support staff training and skills development, the result shows that different departments are not allocated enough funds especially the ICT department. This hinders system integration since, in most organizations; the ICT department is usually at the forefront of any information system

implementation. There is a lack of management support especially concerning specialized training in the selected hospitals in Uasin Gishu County and in terms of budgeting, especially the IT departments. Most of the financial resources are spent on drugs and other hospital consumables.

For successful integration to occur, enough financial resources should be made available for the purchase of physical infrastructures such as computer hardware and network communication medium that can allow secure exchange of healthcare information. The funding of the health information system should be aligned to the interoperability goal of a particular organization (Adebesin, 2013). Financial sustainability is an important organization factor when considering the integration of information systems in an organization, especially in public hospitals in developing countries. Financial management including cost controls was among the main incentives of integrated health systems in the United States of America (Gisheru, 2015). It was believed that integrated health information systems would result in economic benefits because of cost reductions and economies of scale associated with its implementation (Coburn, 2001).

An organization's culture can in most cases if negative contribute to a narrow-minded workforce. In such cases, the organization often lacks innovation and creativity. Hardy et al 1999 believe that system integration requires leadership with a vision supported by a discipline organization culture. This promotes creativity and innovations in the organization (Christen, 2000). According to Lippeveld *et al*, (2000), HIS systems are very expensive to set up and require trained personnel to make use of them. Most health institutions do not see the importance of the IT department and only allocate about 2 to 3 percent of the total budget to IT operations. Integrating new systems with existing ones makes make implementation complex and, in most cases, increases the costs.

Health institutions may not have enough resources to implement affordable and easy to use integrated HIS.

The findings are tabulated in Table 4.4

Table 4.3 Organizational factors in the integration of RIS and HMIS

Sub-variable	SA	A	U	DA	SD	Total
The hospital Management supports staff in skills development	7(11.9%)	28(47.5%)	11(18.6%)	13(22.0%)	0(0.0%)	59(100.0%)
Most hospital staff receive specialized training in their area of work	6(10.2%)	18(30.5%)	15(25.4%)	20(33.9%)	0(0.0%)	59(100.0%)
Each department is allocated funds that are proportional to their needs	3(5.1%)	8(13.6%)	14(23.7%)	34(57.6%)	0(0.0%)	59(100.0%)
There is enough budgetary allocation to the ICT department	2(3.4%)	4(6.8%)	16(27.1%)	31(52.5%)	6(10.2%)	59(100.0%)

Finding are also illustrated in Figure 6

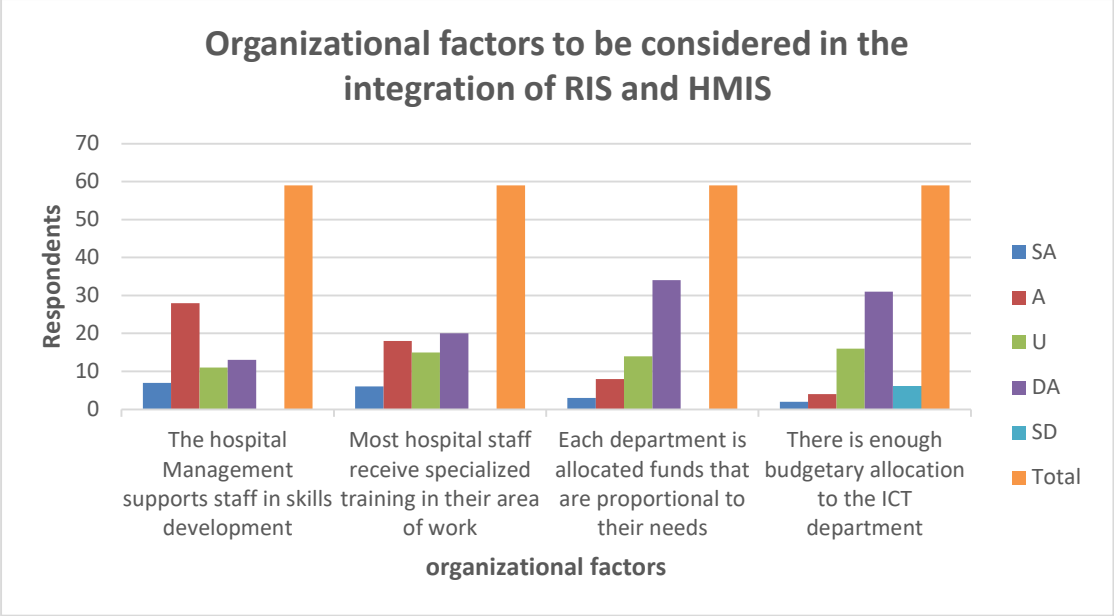

Figure 4.3 Organization factors in the integration of RIS and HMIS

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

This chapter gives an overview of the findings, conclusion, and recommendations made from the study. These are based on the objectives and research questions of the study. The study aimed at develops a comprehensive framework for integrating Radiology and the Hospital Management Information System in a selected public hospital in Uasin Gishu County.

Objectives of the study were to;

i. To assess the status of the design framework of the RIS and HMIS in the selected public hospitals in Uasin Gishu County.
ii. To identify the organizational factors that should be considered while integrating RIS and HMIS in the selected public hospitals in Uasin Gishu County.
iii. To determine the capabilities of the existing infrastructure framework to support the integration of RIS and HMIS in the selected public hospitals in Uasin Gishu County
iv. To develop a comprehensive framework for integrating RIS and HMIS in the selected public hospitals in Uasin Gishu County

5.2 Summary

Study finding is summarized as follow;

5.2.1 Design Framework of the RIS and HMIS

The first objective of the study was to assess the design framework of the RIS and HMIS in the selected public hospitals in Uasin Gishu County. The study sought to

establish if the design framework of the current RIS and HMIS used in the selected hospitals can support the integration. The study findings revealed that there exists both RIS and HMIS in the selected public hospitals in Uasin Gishu County. On the existence of an HMIS, the majority of the respondents agreed (54.2%) whereas (57.6%) agreed to the presence of RIS in the hospital where they work.

The study also sought to find out if the HMIS that exists in the selected hospital is used in all sections and departments. The result from the findings shows that the majority of the respondent disagreed (55.9%). The finding also shows that many of the respondents are not sure if the two systems conform to the international standards for data interchange, which is DICOM and HL7 standards. If RIS is a DICOM complaint, (37.2%) of the respondents are not sure while if HMIS is a complaint with the HL7 standards.

5.2.2 Capability of the existing Infrastructure Framework

Another objective of the study was to determine the capabilities of the existing infrastructure framework to support the integration of RIS and HMIS in the selected public hospitals in Uasin Gishu County. The study findings revealed that the majority of the respondents strongly agreed (45.8%) with the availability of computers in their area of work for daily use. The same findings also indicate that the respondents agree (50.5%) the computers they used are all connected to the local area network. This, therefore, implies that there exists a local area network in the selected public hospital in which the majority of the respondents (61.0%) agree to this fact. The study findings also show that even though there exists a local area network, many of the respondents agree (44.1%) the network infrastructure is not good. This intern implies that the network speeds, both to the internet and within the local area network are slow. This

fact is supported by the finding which shows that most of the participants (50.8%) disagree that the network speeds are fast.

5.2.3 Organizational factors to be considered in the Integration of RIS and HMIS

The second objective of the study was to identify the organizational factors that should be considered while integrating RIS and HMIS in the selected public hospitals in Uasin Gishu County. The study sought to find out from the participants if the management support staff in skills development, if the staff receive specialized training in their area of work if the budget allocated to different departments is proportional to their needs, and lastly if the ICT department is allocated enough funds. The study findings show that most of the respondents agree (47.5%) that the management support staff in skill development. The findings also show that most of the participants disagree (33.9%) with the idea that staff in the selected hospital receive specialized training in their area of work.

5.2.4 Proposed Framework for integrating RIS and HMIS in the Selected Public Hospitals

From the findings, the researcher proposes the following framework of integration on the two systems in the selected hospital in Uasin Gishu County.

Key aspects in the proposed framework are the following;

Infrastructure: This includes Radiology machines which include Digital X-ray machines, Ultrasound, MRI, Mammography, and CT scanners. Computer hardware which includes Data servers to host RIS, PACS, and HMIS systems; Desktop computers used at service points and by the technicians when performing Radiology procedures. Networking Equipment used for data communication between servers, service points, and the Radiology machine. For fast data transfer, fiber optic cables are recommended.

Data standards: In this case, the two main data standards are HL7 and DICOM. HL7 to aid data and information exchange between the HMIS and RIS systems, whereas DICOM to aid in the image exchange between the RIS and HMIS.

Management Support: This should in terms of appropriate budget allocation to key departments within the Selected hospitals. Training of staff in specialized areas and good organizational culture that can aid system integration.

Health Information systems; These are the two systems that are to be integrated that is Radiology Information system and Hospital Management Information System as well as Picture Archiving and Communication Systems(PACS). RIS will be embedded with a Modality Worklist which is part of the DICOM workflow services that enables patient's demographic information available at the Modality, eliminating dual data entry and providing data integrity. PACS will be used for radiological image storage, archiving, and management.

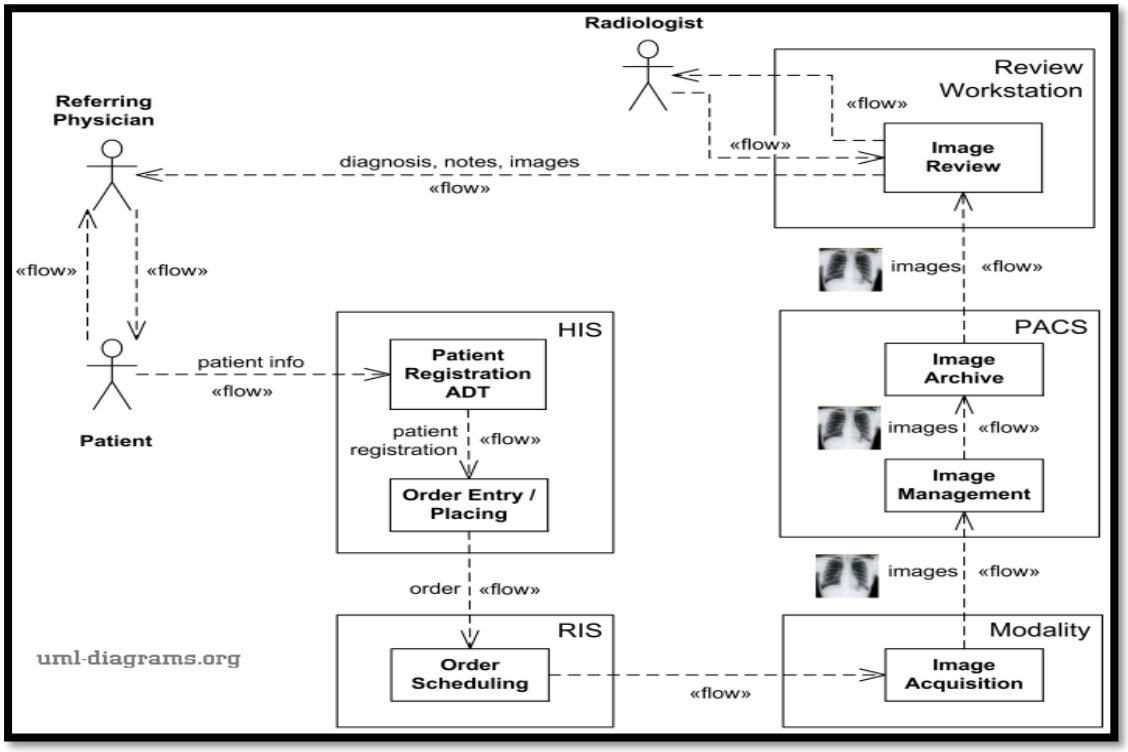

Figure 5.1 Simulation of the Proposed Framework

5.2 Conclusions

The study concluded that both RIS and HMIS used in the selected hospitals exist as independent systems that do not share or interchange information. This could be because of several reasons, one of them being that they do conform to the required standards for data interchange as indicated by the results. Even though the two system exits in the selected hospital, they just do not meet the required data standards for integration. The existence of the systems, pointed out that the system to do not communicate.

Although the selected hospitals have computers that are connected to the local area network for their day to day use, the network infrastructure is not good which is also means the network speeds are very low. This is not an ideal environment for system integration. These, therefore, indicate that the infrastructure framework in the selected hospitals is not ideal for integration. There is a lack of data servers and good network infrastructure to support information system integration. There is a need to upgrade the current data servers and the network channels to aid integration. The used fiber optic cables and high capacity servers would be ideal for the data interchange between the two systems.

The study concluded that whereas the management of the selected hospitals supports staff training and skills development, the different departments are not allocated enough funds especially the ICT department. This hinders system integration since, in most organizations; the ICT department is usually at the forefront of any information system implementation. There is a lack of management support especially concerning specialized training in the selected hospitals in Uasin Gishu County and in terms of budgeting, especially the IT departments.

Furthermore, the study concluded that these are the two systems that are to be integrated that is Radiology Information system and Hospital Management Information System as well as Picture Archiving and Communication Systems (PACS). RIS will be embedded with a Modality Work list which is part of the DICOM workflow services that enables patient's demographic information available at the Modality, eliminating dual data entry and providing data integrity. PACS will be used for radiological image storage, archiving, and management.

5.3 Recommendations

From the study, the following recommendation is made:

The RIS and HMIS used in the selected public hospitals in Uasin Gishu County should be evaluated to integrate the two systems. This should lead to the development of a system integration framework that is based on each hospital requirement. Vendors and system developers of RIS and HMIS should also be engaged to guide the design and implementation of an integrated HMIS.

The study finding shows that even though their exit local area network in the selected hospitals, the network infrastructure is generally poor. The integration of information system requires a stable and reliable network connection. The network connection in the selected hospital should therefore overhaul to aid information systems integration.

Computer hardware including data servers should be upgraded to meet the demands of fast network connectivity. The findings also indicated that even there exit data centers in some of the selected hospitals, the data servers are too old. Financial sustainability is also important when considering the integration of an information system in an organization, especially in public hospitals in developing countries. The ability to support the system financially in the long term is an important factor to consider. This

will enable the selected hospital to have the required tools needed for system integration. They will be able to procure systems that meet the required standards for integration, purchase appropriate infrastructure, and train staff in specialized areas. Complexities associated with the integration of HIS require trained IT personnel to provide technical support. Routine information system users need to have good knowledge and information technology skills to effectively use and sustain the system. Management can do this by allocating enough funds towards staff training and creating an organizational culture that enables personnel to thrive in their specialized areas.

5.4 Suggested Areas of Further Research

The study recommends that more studies should be done in other areas outside of Uasin Gishu County to establish if the same results will hold. A comparative study should also be done in the integration of RIS and HMIS between public and private hospitals. This will aid in setting up required policies and guidelines for system integration in public hospitals. A study should also be done on the impact of health information system integrations on patient care especially in public hospitals in Kenya. This should be done based on studies done on health information system integration.

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APPENDIX I: QUESTIONNAIRE FOR HOSPITAL STAFF

SECTION A: GENERAL INFORMATION

PLEASE ANSWER THE FOLLOWING BACKGROUND QUESTIONS

1. Gender (Check only one please)

   [ ] Male [ ] Female

2. Age (Check only one please)

   [ ] Under 30 years [ ] 30-39

   [ ] 40-49 years [ ] 50 years or Older

3. Which of the selected public hospital in Uasin Gishu county do you work in?(Check only one please)

   [ ] MTRH [ ] Ziwa [ ] Burnt forest

4. How long have you been working in the selected hospital?

   [ ] Less than 5 years [ ] 5-10 years

   [ ] 11- 15 years [ ] More than 15 years

5. What is the job title that most closely matches your current position?

   [ ] Radiologist [ ] Hospital Administrator [ ] Referring Physician

   [ ] Radiology Registrar [ ] Nurse [ ]ICT Technicians

   [ ] Radiographer [ ] Health Records officer

6. Which of the following best describes the level of your computer knowledge and education?

   [ ] Novice(beginner) with minimal computer knowledge and skills

   [ ] Average user who have good grasp of computer knowledge without previous training or education in computer use

[ ] Advanced user who has great computer knowledge with some prior training or education in computer use

[ ] Expert user with advanced knowledge in computer use

SECTION B: DESIGN FRAMEWORK OF THE RIS AND HMIS IN THE SELECTED PUBLIC HOSPITAL IN UASIN GISHU COUNTY

To what extent do you agree or disagree with the following statements regarding the Design framework of RIS and HMIS in the hospital where you work.

Key: SA – Strongly Agree, A – Agree, U- Undecided, D- Disagree, SD- Strongly Disagree

Statement	**SA**	**A**	**U**	**D**	**SD**
There is an existing HMIS in the hospital					
There is an existing RIS in the hospital					
RIS system is only used in the radiology department					
HMIS is used in all sections within the hospital					
RIS used in our hospital is DICOM complaint					
HMIS used in our hospital is HL7 complaint					
There are other Systems in the hospital that are integrated with the HMIS					
The Current HMIS meets your job requirements in your section					

SECTION C: CAPABILITY OF THE EXISTING INFRASTRACTURE FRAMEWORK

To what extent do you agree or disagree with the following statements regarding the Capability of the existing infrastructure framework in the hospital where you work.

For each statement below, please place a right tick as appropriate

Key: SA – Strongly Agree, A – Agree, U- Undecided, D- Disagree, SD- Strongly Disagree

Statement	**SA**	**A**	**U**	**D**	**SD**
There exist computers in your section for use in your daily job activities					
The is an existing network connection in the hospital					
Computers in your section are connected to the hospital network					
The hospital networking infrastructure is good					
The connection speed to the internet and with the hospital network is fast					
The hospital has a data center or a server room					

SECTION D: ORGANIZATIONAL FACTORS TO BE CONSIDERED IN THE INTEGRATION OF RIS AND HMIS

To what extent do you agree or disagree with the following statements regarding the organizational factors to be considered in the integration of RIS and HMIS hospital where you work

For each statement below, please place a right tick as appropriate

Key: SA – Strongly Agree, A – Agree, U- Undecided, D- Disagree, SD- Strongly Disagree

Statement	**SA**	**A**	**U**	**D**	**SD**
The hospital management supports staff in skills development					
Most hospital staff receive specialized training in the area of work					
Each department is allocated funds that are proportional to the needs.					
There is enough budgetary allocation to the ICT department					

APPENDIX III: INTRODUCTORY LETTER

RONGO UNIVERSITY

OFFICE OF THE DEAN
SCHOOL OF GRADUATE STUDIES

Tel. 0771349741

P.O. Box 103 - 40404
RONGO

Our Ref: **MHI/6401/2015**

Date: Thursday, May 16, 2019

The Chief Executive Officer,
National Commission for Science, Technology & Innovation,
off Waiyaki Way, Upper Kabete,
P.O Box 30623-00100,
Nairobi-KENYA.

Dear Sir,

RE: RESEARCH PERMIT FOR MR. KELVIN WAMBIRE OGOT-MHI/6401/2015

We wish to inform you that the above person is a bona fide graduate student of Rongo University in the School of Information, Communication and Media Studies pursuing a Master of Science in Health Informatics. He has been authorized by the University to undertake research titled; ***"A Framework For Integrating A Radiology Information System With Hospital Management Information System In Selected Public Hospitals In Uasin Gishu County.***

This is, therefore, to request the commission to issue him with a research permit to enable him proceed for field work.

Your assistance to him shall be highly appreciated.

Thank you.

RONGO UNIVERSITY
THE DEAN
16 MAY 2019
SCHOOL OF GRADUATE STUDIES
P.O. BOX 103 - 40404, RONGO

Dr. Edward Anino
DEAN, SCHOOL OF GRADUATE STUDIES

Copy to: Vice Chancellor
Deputy Vice Chancellor (Academic and Student Affairs).
Dean, Information, Communication and Media Studies
HoD, Information Science

APPENDIX III: NACOSTI PERMIT

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **458297**

Date of Issue: **09/September/2019**

RESEARCH LICENSE

This is to Certify that Mr.. Kelvin Ogoti of Rongo University, has been licensed to conduct research in Uasin-Gishu on the topic: A FRAMEWORK FOR INTEGRATING A RADIOLOGY INFORMATION SYSTEM WITH HOSPITAL MANAGEMENT INFORMATION SYSTEM IN SELECTED PUBLIC HOSPITALS IN UASIN GISHU COUNTY for the period ending : 09/September/2020.

License No: **NACOSTI/P/19/791**

458297

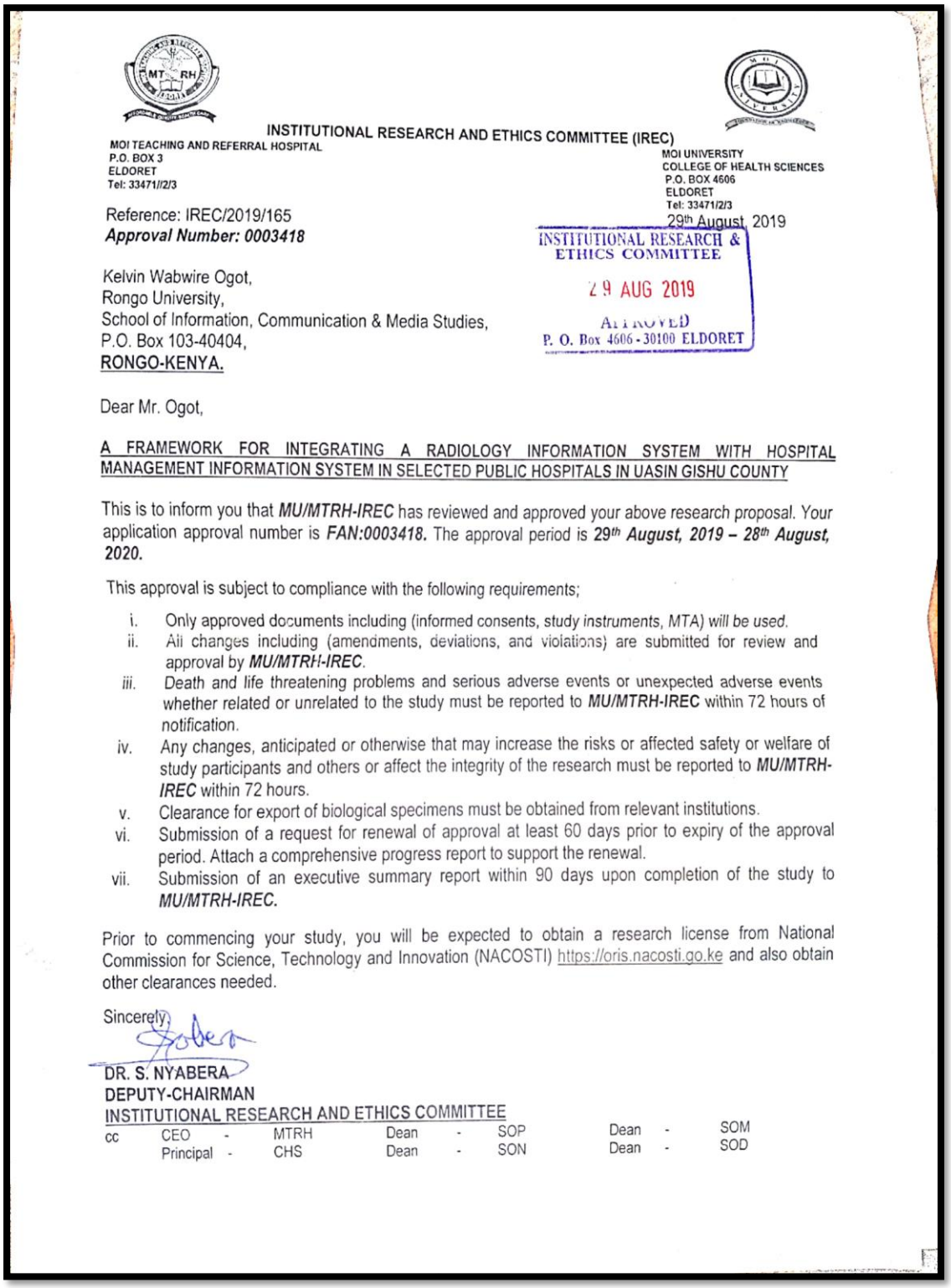
Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

APPENDIX IV: IREC APPROVAL



INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2019/165
Approval Number: 0003418

29th August, 2019

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
29 AUG 2019
APPROVED
P. O. Box 4606 - 30100 ELDORET

Kelvin Wabwire Ogot,
Rongo University,
School of Information, Communication & Media Studies,
P.O. Box 103-40404,
RONGO-KENYA.

Dear Mr. Ogot,

A FRAMEWORK FOR INTEGRATING A RADIOLOGY INFORMATION SYSTEM WITH HOSPITAL MANAGEMENT INFORMATION SYSTEM IN SELECTED PUBLIC HOSPITALS IN UASIN GISHU COUNTY

This is to inform you that ***MU/MTRH-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN:0003418.*** The approval period is ***29th August, 2019 – 28th August, 2020.***

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MU/MTRH-IREC***.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MU/MTRH-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MU/MTRH-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MU/MTRH-IREC.***

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Sincerely,

DR. S. NYABERA
DEPUTY-CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc CEO - MTRH Dean - SOP Dean - SOM
Principal - CHS Dean - SON Dean - SOD

APPENDIX V: RESEARCH AUTHORIZATION

An ISO 9001:2015 Certified Hospital

MOI TEACHING AND REFERRAL HOSPITAL

Telephone :(+254)053-2033471/2/3/4
Mobile: 722-201277/0722-209795/0734-600461/0734-683361
Fax: 053-2061749
Email: ceo@mtrh.go.ke/directorsofficemtrh@gmail.com

Nandi Road
P.O. Box 3 – 30100
ELDORET, KENYA

Ref: ELD/MTRH/R&P/10/2/V.2/2010

3rd September, 2019

Kelvin Wabwire Ogot,
Rongo University,
School of Information, Communication & Media Studies,
P.O. Box 103-40404,
RONGO-KENYA.

APPROVAL TO CONDUCT RESEARCH AT *MTRH*

Upon obtaining approval from the Institutional Research and Ethics Committee (IREC) to conduct your research proposal titled:-

"A Framework for Integrating a Radiology Information System with Hospital Management Information System in Selected Public Hospitals in Uasin Gishu County".

You are hereby permitted to commence your investigation at Moi Teaching and Referral Hospital.

DR. WILSON K. ARUASA, *MBS*
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

cc - Senior Director, (CS)
- Director of Nursing Services (DNS)
- HOD, HRISM