

**A MOBILE PHONE BASED CLINICAL SUMMARIES MODEL FOR
HEALTH CARE PROVIDERS AND PATIENTS AT KABARAK
UNIVERSITY HEALTH CENTRE**

BY

SAMUEL THAIYA MBUGUA

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DECLARATION

DECLARATION BY THE CANDIDATE:

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MBUGUA SAMUEL THAIYA
IS/MPHIL/028/08

DATE

DECLARATION BY THE SUPERVISORS:

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

PROF. DAVID GICHOYA
Department of Information Technology
Moi University, Eldoret

DATE

DR. DAMARIS ODERO

DATE

Department of Library, Records Management and Information Studies
Moi University, Eldoret

DEDICATION

I dedicate this work to:

My wife Sharon for her support and encouragement.

My sons Lawrence Mbugua and Jayden Mbugua who are a strong inspiration.

My parents, siblings and to all my friends.

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ABSTRACT

Recording and communicating patient level data by a Medicare provider is normally done through a clinical summary. However, such communications are normally done in formats which are not easy to understand/translate hence inhibiting current and future interactions between a provider and a patient. This study evaluated the clinical summaries system used by Kabarak University Health Centre with a view of designing and developing a Mobile Phone Based Clinical Summaries model. The study objectives were to: determine parameters that compose a clinical summary; assess providers' and patients' view and use of clinical summaries; establish the challenges with the current system of recording clinical summaries and to design and develop a Mobile Phone Based Clinical Summaries model for Health Care Providers and Patients at Kabarak University Health Centre. The study was guided by Systems Theory, SDMX-HD and REST protocols. Mixed method research approach was adopted utilizing a case study strategy to gather model requirements and prototyping for model development. The study targeted a population of 82 respondents comprising of health care providers: 3 Clinical Officers, 2 Doctors, 2 Laboratory Technicians, 10 Nurses, 3 Pharmacists, 3 Records Officers; 58 Patients and 1 ICT Staff. Purposive sampling was used to draw out all the health care providers and ICT staff targeted while simple random and purposive sampling was used to draw out 10 patients. Data was collected through interview, questionnaires and documentary reviews. Quantitative data was subjected to descriptive statistics while qualitative data was analyzed thematically. The study established that patient demographics, vital signs, medication list, lab results, test ordered, radiological tests and referral information were the parameters that compose a clinical summary. Verbal, handwritten, pre-printed checklist and EMR were the formats used to provide the summaries and the challenges arose from confidentiality and privacy of patient data, technology and communication. The study concluded that the model designed and developed alleviates the challenges inherent in the Kabarak University Clinical Summaries System. It is recommended that the model be adopted by Kabarak University Health Centre and other Hospitals in Kenya who have deployed an Electronic Medical Records System.

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LIST OF ABBREVIATIONS AND ACRONYMS

- CITL:** Centre for Information Technology Leadership
- CPOE:** Computerized Physician Order Entry
- CSV:** Comma Separated Values
- EHRs:** Electronic Health Records
- EMRs:** Electronic Medical Records
- EQA:** External Quality Assessment
- EQC:** External Quality Control
- GoK:** Government of Kenya
- HIS:** Health Information System
- HIT:** Health Information Technology
- HL7:** Health Level Seven
- ICT:** Information Communication Technology
- IQC:** Internal Quality Control
- ISO:** International Standard Organization
- JSON:** JavaScript Object Notation
- KABU:** Kabarak University
- LAN:** Local Area Network
- LOINC:** Logical Observation Identifiers Names and Codes
- MOH:** Medical Officer of Health
- OECD:** Organisation for Economic Cooperation and Development
- OSI:** Open Standard Interconnect
- PDA:** Personal Digital Assistant
- PHRs:** Personal Health Records
- SDMX:** Statistical Data and Metadata eXchange
- SDMX-HD:** Statistical Data and Metadata eXchange- Health Domain
- SNOMED:** Systemized Nomenclature of Medicine
- SOPs:** Standard Operating Procedures
- UML:** Unified Modelling Language
- UX:** User Experience
- WHO:** World Health Organization

DEFINITIONS OF OPERATIONAL TERMS

Electronic Medical Record System: It is a digital version of the paper charts in health care.

Episode of care: It is a set of services offered to a patient in a clinical encounter.

Provider: Personnel who provides or support provision of health services in an episode of care.

Regimen: A cocktail of drugs/medications prescribed by a provider in an episode of care

CHAPTER ONE

INTRODUCTION

1.0 Chapter Overview

This chapter presents the background to the study, statement of the problem, aim of the study, objectives and research questions, assumption of the study, significance and the scope of the study.

1.1 Background to the Study

A clinical summary is an after-visit summary which allows medical providers to make appropriate clinical decision based on patient demographic parameters like weight and temperature that are captured in a visit. And as noted by Lukoshek *et al.* (2003) the summary enhances patients ability to recall the interactions with the care giver. The process of creation of a clinical summary encompasses five steps namely; huddle, pre-visit, rooming the patient, the visit and the generation of the after visit summary (Hummel *et al.*, 2012).

Thus a clinical summary is a patient record created by medical providers after one or more encounters with patient(s) and can be in paper based or electronic formats. Raymond and Dold (2002) as quoted by Burton *et al.* (2004) indicated that paper-based systems supporting clinical care are limited as information storage and retrieval systems and have high rates of failure in retrieval and illegibility and that human memory-based medicine is increasingly unreliable. On the other hand, International Organization for Standardization (ISO, 2005) defines "Integrated Care Electronic Health Record" (EHR) as a repository of information regarding the health of a subject of care in computer processable form, stored and transmitted securely, and accessible by multiple authorized users. According to Ball *et al.* (2006), Electronic Health Records (EHR) describes the

concept of a comprehensive, cross-institutional, and longitudinal collection of a patient's health and healthcare data. It, thus, includes data that is not only particularly relevant to a subject's medical treatment but also to a subject's health in general. The patient is regarded as an active partner in his/her treatment by accessing, adding, and managing health-related data, thereby supporting care. According to the USA National Health Service (NHS) report of 2008 as quoted by Kidd (2008), proponents of the summary care record expect to see improved patient safety, with reductions in preventable errors, improved access to vital information, and better informed patients.

Cayton (2004) as quoted by Pagliari *et al.* (2007) observed that the public demand for flexible access to health information and services is growing due to internet trends and policies promoting patient rights and empowerment. On the other hand, WHO (2006) as quoted by Pagliari *et al.* (2007) observed that the unprecedented global investment in healthcare information and communication technologies has been dominated by efforts to implement electronic health records, which promise improved quality and efficiency through better maintenance and availability of patient data. Hence, there is considerable international interest in the potential of electronic personal health records to bridge these agendas, and NHS HealthSpace is set to become the world's first fully national system (Pagliari *et al.*, 2007). Similarly in Kenya with internet penetration of about 74.2% and with about 38 million registered mobile subscribers, demand for information has grown tremendously (CAK, 2016).

According to Anokwa (2012), workers at small clinics and dispensaries tend to have less medical experience than doctors at hospitals, and therefore need even more decision support to ensure a high standard of care. Inveneo (2010) and Veeraraghavan *et al.* (2009) note that summaries must also be available at smaller sites and in communities

where desktop computers are difficult to deploy. The summaries are also required where, reliable connectivity is not always available and the human capacity for using and maintaining such computer based systems is hard to find (Brewer *et al.* 2006 and Malkin 2007).

In Kenya the current health information systems (HISs) are designed and implemented with no or limited participation of those who are to ultimately operate them and there is inadequate involvement of those who are to use the information generated by the systems. Existing HISs are highly fragmented with no linkages with other healthcare providers at various levels (GoK, 2009). Further, poor integration of vertical programs and administrative information into the routine HIS has resulted to lack of sharing of information among health care providers in the health system (GoK, 2009). Electronic Medical Records (EMR) systems are increasingly being adopted in Kenya to improve medical records management, health program management and the quality of patient care. However, the development and implementation of EMRs has not been properly coordinated, resulting in multiple EMRs with varying objectives and functionality and with no ability to share patient information with other systems and the Government (Standard & Guidelines for EMRs in Kenya, 2010). Similarly, Kabarak University Health Centre uses an EMR in their daily activities.

Further, medical protocols stipulate that medical providers should ensure that patient's health data collected during an episode of care remains confidential. However, OECD (2010) observed that when designing health application the main challenge is how to create a smooth interface between privacy and confidentiality and security requirements for defining access to and use of personal health information.

Consequently, meaningful improvements can only be realized as a result of provision of integrated information generated and used by all health care providers in Kenya. Therefore, to offset the aforementioned challenges spelt out in the HIS policy of 2009 and which are also inherent in the Kabarak University Health Center EMR, the conceptualized Mobile Phone Based Clinical Summaries model interfaces with the EMR enabling real time interaction of the patients and the health care providers irrespective of their geographical disposition and hence acting as a good tool for monitoring and evaluation of patient's health status before and after visiting the health facility while upholding the confidentiality of patient health data. It is hoped that the application of the Mobile Phone Based Clinical Summaries model will lead to improved generation, application and distribution of clinical summaries within Kabarak University Health Centre and other similar health settings in Kenya.

1.1.2 Study Area

Kabarak University is a purpose-built Christian based university on a 600-acre farm located 20 kilometres from Nakuru, Kenya (the fourth largest city in Kenya), on the Nakuru–Eldama Ravine road in Kenya's Rift Valley region. The University is a private chartered institution of higher learning that provides holistic Christian-based quality education, training research and outreach activities for the service of God and humanity. The campus features an outdoor swimming pool, sports areas, tree-shaded lawns and residential facilities for over 1,000 students. The university also operates a Town Campus in Nakuru, conveniently situated close to the commercial centre of the town (www.kabarak.ac.ke).

The University has over 2000 students pursuing various academic courses in Sciences, Engineering, Technology, Business, Law, Theology, Education and soon Health Sciences

(www.kabarak.ac.ke).

The University's mission is to provide a holistic quality education to the youth, equipping them with knowledge, practical skills and Christian moral values necessary for the service of God and Humanity. The University's vision is to become a centre of academic excellence as a Christian Liberal Arts, Science and Technology Institution (www.kabarak.ac.ke).

1.1.3 Kabarak University Health Centre

Kabarak University operates a Health Centre that serves the clients within the Kabarak Community; University, High School, primary school and the surrounding community. The health centre operates a public section and private section and employs a hybrid of paper based and electronic health records system (EHR) running on a LAN. The hybrid system at the health centre provides clinical summaries to providers and patients in paper based format with the EHR component focus on reporting aggregate statistics to institutional managers and stakeholders (www.kabarak.ac.ke)

1.2 Statement of the Problem

Recording and communicating patient level data by a health care provider is central to the process of health care provision wherein this communication is normally done through a clinical summary. Lukoshek *et al.* (2003) note that clinical summaries enhance the ability of patients to remember, and, if necessary, convey to family members, the content of interactions with their care team. It also supports greater patient engagement in making good choices about healthy behaviours and the self-management of chronic conditions, which is essential to improving clinical and patient-oriented quality outcomes (Coulter, 2012).

WHO (2006) observed that the unprecedented global investment in healthcare information and communication technologies has been dominated by efforts to implement electronic health records, which promise improved quality and efficiency through better maintenance and availability of patient data. Similarly, Kabarak University Health centre mainly uses an electronic health records (EHR) system in managing health records. Rather than providing support in the form of patient-level recommendations to health care providers, the EHR focus on reporting aggregate statistics to institutional stakeholders. Attempts at bridging this gap have led to generation of paper-based summaries which are added to the patient record (Anokwa, 2012). Of course, the very properties that make paper-based summaries popular (cheap, available, robust, etc) are tradeoffs for potential increases in functionality.

Often, the patient summaries are sometimes misplaced or wrongly filed. This makes it hard to track patient's medical history, laboratory tests and drug/medication usage during subsequent visits. Further, the summaries are presented in formats which are not easy to understand or translate thus inhibiting interactions between care providers and the patients. According to Markle Foundation (2012), after visit summaries improves the quality of information in an EHR through transparency, by giving patients and family members an opportunity to see information in their records so they can help the care team identify and correct data errors.

Because acting on the summary might require more information (like reviewing weight over the last few visits), exploring latest, up to date underlying data is very critical. Paper-based summaries simply cannot enable such functionality. The proposed model will provide a more robust, user friendly and convenient system to bridge the gap between health data and its users. In addition, it will ensure that the patient information is

used in a format that allows for interoperability while upholding confidentiality of patient health data hence privacy of the patient.

1.3 Aim of the Study

The aim of this study is to evaluate the clinical summaries system used by Kabarak University Health Centre with a view to design and develop a Mobile Phone Based Clinical Summaries model for generating, using and presenting clinical summaries.

1.4 Objectives of the Study

The study sought to achieve the following objectives to:

- i. Determine parameters that compose a clinical summary
- ii. Assess providers' and patients' view and use of clinical summaries.
- iii. Establish the challenges with the current system of recording clinical summaries at Kabarak University Health centre.
- iv. Design and develop a Mobile Phone Based Clinical Summaries model For Health Care Providers at Kabarak University Health Centre.

1.5 Research Questions

The following research questions were used to probe the outlined objectives of the study:

- i. What are the elements of a clinical summary?
- ii. How do health care providers and patients use and perceive clinical summaries?
- iii. What are the challenges faced in using the current case of clinical summaries?
- iv. How can a suitable mobile clinical summaries model be designed and developed for Kabarak Health Centre?

1.6 Significance of the Study

The proposed Mobile Phone Based Clinical Summaries model will assist Kabarak University Health Centre in providing timely, correct and up-to date clinical summaries more consistently and avail them at the point of care while upholding confidentiality of patient health information. Health care providers using a mobile phone or tablet will be more likely to comply with health care provision guidelines, testing procedures and will be more attentive to important medical indicators. The system will assist in providing improved laboratory test orders and results follow up and drug/regimens adherence and monitoring for effectiveness. It will also assist in tracking patients' honor of scheduled return appointments. The study findings will assist Kabarak University Health Center management and policy makers with insights on the level of adherence to patient management processes, upholding of patient privacy and confidentiality as espoused by the Kenya's HIS policy.

The model can be used by any other health care provision centre to improve on clinician-patient communication and timely summaries at point of care thus aiding in operationalization of Kenya's HIS Policy (2009). The output of this study will also be of benefit to those doing similar research in the present and future in a similar or different resource setting.

1.7 Scope of the Study

The study investigated generation, use and presentation of clinical summaries at Kabarak University Health Centre. The scope of clinical summaries parameters in this study included; patient demographics, provider's contact information, date and time of last encounter, an updated medication list, updated vitals, immunizations or medications administered during an encounter, date and time of next appointment or testing if

scheduled, laboratory and other diagnostic test orders. The study did not cover clinical reminders and pre-consultation prevention summaries. Hence, it shall only be implemented at the reception and the records section of Kabarak University Health Centre.

By design, the model is a component of a functional EMR and can be used in all levels of hospitals in Kenya so long as pre-visit and after visit episodes of care exist. It is believed that the findings generated by this scope will be helpful to inform the entire study as well as be useful in other health centres where a similar system is implemented

1.8 Assumptions of the Study

The research was based on the following assumptions:

- The current system used by Kabarak University health centre in providing clinical summaries to providers has gaps and limitations that need to be addressed.
- That Kabarak University health centre embraces ICTs in its provision of health services
- That a mobile based system will provide better, up to date, timely and actionable clinical summaries enhancing effectiveness and efficiency in patient management.

1.9 Chapter Summary

This chapter presented the background of the study, statement of the problem, aim of the study, objectives and research questions, assumptions of the study, significance and the scope of the study. The remaining part of the thesis comprises chapter two which presents the literature review, chapter three which describes the methodology, chapter four which covers data presentation analysis and interpretation, chapter five which is the model design and development and chapter six which gives the summary, conclusions, recommendations of the study and suggests further areas of research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Chapter Overview

This chapter provides the theoretical framework upon which the study is based. It also reviews literature related to the study. A literature review is an objective and critical analysis of the relevant, available research and non-research literature on the topic being studied (Hart, 1998). The literature review focused on the following thematic areas: parameters that compose a clinical summary, assessment of the providers' and patients' use and view of clinical summaries, provision of reports/feedback to health care system stakeholders, protocols governing collection, storage and dissemination of health data, data formats standards, healthcare information exchange and interoperability taxonomy, challenges on the use of electronic health records, recording, storage and communication of patient information, mobile technology, paper-based systems, medical/health technologies, electronic health, electronic medical records/electronic health records and benefits of electronic health records. In reviewing the stated themes, narrative approach was adopted because it is useful in gathering literature on the specific thematic areas for the purpose of summarizing, synthesizing and developing conceptual frameworks (Cronin *et al.*, 2008).

2.1 Theoretical Framework

Labaree (2013) defines a theoretical framework as a structure that can hold or support a theory of a research study. A theoretical framework introduces and describes the theory which explains why the research problem under study exists. It is the lens through which the researcher views the world (Merriam, 1998). A theory is a statement or a set of statements based on empirical evidence found through scientific research. They are formulated to explain, predict, and understand phenomena and, in many cases, to

challenge and extend existing knowledge, within the limits of the critical bounding assumptions.

2.2 Theories, Standards and Protocols Considered for the Study

The study considered Information theory (Shannon, 2002), Systems theory (Bertalanffy, 1968), Health Level Seven (HL7), Statistical Data and Metadata eXchange- Health Domain (SDMX-HD) (WHO, 2009) as the relevant theories and standards informing the study. Further the study considered, Simple Object Access Protocol (SOAP) and Representational State Transfer (REST) (Kumari, 2015) as the relevant protocols.

2.2.1 Information Theory

The information theory as proposed by Claude Shannon is concerned with the transmission of messages across/over a channel of communication. It is concerned with channels of communication; architecture of communication systems; digital representation and its efficiency as well as entropy and information content, (Aftab, 2001). Blum (1986) notes that information theory can be applied in health informatics, to improve “structure, process and outcomes” of data and information processing.

However, in health and particularly its informatics, the information theory faces limitations by aiming at communication issues and channels and neglecting reliability and holistic look at the communicating systems. Further, the nature of fuzziness in health data presentation is not considered in information theory (Wang, 2012). Thus the theory fails to recognize that health information systems are defined by levels of complexities encapsulated by issues of procedures, privacy and confidentiality.

2.2.2 Systems Theory

The general systems theory (Ludwig von Bertalanffy, 1968) as adopted by Friedman & Allen (2011), describes a method to model complex entities created by the multiple interaction of components by abstracting certain details of structure and component, and concentrating on the dynamics that define the characteristic functions, properties, and relationships that are internal or external to the system. A system is a complex of interacting components together with the relationships among them that permit the identification of a boundary-maintaining entity or process. The general systems theory breaks down a system into individual parts and subsystems then learns how each of these parts and subsystems work separately and collectively as a system. These parts or elements are inputs, throughput/process, outputs, outcome and feedback as shown in Figure 2.1.

According to Plsek (1999), Systems theory has been effectively applied in information technology to come up with key clinical systems like medical administration, electronic documentation, physiological monitoring and patient order entry. Petula (2005) notes that Systems theory offers a framework for quality improvement (QI) in healthcare systems since it supports systems thinking. Further, Petula (2005) observed that high-quality care is more likely in systems where relationships and interrelationships are considered important. Similarly, the application of Systems theory in modelling mobile phone based clinical summaries brings about the interaction among the various providers and between providers and patients who are provided with non-actionable summaries.

2.2.3 Standards for Data Exchange.

The model developed needed to read and write data from/to the Kabarak University Health Centre EMR. The data formats in the EMR are not necessarily compatible with the model formats.

Health data is generated and presented in different formats depending on the source system. Thus standards for data exchange ensure that the health data in their different formats are interoperable. Health Level Seven (HL7) and Statistical Data and Metadata eXchange-Health Domain (SDMX-HD) were reviewed.

HL7 Standard

HL7 is a standard for the exchange, integration, sharing and retrieval of electronic health information. It defines how information is packaged and communicated from one party to another by setting the language, structure and data type (www.hl7.org/implement/standards/index.cfm).

SDMX-HD

SDMX is an ISO standard for exchanging information and sharing statistical data and metadata among organizations. It provides standard formats for data and metadata together with content guidelines and IT architecture for exchange of data and metadata (WHO, 2009).

SDMX-HD (Health Domain) is the WHO implementation of the SDMX standard to enable medical facilities to share and exchange medical indicators and metadata between medical organizations (<https://wiki.openmrs.org/display/docs/SDMX-HD>). SDMX-HD was developed based on the SDMX v 1.0 standard (WHO, 2009 & ISO, 2013).

2.2.4 Simple Object Access Protocol (SOAP) and Representational State Transfer (REST) Protocols.

Given that the Mobile Phone Based Clinical Summaries model entails client-server communication, an appropriate message communication protocol had to be chosen. SOAP and REST are the two main web communication protocols (Kumari, 2015). In choosing between the two protocols their advantages and disadvantages were compared as shown in Table 2.1.

Table 2.1: Comparison of SOAP and REST Message Communication Protocols

S/N	SOAP	REST
A.	Advantages	Advantages
1.	Platform and language independent	Platform and language independent
2.	Uses XML to send and Receive Messages	<ul style="list-style-type: none"> • Light bandwidth because it passes message in JSON format. • It can also use multiple other formats including XML
3.	Supports asynchronous messaging	Efficiently uses HTTP verbs
4.	Vendor Neutral	It can be consumed by any client
5.	It makes data available as services	<ul style="list-style-type: none"> • It makes data available as a resource • Supports stateless communication
B.	Disadvantages	Disadvantages
1.	Too much reliance on HTTP	It is not suitable for large amount of data
2.	It is not stateless	It does not cover all varieties of web standards like security and transactions
3.	Can be too slow because of XML generation	
4.	Bandwidth intensive due to its format of message generation	

Source: (Kumari, 2015).

2.2.5 Preferred Theory, Standard and Protocol

The study adopted the general systems theory as proposed by Ludwig von Bertalanffy (1968) and adopted by Friedman & Allen (2011) for the clinical practice domain, HL7 and SDMX-HD standards (WHO, 2009) and Representational State Transfer (REST) protocol (Kumari, 2015).

Systems Theory

The study adopted the Systems theory introduced by Ludwig V. Bertalanffy (1968) and adopted for clinical social work by Friedman *et al.* (2011) since it allows the study of complex systems by looking into its sub-systems and components and their performance separately and collectively as a system as shown in Figure 2.1. Further, to understand an EHR clearly is to look at it holistically as a system.

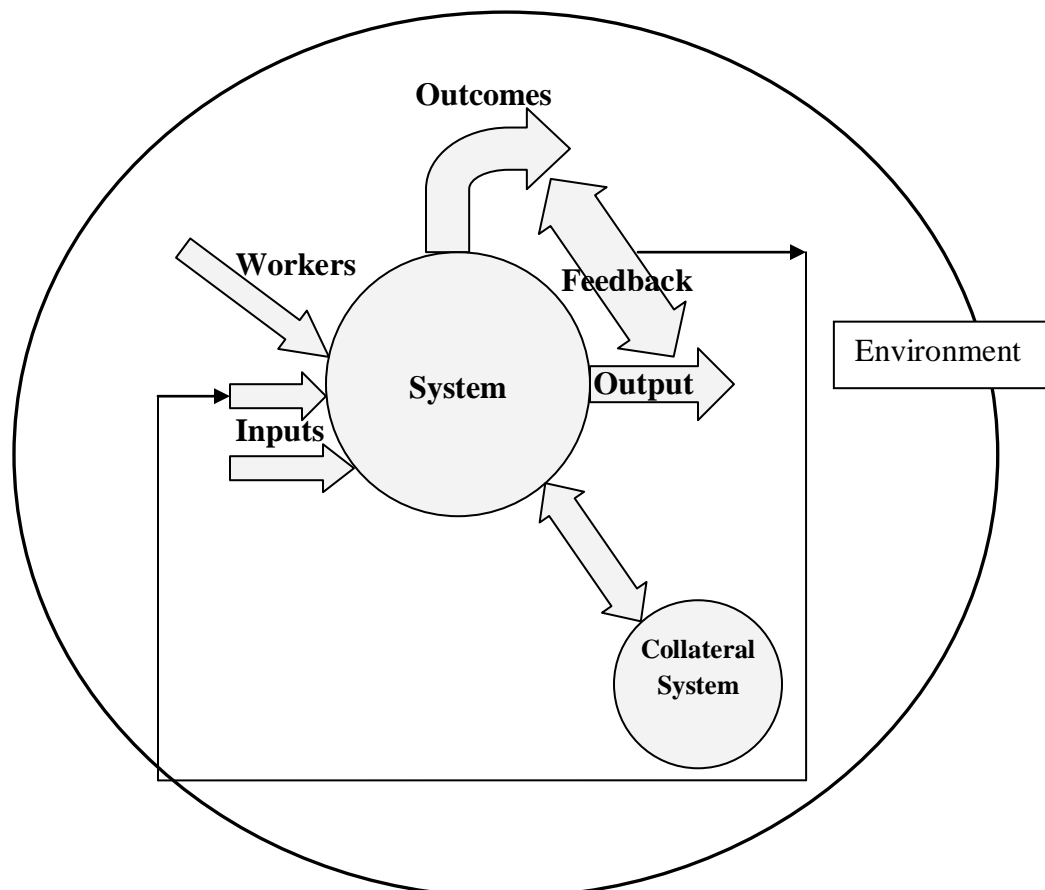


Figure 2.1: Systems Theory Model
Source: Friedman & Allen (2011)

Thus, the general systems theory informed the study by modelling various elements as per the study objectives into system components thus;

- **Input** refers to the information, materials and all other resources required for processing to take place (Friedman & Allen, 2011).
- **Throughput/Process** refers to activities undertaken on inputs to transform them into the desired output or result. It is the activities used by the system to convert inputs into products that are usable by either the system itself or the environment (Friedman & Allen, 2011).
- **Output** refers to the end products or final result of the system after processing the inputs. It could be a service which results from the system's throughput or processing technical inputs (Friedman & Allen, 2011).
- **Outcomes/goals** refer to the overall purpose for existence or the desired outputs. It is the relationship of the system outputs and the objectives of the system processes to determine if the initial aim and objectives has been attained (Friedman & Allen, 2011)
- **Feedback** refers to the information about some aspect of inputs processing that can be useful to evaluate and monitor the system and guide it to more effective performance (Friedman & Allen, 2011).

Hence, Figure 2.2 illustrates the conceptual framework as derived from Systems Theory that guided the researcher in designing and developing the Mobile Phone Based Clinical Summaries model.

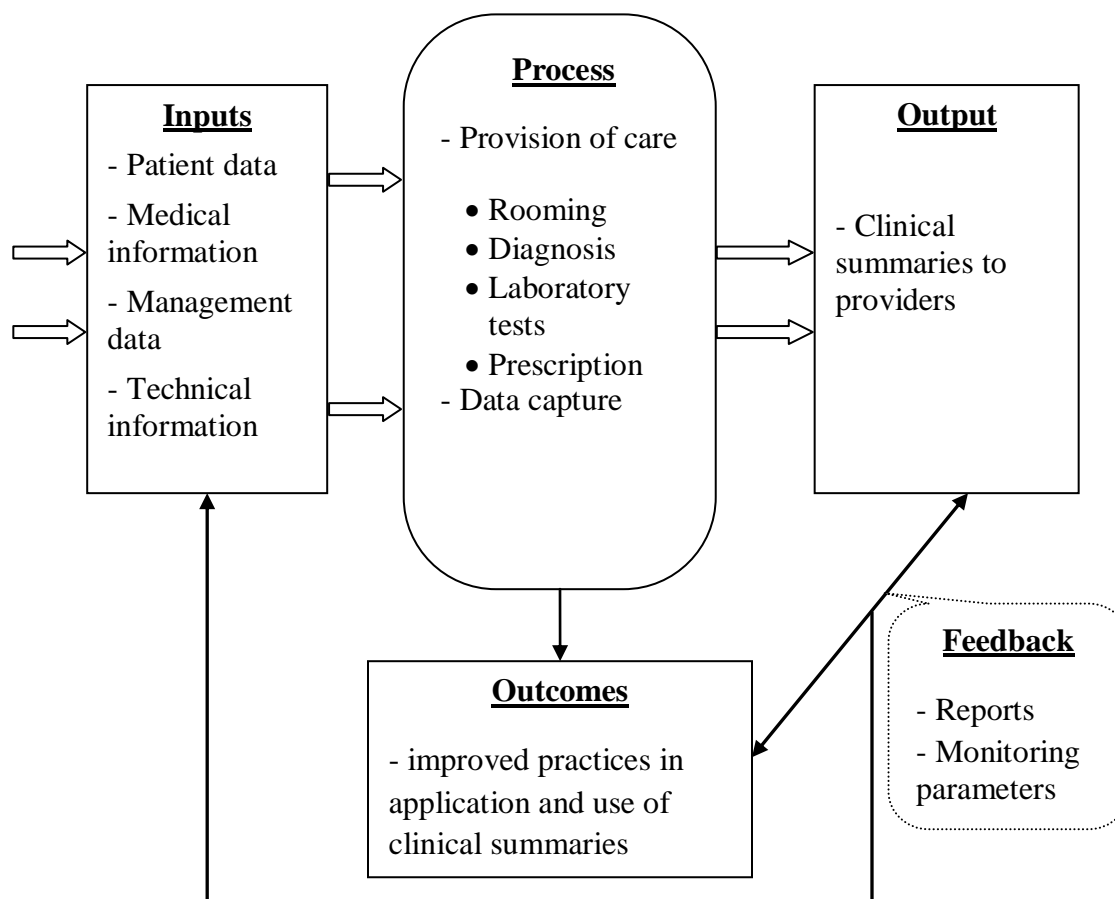


Figure 2.2: A Mobile Phone Based Clinical Summaries Conceptual Model (Adopted with modifications from Systems Theory (Friedman & Allen, 2011)).

From Figure 2.2, the general systems theory informed the study by modelling various elements as per the study objectives into system components thus: The conceptual model inputs included information (patient, health and management), medical algorithms and protocols as per objective one of the study as well as medical practitioners (doctors, nurses and laboratory technicians), patients as per objective two of the study. Further it included technical requirements (computers, software, mobile devices) needed to design and develop the Mobile Phone Based Clinical Summaries model as per objective four of the study (Figure 2.2).

Petula (2005) opines that when systems theory is applied to healthcare systems, then processes within the system are recognized as being as important as the component parts and the interdisciplinary relationships, among disciplines like nursing, medicine, social work, and administration which are central to social processes cannot be taken for granted. Thus in the study, the processes encompassed patient care procedures and data capture (Figure 2.2).

In the study, the outputs included revised form of clinical summaries, provision of instants mobile clinical summaries to health care providers, better protocols to enhance the system of generation and use of clinical summaries in Kabarak University Health Centre as per objective four of the study (Figure 2.2).

It is postulated that the Mobile Phone Based Clinical Summaries model, outcome will lead to improved generation, application and distribution of clinical summaries within Kabarak University Health Centre as per objective two and three of the study (Figure 2.2).

The study feedback covered monitoring parameters like; are the current prescriptions working? is mobile technology effective in sharing clinical summaries? reports on medication adherence and patient satisfaction reports (Figure 2.2). These were evaluated upon testing the model as per the adopted Mobile Application Development Life Cycle (MADLC) framework (Vithani and Kumar, 2014).

HL7 and SDMX-HD

In the design and development of the Mobile Phone Based Clinical Summaries model, the HL7 and SDMX-HD v1.0 standards were adopted.

The HL7 standard operates at the level seven layer of the ISO's Open Standard Interconnect (OSI) model. It is concerned with data contents and relationship (Figure 2.3) between messages with limited support for application level error. The communication environment including its structure and architecture is outside the scope of HL7 (Stevens, n.d). It is organized into chapters based on message category: control, patient administration, orders, query, financial management and results as shown in Figure 2.3

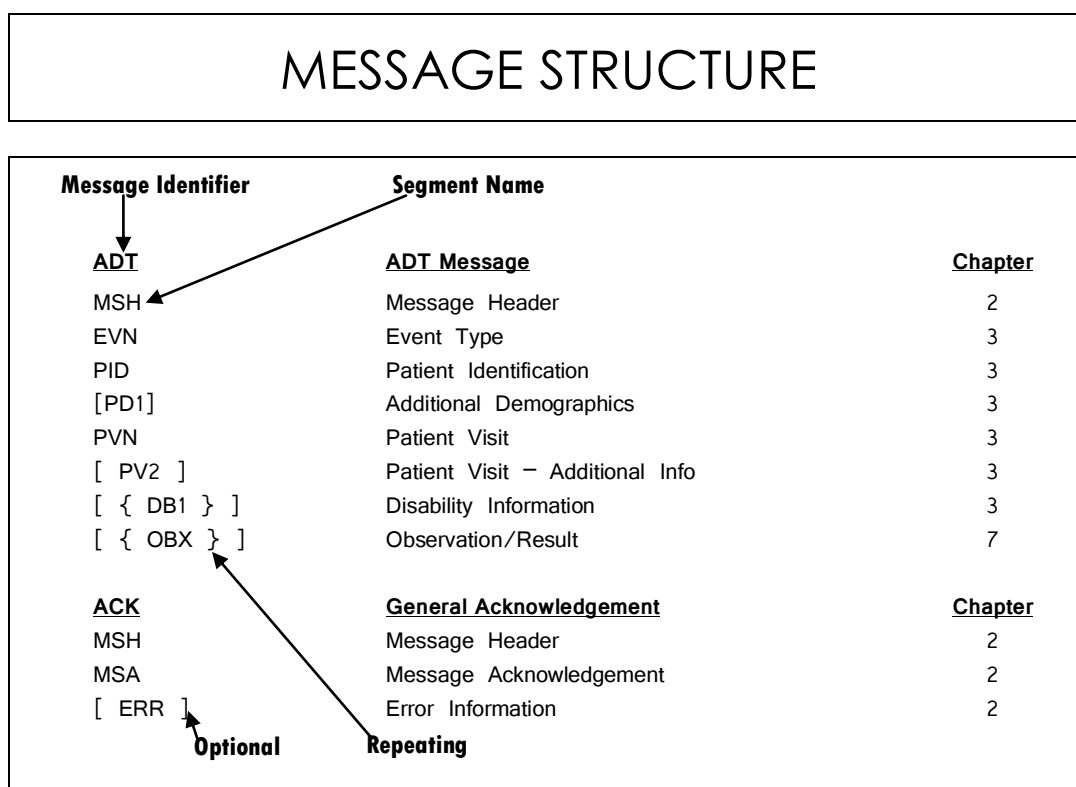


Figure 2.3: HL7 Message Structure.

Source: (Stevens, n.d)

- **Message** is a group of segments and it is uniquely identified by a message ID. In the study, a message is generated and processed as conceptualized in Figure 2.2 when actions on the inputs is triggered by an event such add drug as illustrated in Figure 5.22.

- **Data field** is a clinical concept being messaged where in the study it includes medical and management parameters (Figure 2.2) composing a clinical summary as per objective one of the study.
- **Segment** is a logical grouping of data fields and is identified by a unique 3 character code called a segment ID. A segment may be required, optional and/or repeated.

Since HL7 is not concerned with the communication environment including its structure and architecture (Stevens, n.d), the study therefore adopted the SDMX-HD standard to counter the limitation. The SDMX-HD standard is made up of four sub-components namely External files, Data Structure Definition (DSD), MetaDataSet (MDS), Compact DataSet (CDS) and Compact MetaDataSet (CMS) as shown in Figure 2.4.

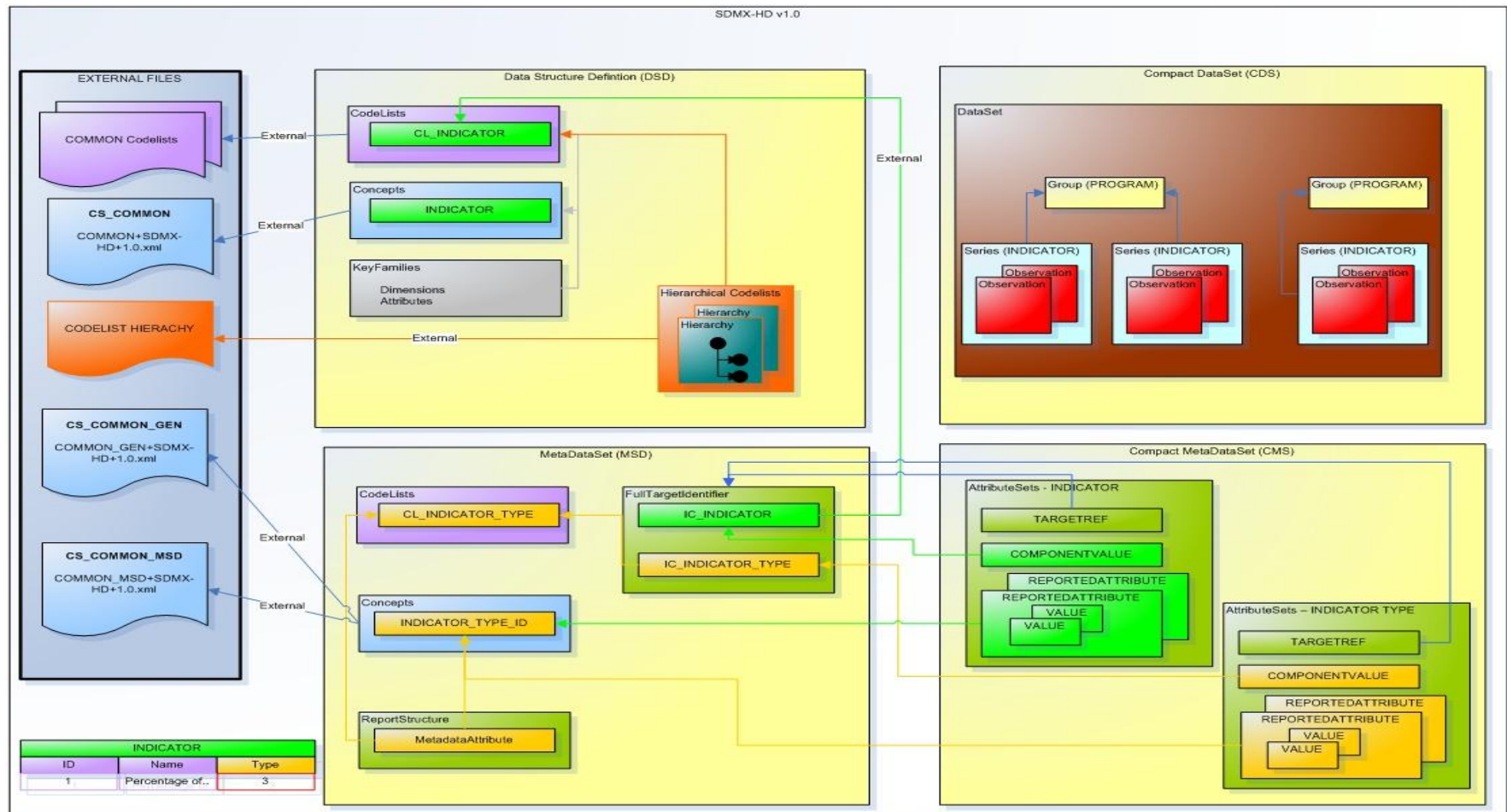


Figure 2.4: SDMX-HD Model Structure.

Source: <https://wiki.openmrs.org/display/docs/SDMX-HD>

- **External files**

It represents the source of data and its formats. In the study the data source was Kabarak University Health Centre EMR as illustrated in Figure 5.7.

- **Data Structure Definition (DSD)**

It specifies a set of concepts which describe and identify a set of data by specifying which concepts are dimensions (identification and description) and which are attributes (identification only). In addition, it gives the attachment level for each of the concepts, according to the packaging structure (Data Set, Group, Series and observations). Further, it gives the status of the concepts (mandatory or conditional), (<https://wiki.openmrs.org/display/docs/SDMX-HD>). In the study, this was represented by medical parameters that compose a clinical summary and processed as HL7 messages as per objective one of the study.

- **MetaData Structure Definition (MSD) and MetaData Set (MDS)**

SDMX-HD defines two types of metadata: structural metadata which describes how data is organized and referential metadata describing the context of a data element identified as a concept. MSD/MDS defines the grouping and reporting of metadata and their targets. It represents the clinical summary templates (Figure 5.15) used to consume patient data as HL7 messages to generate a clinical summary as per objective four of the study.

- **Compact DataSet (CDS)**

CDS defines the grouping/packaging structure of statistical data into various levels namely: observation, series and group level as shown in Figure 2.4. The observation level defines the measurement of a phenomenon while the series level defines the measurement of phenomena over a regular interval of time. The group level defines a

group of series (<https://wiki.openmrs.org/display/docs/SDMX-HD>). However, this sub-component was beyond the scope of this study.

- **Compact MetaDataSet (CMS)**

CMS defines the grouping/packaging structure of metadata sets into grouped sets of reference and structural attributes which has data objects that the metadata can be attached. CMS attaches an aspect of period/time series to a MDS for the purpose of reporting (www.metadatatechnology.com/sdmx.php). However, this sub-component was beyond the scope of this study.

REST

Based on the stated advantages and disadvantages (Table 2.1), the study adopted REST protocol because of its lightweight nature and would yield a stateless Mobile Phone Based Clinical Summaries model as opposed to SOAP which is a stateful protocol. In addition, the target consumers of the summaries who are located in Kabarak University and its environs would need to access an application which is not bandwidth intensive hence affordable to use. Such cost saving would not be realised by the use of the heavy weight SOAP messaging protocol.

Hence, based on Systems Theory, SDMX-HD and HL7 standards and the REST protocol, the design block diagram depicting communication between Mobile Phone Based Clinical Summaries model and the Kabarak University Health Centre EMR (Figure 5.7) was conceptualized for design and development in the study.

2.3 Health Information Technology

Electronic healthcare (e-health) refers to the organization and delivery of health services and information using internet and related technologies. E-health is not only a technical development but also a new way of working, an attitude, and a commitment to

networked, global thinking so as to improve healthcare locally, regionally and globally by use of information communication technology (World Bank, 2006).

On the other hand, Health information technology (HIT) encompasses a wide range of products and services - including software, hardware and infrastructure - designed to collect, store and exchange patient data throughout the clinical practice of medicine. (www.ama-assn.org). HIT provides an opportunity for engaging populations not historically well served by the traditional health community. The impact of facilitating patient and population contribution to, and control of, their health information has the potential to provide further insights into, and opportunities to address, disparities in underserved population (McGinnis and Grossman, 2011). Health IT includes: Electronic Records (EHRs), Personal Health records (PHRs) and Electronic Prescribing. Hence, as per the scope of the study the model developed was part of the Kabarak University EHR.

In Kenya, the application of information and communication technology (ICT) in the health sector aims to simplify administrative processes and reduce data gathering and processing costs and to facilitate the delivery of health related information to remote locations within the sector, HIS Policy (GoK, 2009). However, as the use of ICT and the exchange of electronic health information increases, concerns about the protection of personal health information exchanged electronically within a nationwide health information network will also increase. Hence, the health sector will have to initiate activities that, collectively, will address aspects of key privacy principles, HIS Policy (GoK, 2009).

According to the Kenyan Ministry of Health, health Information is not integrated with information technology to the extent witnessed in developed countries. This is attributed to the limited availability of the requisite skills and equipment at the various levels and

the high levels of IT illiteracy, HIS Policy (GoK, 2009). However, the Healthcare policy makers in Kenya recognize the application of appropriate ICT for the 21st century is critically needed to enable improved communication between levels and the dissemination of information outside the health sector. The policy addresses the identified challenges by ensuring there is: integration of health information with technology; application of appropriate technology for generation and use of health information; simplification of administrative processes and facilitation of the delivery of health related information to and from remote areas within the sector; use of uniform ICT specifications in the public sector; use of standardized and interoperable ICT applications; adequate security measures for protecting health information including defined access rights, liability and sanctions; development and maintenance of databases and the use of cost-effective and sustainable ICT taking into account, ethical and cultural considerations, HIS Policy (GoK, 2009).

Therefore, through the design and development of the Mobile Phone Based Clinical Summaries model the study sought to aid in the bridging of the gap that exist between technology and health information in Kenya, and thus actualizing the Kenyan HIS Policy as envisioned in 2009.

2.3.1 Electronic Health Records

Electronic Health Records (EHR) describes the concept of a comprehensive, cross-institutional, and longitudinal collection of a patient's health and healthcare data. It, therefore, includes data that is not only particularly relevant to a subject's medical treatment but also to a subject's health in general. The patient is regarded as an active partner in his/her treatment by accessing, adding, and managing health related data, thereby supporting care (Ball *et al.*, 2006).

International Organization for Standardization (ISO, 2005) defines “Integrated Care Electronic Health Record” (EHR) as: “...a repository of information regarding the health of a subject of care in computer processable form, stored and transmitted securely, and accessible by multiple authorised users. It has a commonly agreed logical information model which is independent of EHR systems. Its primary purpose is the support of continuing, efficient and quality integrated health care and it contains information which is retrospective, concurrent and prospective.” Figure 2.4 shows the conceptual diagram of EHR system with a single provider

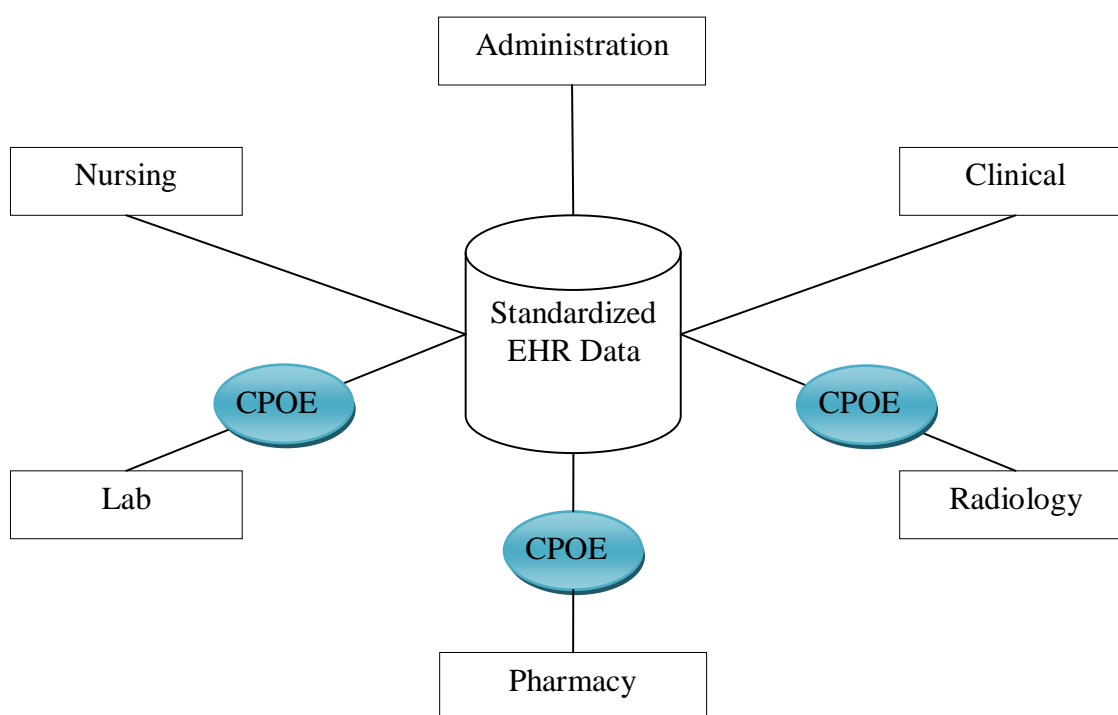


Figure 2.5: EHR Concept-Single Provider

Source: (Razi et al., 2011)

The standard EHR components shown in Figure 2.4 are as described below:

- i. Administrative component: Patient, admissions, discharges, and transfer information
(National Committee for Vital Health Statistics, 2002 in Razi *et al.* (2011))
- ii. Laboratory component: Orders of tests, results, and billing information.

- iii. Radiology component: Orders of images, results, and billing information. Lorenzetti (2003) as quoted by Razi *et al.* (2011) mentioned that about 80% of institutions had this capability in 2001.
- iv. Pharmacy: Automated entry of prescription drugs is highly desirable and would eliminate manual entry error (Ondo and Hess, 2005 in Razi *et al.* (2011)).
- v. Computerized physician order entry (CPOE): CPOE allows integration of components ii, iii, and iv. CPOE is a must and should also be compatible with other EHR components.

2.3.2 Characteristics of EHR

- Patient Centeredness: In this case, one EHR relates to one subject of care, not to an episode of care at an institution;
- Longitudinal: It is a long-term record of care, possibly birth to death;
- Comprehensiveness: It includes a record of care events from all types of carers, providers and institutions tending to a patient, not just one specialty; that is, there are no important care events of any kind not in the EHR;
- Prospectiveness: This means that not only are previous events recorded, but also instructions and prospective information such as plans, goals, orders and evaluations (ISO, 2005).

Sepucha *et al.*, (2004) observed that successful implementation of electronic health records is more than shifting from paper to digital records. Electronic systems can provide clinicians with real-time information, which can lead to improved clinical decisions through reminders, alerts, and other just-in-time references. In addition, studies have shown that along with the improvement in quality, efficiency, and effectiveness, many medication errors, which are the most common cause of preventable injuries in

hospitals, can be prevented by such EHR systems (Torda, Han, Scholle, 2010; Poon, Blumenthal, Jaggi, Honour, Bates & Kaushal, 2004).

Electronic Medical Record (EMR) systems are increasingly being adopted in Kenya to improve medical records management, health program management and the quality of patient care. It is however worthy to note that the development and implementation of EMRs has not been properly coordinated, resulting in multiple EMRs with varying objectives and functionality and with no ability to share patient information with other systems, programs and the Government, Standard & Guidelines for EMRs in Kenya (GoK, 2010). Similarly, Kabarak University Health Centre uses an EMR in their daily activities and the Mobile Phone Based Clinical Summaries model shall be integrated with it to enable real-time dissemination and sharing of patient health information hence actualizing the HIS Policy of 2009.

2.4 Parameters that Compose a Clinical Summary

As observed by Lukoshek *et al.* (2003) after visit summaries enhances the ability of patients to remember, and, if necessary, convey to family members, the content of interactions with their care team. In addition, it supports greater patient engagement in making good choices about healthy behaviours and the self-management of chronic conditions, which is essential to improving clinical and patient-oriented quality outcomes (Coulter, 2012).

Hummel *et al.* (2012) note that, there are five steps that leads to a successful delivery of reliable and valid after visit summaries. They include: the huddle, pre-visit summary, rooming the patient, the visit and the production of the after visit summary.

Bodenheimer (2007) states that the purpose of the huddle is to mentally prepare the clinical team, synchronize staff expectations, and assemble the information and equipment needed for the visit. This step of mental preparation for each patient on the day's schedule is designed to improve the team's efficiency in making clinical decisions during the limited time the patient is in the clinic. Further, Murray *et al.* (2003) note that the huddle should result in the following three action items: decisions to assemble information and resources prior to patient's arrival, decisions to close quality gaps in a patient's overall care and contingency planning strategies for same day access. This enables the patients to think about their medications in advance hence, reducing the time and effort spent by the records officer and pharmacist updating the medication list.

The purpose of the pre visit summary step is to engage and activate patients in thinking about specific details of their health information, ensure accurate current information by showing the patient the EHR record of recommended health maintenance issues and have the patient identify gaps, and reduce the time required to update patient charts prior to their seeing the provider Beard (2012), Keshavjee (2008) and Krist (2011) as quoted by Hummel *et al.* (2012).

Coleman *et al.* (2010), note that the complexity of clinical practice has increased dramatically in recent years, with patients having more chronic illnesses, taking more medications, health care staff being required to work in more complex teams and requiring more information for providers to make informed clinical decisions and hence the need of rooming the patient. Thus, the purpose of rooming the patient is to enable the health care staff get basic information before meeting the provider. The second purpose of this step is to gather as much information as possible for the visit and enter it correctly into the EHR before the provider and patient use that information to make clinical

decisions. The scope of information that needs to be gathered for the provider-patient interaction to be productive will vary according to the patient's needs. The basic information includes vital symptoms, smoking history, allergies, and medications.

The visit ensures that the AVS is as accurate and complete at the end of the visit by engaging patients in their care, empowering support staff to be active members in the care team, and leveraging the technology (Christiansen, 2008). The goal for the visit should be for the provider to fill in as much of the information from the examination as possible during an encounter and to complete the chart note in the exam room. This is preferable to waiting until the visit is over and the patient has left at which point reconstructing a prior thought process usually takes the provider an order of magnitude more time than it does to complete the same task in the room (Hummel *et al.*, 2012).

The final step in this process is availing the AVS report to the patient either in hardcopy or electronic form. This enables the patient easy access to a record of what happened in the office visit for later reference and, or share with a family member, or to take to an encounter with a different provider (Hummel *et al.*, 2012).

2.5 Clinical Summaries in Health Care

According to HIS policy framework (GoK, 2009), the current health information systems in Kenya are designed and implemented with no or limited participation of those who are to ultimately operate them and there is inadequate involvement of those who are to use the information generated by the systems. In addition, existing HISs are highly fragmented with no linkages with other healthcare providers at various levels. This is because the design and implementation of the HISs does not facilitate integration of different sources of health information within the health system. Further, poor integration of vertical programs and administrative information into the routine HIS has resulted to

lack of sharing of information among health care providers in the health system. Meaningful improvements can only be achieved as a result of provision of integrated information generated and used by all health care providers in Kenya.

Therefore, to offset the aforementioned challenges spelt out in the HIS policy of 2009 and which are also inherent in the Kabarak University EMR, the conceptualized Mobile Phone Based Clinical Summaries model (Figure 5.7) interfaces with the EMR enabling real time interaction of the patients and the health care providers and hence acting as a good tool for monitoring and evaluation of patient's health status before and after visiting the health facility.

2.5.1 Roles and Responsibilities of Health Care Providers

The summary of the roles and responsibilities of various health care providers at Kabarak Health Centre is as shown in Table 2.2.

Table 2.2: Roles and Responsibilities of Health Care Providers in Kabarak University Health Centre

Health care Provider	Role/Responsibilities
Receptionist	<ul style="list-style-type: none"> • Receives and records patient's details • Directs the patients to the nurse
Nurse	<ul style="list-style-type: none"> • Takes and records the patient's vitals. • Sends the patient to the clinician for assessment. • Does minor procedures such as dressing, removal of stitches and administration of drugs
Clinical Officer/Doctor	Assesses the patient's condition and gives appropriate plan for treatment
Laboratory Technician/Technologist	Does laboratory tests and give accurate results
Physiotherapist	Plans and carries therapy in the care of patient
Pharmacist	Dispensing of prescriptions and other drugs
Cashier	Billing services

Source: (Kabarak University, 2015)

From Table 2.2 it can be seen that the receptionists not only receives and directs patients to the nurse but also records patients' details. To allow for segregation of duties the responsibility of recording patient details should specifically be performed by a records officer. However, a record officer does not exist in this establishment of Kabarak Health centre. Therefore to bridge this gap the designed Mobile Phone Based Clinical Summaries model ensures that roles and privileges are assigned to the right care provider and clinical assistants as per their specific field of professionalism.

2.5.2 Provision of Reports/Feedback to Health Care System Stakeholders

A notable challenge with the Kenyan HISs is lack of feedback to information providers and users. In the event that the feedback is eventually received, it inevitably comes too late to impact on decisions. Thus to address the aforementioned gaps, the HIS policy formulated by the Ministry of Health sought to ensure that: all activities shall be reported in line with the existing regulations which will be updated from time to time by the HIS; streamlined ethics of reporting health information within and across levels of health administration in the country; enforcement of mandatory reporting by all health care providers; putting in place administrative guidelines for mandatory standard reporting of health and health related data and information to a central authority. Such guidelines shall spell out:- responsibilities and reporting mechanisms and schedules to be applied to all data, type and content of data to be collected and reported by all health care providers in Kenya, a minimum set of indicators to be reported and formats for reporting them to enable data to be submitted to higher levels, mechanisms for reporting and feedback at all levels and establishing feedback mechanism at all levels; regular submission of reports to the next level of service who shall observe timely feedback to submitting facilities or levels; mandatory requirement to report and give feedback on health information by all and alignment of multiple stakeholders towards a common reporting

mechanism and objective (GoK, 2009). To this end, the clinical summaries model developed as conceptualised in Figure 5.7 shall provide real time and relevant information to the health care providers as compared to the existing EMR which provide aggregate statistical information only relevant to the policy makers in government.

2.5.3 Protocols Governing Collection, Storage and Dissemination of Health Data

Healthcare industries are intensely promoting and adopting ICT to improve healthcare during this era of globalization and information age. However, as more patients and healthcare consumers seek and prioritize quality in their lives through enhanced healthcare treatments and services, greater demands are placed on the healthcare industry's information handling abilities and infrastructure (Bodenheimer, 1999). Ragam (2007) asserted that successful ICT adoption will lessen errors considerably, if not totally eliminate them.

However, there exist various challenges that inhibit countries globally from realizing efficiency in the delivery of health services through ICTs. These include privacy and confidentiality concerns and lack of commonly defined and consistently implemented standards. It is noted that because of the sensitivity of patient health information, and the generalized uncertainty on how existing legal frameworks apply to health ICT systems, privacy constitutes the most significant barrier to the widespread implementation of ICT. Many physicians hold the view that sharing identifiable patient data among different providers in a network raises the question of who should be allowed access to the file and how such access should be regulated (OECD, 2010).

According to OECD (2010), healthcare providers struggle with inconsistent medical terminology, clinical records and data storage, in addition to multiplicity of schemes introduced to facilitate interconnection and communication between specific ICT

systems. Thus, the absence of agreed industry-wide standards and compliance with existing rules, providers investing in technological infrastructure face high risk of failure and poor returns. Interoperability is also dependent on the adoption of common standards and compliance with them.

2.5.3.1 Privacy, Confidentiality and Security of Electronic Health Records

Warren and Brandeis (1890) as quoted by Harman *et al.* (2012) defined privacy as the right “to be let alone”. It is the right of the individual to keep information about them from being disclosed to others; the claim of individuals to be let alone, from surveillance or interference from other individuals, organizations or the government (Rognehaugh, 1999). Thus, the information that is shared as a result of clinical relationship is considered confidential and must be protected (Harman, 2006).

OECD (2010) observed that during the process of patient treatment, a patient’s health information is accessed by different health care providers and thus during the design of an application the main challenge is how to create a smooth interface between privacy and confidentiality and security requirements for defining access to and use of personal health information. Subsequently, article 9 of the UNESCO Universal Declaration on Bioethics and Human Rights states:

“The privacy of the persons concerned and the confidentiality of their personal information must be respected. To the greatest extent possible, such information should not be used or disclosed for purposes other than those for which it was collected or consented to, consistent with international law, in particular international human rights law.”

And as such, data collection that fails to conform to the aforementioned standard should not be used for a program activity (UNESCO, 2005). Hence, the developed model as conceptualized in Figure 5.7 ensures patient privacy and confidentiality by generating and presenting clinical summaries from privilege-based templates ensuring that every provider only views allowed summaries with only relevant parameters.

2.5.3.2 Laboratory Protocols

The purpose of a laboratory within a health system is to provide information that is critical for evidence-based decision making to guide laboratory technicians in health care interventions. The role of laboratory technicians include; provision of quality and timely test results, analysis of laboratory data and provision of reports, following quality policies and procedures applicable to all tasks performed, providing advice on relevant samples and pre-test information to patients and interpreting test results as appropriate. However, quality laboratory services in Kenya have been hampered by lack of laboratory documentation, monitoring and evaluation systems (Ministry & Ministry, 2011). The developed model as conceptualised in Figure 5.7 offsets the aforementioned challenges by ensuring that the laboratory technicians can reliably and in real time review and update patient test results through clinical summaries in their provided smart phones thus ensuring traceability of any laboratory transaction.

In order to produce and maintain quality test results in the execution of their responsibilities, laboratory technicians in Kenya are guided by internal quality controls (IQC), external quality assessment (EQA), standard operating procedures (SOPs) and appropriate ISO standards (Ministry & Ministry, 2011). Hence, this implies that laboratory staffs are required to maintain confidentiality while handling patient information.

2.5.3.3 Health Data Ownership in Kenya

According to the HIS Policy (GoK, 2009), records (documents or disks) are unequivocally the property of the practitioner or institution, the data is not capable of being owned, and many different people have an interest in it, including the person to who it relates. Hence, it is postulated that the HIS policy will be enforced to ensure that: all the health and health related data and information shall belong to the Government of Kenya; GoK shall grant right to access health and health related data and information through defined protocols; personal data as inpatient records are in reality the property of the facility and are held in trust on behalf of the patients, all patients shall have access to information contained in their health records upon request or whenever it is considered to be of benefit to the patient; health workers who have privileged access to patient records shall be accountable to maintain the highest level of confidentiality and ensure that shared confidentiality is practiced in the interest of the patient; the MOH is responsible for ensuring that data and information required for defined global surveillance systems is collected in compatible formats and submitted to relevant authorities in time (GoK, 2010).

2.5.3.4 Data Formats Standards

The implementation of EMRs is a complex process because it covers the various subsections of the health sector namely clinical, pharmaceutical, laboratory and hence the need to develop standards governing system functions and the promotion of information sharing between systems. The most important feature of an EMR is its ability to share information between different users at the HIS enterprise architecture and at the clinical level (GoK, 2010).

Globally, ISO standards, HL7 standards, International Classification of diseases (ICD-10), LOINC and SNOMED govern the development and use of electronic health systems. Kenya Bureau of Standards (KeBs) is mandated with the development and adoption of standards in Kenya and has been domesticating the ISO Health Informatics Standards developed by ISO TC 215 (ISO Catalogue, 2005).

Therefore interoperability is vital to facilitate seamless exchange of information between the EHR's subsystems. This is because the exchange of information between the subsystems can result in increased efficiency through decreased entry of duplicate data, decreased errors in medical information and increased availability of the health information. This will promote better clinical decision making and improved continuity of patient care. Therefore, the implementation of clinical data standards ensures that data in an EMR system are available and meaningful in the related subsystems (GoK, 2010). Table 2.3 illustrates some of the recommended international standards/protocols used for transmission of patient level data.

Table 2.3: Standards that Govern Transmission of Patient Level Data

S/N	Standard	Meaning
1.	HL7	A flexible standard by which various health care systems can communicate with each other and is used for transmission of patient level data.
2.	Quality Reporting Document Architecture (QRDA)	Developed on the HL7 Clinical Document Architecture model.
3.	Statistical Data and Metadata Exchange (SDMX-HD)	A data exchange format developed by WHO, based on ISO SDMX reporting standard. It facilitates exchange of indicator definitions and data in aggregate data systems.

Source: (GoK, 2010).

Thus, the study adopted the SDMX-HD standard in modelling the Mobile Phone Based Clinical Summaries given that the model developed was required to fetch information from the Kabarak University Health Centre EMR. This is as illustrated in Figure 5.7.

2.5.3.5 Health Care Information Exchange and Interoperability Taxonomy

The Centre for Information Technology Leadership (CITL) developed a four level taxonomy based on three factors in data exchange namely: amount of human involvement, the sophistication of the ICT and the adoption of standards OECD (2010). Most typical health care entities are communicating at levels 1 and 2 hence limiting the opportunities for reducing error rate or cutting cost. Walker *et al.*(2005) as quoted by (OECD, 2010) made prediction to the effect that connectivity and effective HIS between providers and labs would provide reduction of redundant tests, in addition to reducing delays and costs associated with paper based ordering of tests and reporting of results. Table 2.4 shows the four level taxonomy with the attributes and examples of each level.

Table 2.4: Health Care Information Exchange and Interoperability Taxonomy

Level	Attributes/Characteristics	Example
4	<ul style="list-style-type: none"> • Machine-interpretable data: transmission of structured messages containing standardized and coded data—the ideal situation in which all systems exchange information using same formats and vocabularies • All systems exchange data using the same messaging, format and content standard, removing the need for multiple customized interfaces. • All content can be extracted and converted electronically in each field and no longer require human intervention. 	<p>Automated exchange of coded results from an external lab into a provider’s EMR, Automated exchange of a patient’s “problem list”.</p>
3	<ul style="list-style-type: none"> • Machine-organisable data: transmission of structured messages containing non-standardized data. • Requires multiple interfaces that can translate incoming data from each of the sending organisations vocabulary to receiving organisation’s vocabulary; usually results in imperfect translation because the vocabularies used have incompatible level of details. • Data content is indexed down to single fields; human translation is required to convert actual data in each field from vocabulary of sending organisation to that of the receiving organisation. 	<p>Secure-email of free text, HL-7 messages, PC-based exchange of files in incompatible/proprietary file formats</p>
2	<ul style="list-style-type: none"> • Machine transportable data: Involves transmission of non-standard information via basic ICT-Information within the document cannot be electronically manipulated. • Clinicians can access the information, but no computerised data processing or logic can be applied. 	<p>PC-based exchange of scanned documents, pictures, pdf</p>
1	<ul style="list-style-type: none"> • Non-electronic data: does not encompass use of ICT to share information but manual process for sharing information via writing or orally. • Human facilitation is exclusively relied upon to aggregate, review and abstract data from data sources. 	<p>Postal mail, phone</p>

Source: (OECD, 2010)

2.6 Challenges on Implementation of ICT in Health and Stakeholder Participation

According to WHO, the application of ICT in health is not just about technology, but can be a means to realization of the following outcomes: health workers making better treatment decisions, hospitals providing higher quality and safer care, governments becoming more responsive to health needs, national and local information systems supporting the development of effective, efficient and equitable health systems, and people having better access to the information and knowledge they need for better health hence making informed choices about their own health (Dzenowagis, 2005).

However, Chetley *et al.* (2006) note that the successful implementation of ICT and health programmes requires complex balancing of competing views and concerns of different stakeholders. For example, health policy makers would need to be convinced that initial investments in the new technology will yield the benefits promised while clinicians will view new technology with suspicion, fearing its challenge to their professional autonomy and status. On the other hand, patients are concerned about security and confidentiality of any of their electronically held health data. In addition, Kahn *et al.* (2010) observed that health system performance in developing countries is constrained by many factors including limited infrastructure, disease burden and shortage of health workers. According to Scheffler *et al.* (2009) the shortage of health care workers in Africa is estimated at 800,000 and that it is difficult to recruit and retain such workers especially in rural areas. Further, in order to provide adequate coverage with primary care interventions and achieve Millennium Development Goals, it is recommended that provider to people ratio be at least 1:400 (WHO, 2006). Conversely, the Kenyan ratio stands at 1:5000 (WHO & OECD, 2011).

2.6.1 Recording, Storage and Communication of Patient Information

According to OECD (2010), the most recognised source of inefficiency in health care system is the fragmentation of the care delivery process and the poor transfer of information. The centrality of information in health systems and the diversity of uses to which it can be put imply that ICTs that ensure the timely and accurate collection and exchange of health data are likely to foster better care co-ordination, and more efficient use of resources (OECD, 2010). Subsequently, the developed Mobile Phone Based Clinical Summaries model as conceptualized in Figure 5.7 automates the manual process of generation and presentation of clinical summaries ensuring that patient level information captured and stored in the centralized Kabarak University Health Centre EMR is availed to healthcare providers and patients reliably, timely and accurately.

2.7 A Review of the Requirements for the Design of Mobile Clinical Summaries Model

The study reviewed the use of paper-based and mobile phone technology in health care settings in order to compare the pros and cons of each approach.

2.7.1 Paper-Based Systems

Raymond and Dold (2002) as quoted by Burton *et al.* (2004) observed that paper-based systems supporting clinical care are limited as information storage and retrieval systems and have high rates of failure in retrieval and illegibility; that human memory-based medicine is increasingly unreliable; that the capture of clinical data has become necessary for billing, appointment scheduling, prescription refills, and results reporting; and that consumers' expectations for improved care and service are rising. But on the other hand, Burton *et al.* (2004) stated that lack of a common format or standard for recording clinical information, patients' concerns about information sharing and possible loss of privacy, physicians' concerns about legal liability, no demonstrated clinical and/or

financial benefits for ambulatory care, physicians participating in shared information systems and the high costs of implementation and maintenance are the five major barriers to the wide spread adoption of EHRs hence impeding clinicians ability to share information about patients easily and effectively.

2.7.2 Mobile Technology

Reliable information and effective communication are crucial elements in public health services and hence the use of appropriate technologies can increase the quality and reach of information and communication (World Bank, 2006). Frenzel and Frenzel (2003) defined ICTs as tools that facilitate communication, processing and transmission of information and the sharing of knowledge by electronic means. According to WHO (2004) as quoted by Zakaria *et al.* (2010) technologies form the backbone of services to prevent, diagnose and treat illness and diseases. ICTs are only one category of the vast array of technologies that can be powerful in the hands of those working to improve health. Information Technologies includes manual and computerized data systems, medical records, clinical and administrative documentation, communication resources, fax machines, telephone, e-mail, the internet, handheld computers and portable digital assistants (PDAs), electronic medical records and smart cards.

Zakaria *et al.* (2010) observed that the methods people use to communicate with each other have changed significantly. Thus mobile telephony, electronic mail and videoconferencing, twitter, whatsapp, facebook have provided new platforms for people to share voice information and visual images globally and in real time.

The use of appropriate technologies can increase the quality and the reach of both information and communication leading to the creation of a knowledge base which enables people to produce their own health data. In addition, social organizations assist

people to achieve health through health care systems and public health processes. Hence, the ability of impoverished communities to access services, engage with and demand a health sector that responds to their priorities and needs, is influenced by wider information and communication processes, mediated by ICTs (Zakaria *et al.*, 2010).

Moreover, the emergence of mobile and wireless applications that allow remote submission of data to a shared record provide new possibilities for patient monitoring and real time decision support. Additionally, electronic records may help to promote partnership between carers and health professionals through sharing information (Pagliari *et al.*, 2007). In Kenya, a total of 37.8 million mobile subscribers were registered by the end of first quarter of the 2015/2016 financial year. During the period, mobile penetration stood at 88.1% up from 78% during the previous period (CAK, 2016). This implies that a majority of Kenyans have access to information through mobile telephony.

However, Chetley *et al.* (2006) point out that health workers involved in primary health care in developing countries are often isolated, work in remote settings, mostly alone and have little or no access to up to date information and opportunities to exchange experience with colleagues. This can be bridged by adoption of mobile technologies in the dissemination of healthcare information between the providers and the patients. Kahn *et al.* (2010), note that mobile phones, tablets and other mobile devices provide portable computing and connectivity in places where traditionally there would have been none. In addition to enabling rapid collection of patient data at the point of care, these devices could also address the logistics of generating, distributing, and monitoring paper summaries for the hundreds of thousands of patients dispersed across rural areas (Noormohammad *et al.*, 2010).

2.7.2.1 Types of Mobile Devices

The various types of mobile devices which can be adopted in the implementation of EHR include: Personal Digital Assistant (PDA), Basic Phone, Feature Phone and Smart Phone. The type of phone chosen will be determined by cost and the type of medical application to be implemented.

- **PDA**

Lu *et al.* (2005) state that most care providers found PDAs to be functional and useful in areas of documentation, medical reference, and access to patient data. Major barriers to adoption were identified as usability, security concerns, and lack of technical and organizational support. In Ghana, Kenya and Uganda AED-Satellite (www.satellite.org) has been building experience around the use of PDAs to enable health workers in remote settings to gain access to information, capture, store and share important health data and link to the experience of other providers (Chetley *et al.*, 2006).

- **Basic Phone**

The strength of these platforms is the wide availability of SMS service and their low cost. But SMS is unreliable and expensive as a transport mechanism and is impractical for transferring large amounts of data needed to deliver clinical summaries (www.vodacom.co.tz).

- **Feature Phone**

Feature phones add more programmability to basic phones and are typically built on Java Platform, Micro Edition (J2ME). They have small screens, slow processors and inadequate memory, and thus cannot handle large amounts of data.

- **Smart Phone**

Smart phones are mobile phones with features such as built-in cameras, GPS, and touch screens. Unlike their predecessors, smart phones are equipped with powerful operating systems, large amounts of memory, fast network connectivity, processors that approach the speed of laptop computers, and, fortunately, prices that continue to fall.

2.7.3 Functional Characteristics of a Basic and Fully Functional EHR System

According to DesRoches *et al.* (2008), an EHR has four domains and each domain has different number of functions which qualifies an EHR system as either basic or fully functional. This is as illustrated in Table 2.5.

Table 2.5: Functional Characteristics of a Basic and Fully Functional EHR System

S/N	Functions	Number of functions	Nature of functions	
			Basic system	Fully functional system
1	Health Information and data	Five		
	Patient demographics		×	×
	Patient problem lists		×	×
	Electronic lists of medication taken by patients		×	×
	Clinical notes		×	×
	Notes including medical history and follow up			×
2	Order- entry management	Five		
	Orders for prescription		×	×
	Orders for laboratory tests			×
	Orders for radiology tests			×
	Prescription sent electronically			×
	Orders sent electronically			×
3	Results management	Three		
	Viewing laboratory results			×
	Viewing imaging results		×	×
	Electronic images returned		×	×
4	Clinical decision support	Three		
	Warnings of drug interactions or contraindications provided			×
	Out of range test levels highlighted			×
	Reminders regarding guideline-based interventions or screening			×

Source: (DesRosches *et al.*, 2008).

2.7.4 Benefits of Electronic Health Records and the Mobile Clinical Summaries System.

According to Zakaria *et al.* (2010), the beneficiaries in the of adoption of ICTs in health range from individual and collective group of patients and health care providers through to national and international policy makers. In addition, they observed that ICTs can enable the extension of access to health care from urban to rural areas, helping to connect people to advice and information. This encompasses people being able to access their own health care information, and health care workers who are in the more remote settings being able to link with colleagues who have access to better facilities and information sources to get advice and support.

Thus, since the designed model shall utilise the existing mobile telephony infrastructure in Kenya as provided by telecommunication companies such as Orange, Airtel and Safaricom, it is envisioned that it shall enable providers have access to patient state of care irrespective of the geographical topography and time zones when interacting with the facility's EMR.

2.8 Chapter Summary

This chapter identified and described in detail the theoretical framework the study was based on. It discussed various themes in line with the objectives of the study including health information technology, electronic health records; parameters that compose a clinical summary; clinical summaries in health care, roles and responsibilities of health care providers, provision of reports/feedback to health care system stakeholders, protocols governing collection, storage and dissemination of health data; challenges on implementation of ICT in health and stakeholder participation, recording, storage and communication of patient information; analysis of requirements for the design of the Mobile Phone Based Clinical Summaries model, paper-based systems, mobile

technology, functional characteristics of a basic and fully functional EHR systems and benefits of electronic health records and the mobile clinical summaries system.

The reviewed literature indicates considerable efforts have been undertaken by organisations, governments and institutions to enhance the use of clinical summaries in patient care and adoption of electronic systems in offering health care. However, the review evidences that the literature available in this area mainly focus on the developed world. This can be attributed to the fact that the health space is a rapidly changing field, ICTs are still being absorbed into different fields in the developing world at different rates, and that resources to implement the enabling infrastructures are limited.

Although studies have been undertaken on importance of clinical summaries in healthcare and the importance of ICT adoptions in social welfare, they fail to appreciate the application of mobile technology in provision of clinical summaries especially in low resource settings. This study thus offers empirical evidence on the impacts of application of ICTs in generation and use of clinical summaries.

The review on the parameters that compose a clinical summary revealed that there are five stages wherein the patient and the health care provider interact which include: the huddle, pre-visit summary, rooming the patient, the visit and the production of the after visit summary. It is through the interactions at the specified stages, that the providers are able to get various patient information like vital signs and medical health condition of the patient.

It was established that HISs in Kenya do not provide relevant information and timely feedback to the major stakeholders who are the health care providers and patients albeit due to their lack/limited involvement during design and implementation of the systems.

Additionally, HISs in Kenya do not allow for sharing of patient level information mainly contained in clinical summaries among care providers due to poor vertical and horizontal integration, absence of agreed industry-wide standards that enables recording of clinical information, interconnection and communication between specific ICT health systems. Further, patients are concerned about the privacy of their information while health care providers ponder about legal liabilities in case of breach of confidentiality.

This study addresses the aforementioned challenges/gaps, designing and developing a Mobile Phone Based Clinical Summaries model as informed by Systems Theory. The model integrates with the Kabarak University Health Centre EMR via REST and standardised by WHO's SDMX-HD and enables horizontal sharing of information between providers and providers and between providers and patients. This horizontal integration function is not provided by the existing HIS hence leading only to generation of aggregate statistics consumable vertically. In addition, privacy, confidentiality and security of patient information in the model are enforced through apportioning of appropriate permissions as per user roles and responsibilities in Kabarak University Health Centre and as per relevant professional medical protocols.

The next chapter deals with the research methodology used in the study, describing how the research was carried out.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter presents the research design and methodology employed in the study. It describes research design, research study site, target population, sample size and sampling techniques, data collection instruments, validity and reliability of research instruments, data collection procedures, data analysis and presentation methods as well as ethical considerations employed in the research.

3.1 Research Design

Research design is the plan and structure of investigation used to obtain evidence and answer research objectives, Mugenda (2003). Further, Robson (2002) posits that research design is the general plan of how research questions will be answered; it encompasses research approach and strategy. Thus, the study adopted a mixed method research approach. Qualitative research design, techniques and measures do not produce numerical data while quantitative approach produces numerical or quantifiable data (Mugenda and Mugenda, 1999). The qualitative study data sought included: activities performed by providers at the specified stages of care; the importance of clinical summaries in improving health care provision in Kabarak University; protocols that govern the collection, storage and use of patient information contained in clinical summaries; how health centre system aggregates the patient information and the challenges with the current system of recording clinical summaries at the public and the private sections of the University's Health Centre. On the other hand, the quantitative data targeted were: the specific parameters that compose a clinical summary; the kind of patient information contained in the clinical summary; kind of tests received by laboratory technicians from providers, respective test results generated and the recipients of the generated test results;

the kind of information recorded by Records Officers in an episode of care; patient vital signs recorded by nurses during previous and current visits; after visit information given to a patient; formats used by the providers when interacting with patients and amongst themselves; promptness of provision of patient information and their level of satisfactions and the requirements needed to design and develop the Mobile Phone Based Clinical Summaries model.

Further, the study used the case study research method. A case study is an analysis of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods and within their real-life context (Thomas, 2011).

Moore (1983) states that “Case studies are useful for two purposes; first, they reduce the scale of the research by focusing on a smaller number of units than would otherwise be involved. Secondly by reducing the area to be studied, case studies increase the range of different units within the study. They are used when the researcher is attempting to understand complex organizational problems, or diffuse causes and effects of change”. Informed by the intensive observations and investigation of particular settings, the researcher employed the case study method in order to answer the research questions satisfactorily.

3.2 Study Area

The study was carried out at Kabarak University and the focus was a case of University Health Centre as described in section 1.1.3. The health facility is located in Nakuru County in Kenya.

3.3 Study Population

The population of the study included respondents falling into three main categories: health care providers, informaticians and patients. This is because the health care providers are the main generators and consumers of clinical information in a health care environment; informaticians manage health information while patients are the recipients of health information as contained in clinical summaries. This was in line with Castillo (2009) who noted that a target population is a precise group of people or objects that have the characteristics questioned in the study. Hence, the health care providers' included doctors, clinical officers, nurses, records officers, laboratory technicians and pharmacists. The researcher targeted patients who had at least one previous visit to the health centre given that they have an existing medical history at Kabarak University Health Centre. The population of this target category of patients as provided in terms of monthly patient loads for the four month University trimester period preceding the research is as illustrated in **Appendix XIV** where the average patient load was fifty eight (58). The study thus targeted a total population of eighty two (82) comprising of twenty three (23) health care providers, one (1) informatician and fifty eight (58) patients as specified in Table 3.1.

Table 3.1: Target Population

Category	Target Population
Doctor	2
Clinical Officer	3
Nurse	10
Pharmacist	3
Laboratory Technician	2
Records Personnel	3
Patients	58
Informatician	1
TOTAL	82

Source: (Research Data, 2016)

3.4 Sampling Procedure

Since the study targeted three main groups of population as described in section 3.3, it implied that there had to be three samples drawn from each of the three groups. And this is in agreement with Kothari (2004), who observed that it may not be practical to study all elements in a population.

3.4.1 Sampling Methods and Sample Size

In a case study research, an average case will not be the richest in information. It is therefore useful to use information-oriented sampling. Purposive sampling where subjects are chosen due to some known characteristics or because of the researcher's in-depth local knowledge is the best option for a case study research, Fenno (1986). The researcher thus used purposive sampling to select the study area - Kabarak University Health Centre.

The study then used stratified random sampling to select respondents within the study area to whom research instruments were administered. A stratified sample is a mini-reproduction of the population. Prior to sampling, the population is divided into strata based on characteristics of importance for the research. In the study, the strata were doctors, clinical officers, nurses, laboratory technicians, pharmacists, records officers, patients and informaticians.

Further Krejcie and Morgan (1970) observed that if a population has 10 or less respondents then the entire population should be sampled (**Appendix XVI**). Hence in the study, the researcher sampled all the targeted healthcare providers in each of their specific professional areas and the targeted informatician (Table 3.1). Patient respondents were first randomly sampled according to availability and willingness to participate in the research and further the patients who had been in the clinic at least once were

purposively selected owing to their ability to provide their medication history at the study area. Thus, the researcher sampled 10 patients. Therefore a total of thirty four (34) respondents were sampled as shown in Table 3.2.

Table 3.2: Sample Size

Stratum	Sample Size
Doctor	2
Clinical Officer	3
Nurse	10
Pharmacist	3
Laboratory Technician	2
Records Personnel	3
Patients	10
Informatician	1
TOTAL	34

Source: (Research Data, 2016)

3.5 Data Collection Instruments

A research instrument is a device/tool used to collect and measure data during research. Research instruments include but not limited to: questionnaires, interviews, observations and documentary analysis. The researcher collected data from primary sources using interview schedules and questionnaires. Further in the study the researcher employed documentary reviews to gather secondary data. This approach yielded both quantitative and qualitative data from the sampled case respondents specified in Table 3.2.

3.5.1 Questionnaires

A questionnaire is a data collection tool in which a researcher formulates a set of questions to be answered by selected respondents in a study. A questionnaire as a

research tool is mostly in the hands of the respondents, and is completed by them at their convenient time/place and returns them to the researcher (BMRA, 2003).

In the study, the researcher administered different types of semi structured questionnaires to different categories of respondents (**Appendices III, V, VI, VII, VIII, IX and XI**) and their design was guided by the aim, objectives and research questions of the study and the literature reviewed by the study. Questionnaires were administered to patients owing to their uncontrolled availability at the study area. The researcher structured the questionnaires with both open-ended questions to allow the respondent express him/herself openly and closed ended questions to conserve time and motivate the respondent to respond to the questionnaire. Closed ended questions in the questionnaires captured objectives one and three of the study which were parameters that compose a clinical summary and challenges with the current system of recording clinical summaries at the Health Centre respectively. Whereas, open ended questions addressed objectives one, two (assess providers' and patients' view and use of clinical summaries) and three of the study.

3.5.2 Interview Schedules

Interviews are particularly useful for getting the story behind a participant's experiences. The interviewer can pursue in-depth information around a topic (McNamara, 2009). Mugenda and Mugenda (1999) notes that an interview is an oral administration of a questionnaire to a respondent in a face-to-face episode. In semi-structured interviews, the interviewer asks a set of standard, predetermined questions about a topic and the respondent answers in their own words, McNamara (2009). In the study, semi-structured interviews were employed to corroborate data collected through the questionnaires. Interview (**Appendix IV**) was administered to the doctor in charge of Kabarak

University Health Centre within the stratified sample of health care providers while interview (**Appendix XIII**) was administered to the informatician in charge of the Kabarak University Health Centre EMR.

3.5.3 Documentary Review

Document analysis and review is a way of collecting data by reviewing existing documents (CDC, 2009). According to Tearle (2003), documentary evidence is employed in research to provide supportive and exploratory means of collecting and interpreting data. Thus, documents informing the study were reviewed to obtain knowledge in the domain of clinical summaries and the roles and responsibilities of Health care providers at Kabarak University Health Centre in relation to the stipulated national/international roles. The researcher reviewed existing medical protocols, Revised Scheme of Service for Health Records and Information Management Personnel (GoK, 2012), Kenya HIS Policy (GoK, 2009), Standard and Guidelines for Electronic Medical Systems in Kenya (GoK, 2010) and procedures employed at Kabarak University Health Centre in provision of healthcare, to generate and share clinical summaries within its environment (Kabarak University, 2015). Thus, the data from the documentary evidence was used to identify issues to follow-up during interviews and for triangulation with the questionnaire and interview data. This was done strictly in adherence to professional ethics within the field and within protocols of the industry.

Further, **Appendix XIV** is an illustration of the reviewed average monthly patient loads at Kabarak University Health Centre showing first time versus continuing patients for the last four months trimester period.

3.6 Data Collection Procedures

The study being in the health care industry where data confidentiality, privacy and security are paramount factors, the researcher employed procedures necessary for the study to be a success. A study abstract and letter of introduction (**Appendix I**) from Moi University were used to obtain permission to conduct the study. Further, the researcher made a formal request to the management of Kabarak University and was granted (**Appendix II**) permission to conduct the study. These tools also introduced the researcher to the respondents. Appointments with respondents for administration of research instruments were sought and obtained in advance.

3.7 Reliability and Validity of the Research Instruments

According to Joppe (2000), "...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." (p. 1). The researcher ensured reliability by applying a consistent structure of questions in both questionnaires and interviews.

Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are (Shenton, 2004). Hence to ensure the validity of the research instruments, a pilot study involving a small group of respondents in the public section of the health centre (not included in the sample population) was conducted, the result of which were used to adjust the instruments accordingly. In addition, questionnaires were administered to patients in order to verify information given by providers. The researcher also sought the review of supervisors, other researchers and faculty in the School of Information Science to assess the validity of the research instruments.

3.8 Knowledge Modeling

Knowledge capture systems support process of eliciting explicit or tacit knowledge from people, artefacts, or organizational entities, (Becerra & Leidner, 2014). Knowledge modelling packages combinations of data or information into a reusable format for the purpose of preserving, improving, sharing, aggregating and processing knowledge to simulate intelligence. The fundamental goal of Knowledge Modelling is to bring methodologies and technologies together in an implementation neutral framework as a practical solution for maximizing the leverage of knowledge (Makhfi, 2007). Hence, the study sought inputs from domain experts (Table 3.2) in the field of health for the purpose of interpretation of medical protocols which were combined with ICT (mobile) technology to design and develop the clinical summaries model.

3.9 Data Analysis

Data analysis involves working with data, organizing them, breaking them into manageable units, synthesizing them, searching for patterns, discovering what is important and what is to be learned, and deciding what to tell others (Bogdan and Biklen, 1992 in Ohio State University (OSU, 1996)). Thus, the study employed qualitative and quantitative data analysis techniques to analyze data collected.

Qualitative data collected using interview schedules and open ended questions were analyzed thematically. The data encompassed parameters that compose a clinical summary, patients' and providers' views and use of clinical summaries and the challenges with the current system used in the provision of clinical summaries in Kabarak University Health Centre. Quantitative data collected using closed ended questions in the questionnaires was coded for analysis using SPSS v17 and Microsoft

Excel. These included parameters that make up clinical summaries and format used in the provision of summaries.

3.10 Ethical Considerations

The researcher sought consent from Kabarak University Health Centre and School of information Sciences to conduct research in the study area, (**Appendix I&II**). All target respondents were notified of the study intent and purpose and their individual consent sought before being incorporated into the study as respondents. All data recorded was anonymized to maintain privacy and confidentiality and the findings presented honestly without alterations as guided by the UNESCO (2005) declaration.

The study being in an industry where confidentiality and privacy are requirements, the researcher observed the highest standards of confidentiality.

3.11 Mobile Phone Based Clinical Summaries Model, Design and Development Methodology

The study adopted the Mobile Application Development Life Cycle (MADLC) methodology which consists of five phases namely; identification, design and development, prototyping, testing, deployment and maintenance phases (Vithani and Kumar, 2014) in the design and development of clinical summaries model mobile side application. Further, the study adopted Model Driven Software Development (MDSD) methodology which defines four stages namely; abstraction, tagging the model, separation of code, tagging the code (Stahl *et al.*, 2006) in designing and developing the interfacing REST API model for use by Kabarak University Health Care Providers.

3.12 Chapter Summary

The chapter discussed research design, location of the study, target and sample population, sampling procedures, data collection instruments, reliability and validity of research instruments and evaluation results, data analysis, ethical considerations and gave an overview of the Mobile Phone Based Clinical Summaries model, design and methodology. The next chapter details data analysis and interpretation.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.0 Chapter Overview

Data analysis is the process of bringing order, structure and meaning to the mass collected data (Marshall and Rossman, 2014). According to Hitchcock and Hughes (1995), it is the ways in which a researcher moves from a description of what is the case to the explanation of why what is the case is the case. In order to achieve its objectives, the study collected data from respondents in the study area. This chapter presents the study findings, interpretation and analysis of the collected data. The presentation is structured as per the study aim by organizing the data into categories based on type and strata of respondents as well as themes derived from the objectives.

Since the study employed mixed research approach, both qualitative and quantitative techniques were used in data analysis and presentation. Qualitative data analysis is the process of systematically searching and arranging collected data in order to increase the researchers own understanding of the data and to help the researcher in presenting what has been discovered to others (Bogdan and Biklen, 1992). Qualitative data was coded and analysed thematically. Themes were organized as per the study objectives into: parameters that compose a clinical summary, assessment of providers' and patients' use and views of clinical summaries and the challenges with the current system of recording clinical summaries at Kabarak University health centre.

Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across

groups of people or to explain a particular phenomenon (Muijs, 2010). Quantitative analytical approaches allow the reporting of summary results in numerical term to be given with a specified degree of confidence as descriptive statistics – mean, variance, frequencies and percentages. Quantitative data collected through questionnaires was coded for analysis in Statistical Package for Social Sciences (SPSS v17) and subjected to descriptive statistics to summarize and present results and emanating meanings. This chapter further presents data interpretation by applying descriptive narrative approach to the analysed data as per the study objectives.

4.1 Respondent's Designation

The respondents sampled for the study were care givers (providers), recipient of medical care (patients) or informatician. This is because the researcher sought to establish the views of the three categories of respondents in regards to the use of clinical summaries at Kabarak University Health Centre. The distributions of respondents are as shown in Table 4.1.

Table 4.1: Distribution of Respondents

Designation	Frequency	%(N=34)
Clinical Officer	3	8.8
Doctor	2	5.9
Informatician	1	2.9
Laboratory Technician	2	5.9
Nurse	10	29.4
Patient	10	29.4
Pharmacist	3	8.8
Records Officer	3	8.8
Total	34	100

Source: (Research Data: 2016)

4.2 Response Rate

Two interviews were conducted while a total of 32 questionnaires distributed to respondents and returned giving a response rate of 100% as shown in Table 4.2.

Table 4.2: Response Rate

Designation	Issued	Returned	Response Rate (%)
Clinical Officer	3	3	100
Doctor	2	2	100
Informatician	1	1	100
Laboratory Technician	2	2	100
Nurse	10	10	100
Patient	10	10	100
Pharmacist	3	3	100
Records Officer	3	3	100
Total	34	34	100

Source: (Research Data: 2016)

4.3 Parameters that Compose a Clinical Summary

Objective one of the study sought to determine the parameters that make up a clinical summary. The parameters are the functional requirements needed to design and develop the Mobile Phone Based Clinical Summaries model as per objective four of the study. Moreover, the parameters are dependent on the stage of medical care that providers handle the patients and the activities undertaken at the given stage. Hence in order to determine the necessary parameters, the researcher sought to establish the stages of medical care that a provider handles a patient and the activities performed at the given stages.

4.3.1 Stages of Medical Care that Provider Handle Patients

Each provider renders his/her service at a specific stage(s) of medical care as per their respective professional training. Figure 4.1 indicates the numbers of providers handling patients at each stage of medical care.

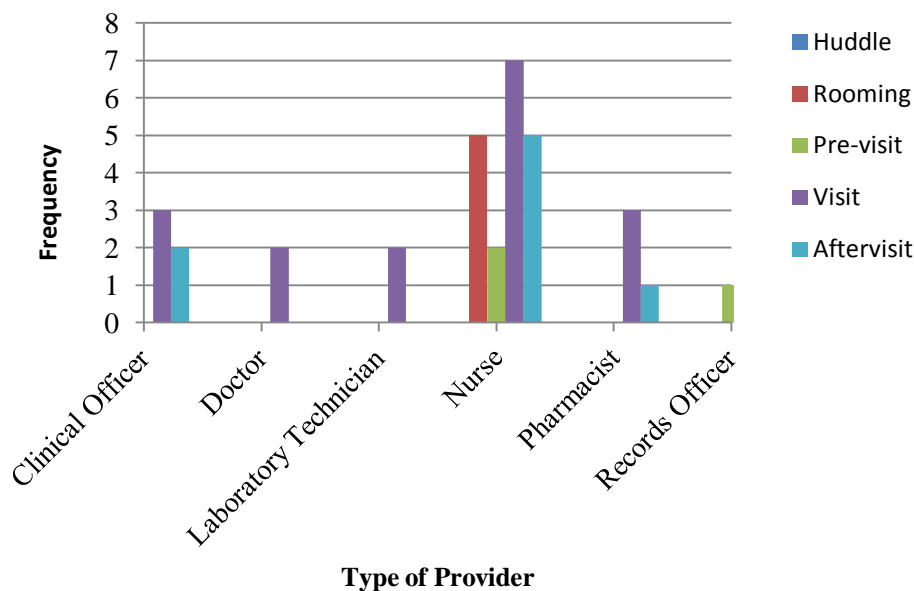


Figure 4.1: Distribution of Providers as per stage of Medical Care
Source: (Research Data: 2016)

As shown from Figure 4.1, 3 (100 %) and 2 (66%) of the clinical officers sampled handle patients at the visit and pre-visit stage of medical care respectively. 100%(2) of doctors and 100% (2) of the laboratory technicians only handle patients at the visit stage of medical care. On the other hand, nurses handle patients at four stages (80%) of the medical care. That is rooming (50%), pre-visit (20%), visit (70%) and after visit (50%) while pharmacist handles patients at two stages of medical care namely: the visit (100%) and 10% at the after visit. Finally, records officers handle patients at three stages of medical care namely: pre-visit (33%), visit (66%) and after-visit (33%). None (0%) of the providers handle patients at the huddle stage.

4.3.2 Activities Performed by the Providers at the Specified Stages of Medical Care

Having established the stages at which each of the respective providers participates in the provision of services to patients, the researcher then sought to determine the activities carried out at each stage by specific respondents. The activities carried out at each stage will influence the type of clinical summary generated and the parameters contained herewith. Table 4.3 is the set of activities carried out at each stage by the providers as guided by Figure 4.1.

Table 4.3: Activities Performed by the Providers at the Specified Stages of Medical-Care

Respondent	Stage	Activity
CO ₁	Visit	<ul style="list-style-type: none"> • <i>“History taking.”</i> • <i>“Laboratory Investigation.”</i> • <i>“Prescription of Medicine.”</i>
CO ₂	Visit, After visit	<ul style="list-style-type: none"> • <i>“Physical examination of Patient.”</i> • <i>“Sieve return visits.”</i>
CO ₃	Visit, After visit	<ul style="list-style-type: none"> • <i>“History taking.”</i> • <i>“Physical Examination.”</i> • <i>“Review Previous visits.”</i> • <i>“Request for investigation where necessary.”</i>
D ₁	Visit	<ul style="list-style-type: none"> • <i>“Taking patient’s history of presenting illness.”</i> • <i>“Examining the patient.”</i> • <i>“Sending the patient for lab investigations or any other and investigating the findings as well as prescribing the appropriate treatment.”</i>
D ₂	Visit	<ul style="list-style-type: none"> • <i>“Receive patients in consultation room.”</i> • <i>“Do History.”</i> • <i>“Do physical exam.”</i> • <i>“Send for lab test if need be.”</i> • <i>“Make a diagnosis.”</i> • <i>“Make a prescription.”</i> • <i>“Refer patient if necessary.”</i>
LT ₁	Visit	<ul style="list-style-type: none"> • <i>“Perform laboratory tests and give quality results to the clinicians for patient management.”</i>
LT ₂	Visit	<ul style="list-style-type: none"> • <i>“Perform requested lab test and give out results to the clinician.”</i>
N ₁	Rooming, Pre-visit, Visit, After-visit	<ul style="list-style-type: none"> • <i>“History taking.”</i> • <i>“Physical examination (head to toe).”</i> • <i>“Investigations.”</i>

Respondent	Stage	Activity
N ₂	Visit	<ul style="list-style-type: none"> • <i>“Take vital signs.”</i> • <i>“Injection.”</i> • <i>“Send patient to laboratory.”</i> • <i>“Health talks.”</i> • <i>“Counselling.”</i>
N ₃	Visit, After-visit	<ul style="list-style-type: none"> • <i>“Take vital signs.”</i> • <i>“Do physical examination.”</i> • <i>“History taking.”</i> • <i>“Send to laboratory for investigation.”</i> • <i>“Provide treatment.”</i> • <i>“Health education.”</i>
N ₄	Visit	<ul style="list-style-type: none"> • <i>“History taking.”</i> • <i>“Clinical diagnosis.”</i> • <i>“Do head to toe examination.”</i>
N ₅	Rooming, Pre-visit, Visit, After-visit	<ul style="list-style-type: none"> • <i>“Giving treatment.”</i> • <i>“Counselling.”</i> • <i>“Enacting appropriate care to patients according to needs.”</i>
N ₆	Rooming,	<ul style="list-style-type: none"> • <i>“Measuring of weight, blood pressure, pulse and temperature.”</i>
N ₇	Rooming	<ul style="list-style-type: none"> • <i>“Taking vital signs e.g. temperature, weight, BP. ”</i> • <i>“Injections.”</i>
N ₈	Rooming	<ul style="list-style-type: none"> • <i>“Vital signs.”</i> • <i>“Dressing.”</i> • <i>“Injections.”</i>
N ₉	Visit	<ul style="list-style-type: none"> • <i>“Vital signs</i>
N ₁₀	Visit, After -visit	<ul style="list-style-type: none"> • <i>“Take history of illness, past medical/surgical history.”</i> • <i>“Do laboratory tests if necessary.”</i> • <i>“Make diagnosis and prescribe medication and give it.”</i>
PH ₁	Visit	<ul style="list-style-type: none"> • <i>No response.</i>
PH ₂	Visit	<ul style="list-style-type: none"> • <i>“Dispensing of prescribed drugs.”</i>
PH ₃	Visit, After-visit	<ul style="list-style-type: none"> • <i>“Dispensing prescribed drugs and advice the patient appropriately.”</i>
RO ₁	Pre-visit, After-visit	<ul style="list-style-type: none"> • <i>“Filtering patients.”</i> • <i>“Filling and retrieval of files.”</i> • <i>“Coding and indexing of diseases. ”</i> • <i>“Booking patients for appointments</i>
RO ₂	Visit	<ul style="list-style-type: none"> • <i>“Patient registration and booking of appointments.”</i>
RO ₃	Visit	<ul style="list-style-type: none"> • <i>“Registration of patients. ”</i>

Source: (Research Data: 2016)

Table 4.3.1: Key

S/N	Respondents	Represents
1.	CO ₁ , CO ₂ , CO ₃	The three respective Clinical Officer
2.	D ₁ , D ₂	The two respective doctors
3.	LT ₁ , LT ₂	The two respective laboratory technicians
4.	N ₁ , N ₂ , N ₃ , N ₄ , N ₅ , N ₆ , N ₇ , N ₈ , N ₉ , N ₁₀	The ten respective nurses
5.	PH ₁ , PH ₂ , PH ₃	The three respective pharmacists
6.	RO ₁ , RO ₂ , RO ₃	The three respective records officers

Source: (Research Data: 2016)

From Table 4.3, it can be seen that some providers execute their activities at one stage only while others provide the activities at two or more stages of medical care. All the doctors and clinical officers handle the patients only the visit or after visit stage of medical care and thus the activities they perform is as per their specified roles and responsibilities (Table 2.2). Similarly, all the laboratory technicians handle the patients at the visit stage (Table 4.3) and this is in conformity with the specified roles and responsibilities (Table 2.2). However, while the roles and responsibilities of nurses are defined as record patient vitals, refer patients to clinicians, administer minor procedures and administration of drugs, nurses: N₂ and N₃ “sends patients to laboratory”, N₃ “provides treatment”, N₄ performs “clinical diagnosis”, N₅ “gives treatment”, N₁₀ “does laboratory tests” and “...makes diagnosis, prescribe and dispense medication” in violation of the roles and responsibilities (Table 2.2). All the pharmacists handle the patients at the visit and after visit stages which in agreement with their defined roles and responsibilities (Table 2.2). RO₁ handle patients at the pre-visit and after visit stages and “filters patients”, “books patients for appointments” which are responsibilities of the receptionist (Table 2.2), Similarly, RO₂ and RO₃ performs “registration of patients” and RO₃ “books patients”. These are duties of the receptionist (Table 2.2). Hence, the findings demonstrate that the

specified providers perform duties which are not in line with their defined professional roles implying a breach of privacy and confidentiality of patient information (UNESCO, 2005). The conceptualized Mobile Phone Based Clinical Summaries model (Figure 5.7) bridges this gap by ensuring that each provider is assigned specific roles and privileges which are not transferrable.

4.3.3 Types of Clinical Summaries Provided by the Providers

The two types of clinical summaries are pre-visit and after-visit provided before and after a visit respectively. Thus, the researcher sought to establish the type of clinical summaries provided specifically by doctors and clinical officers. Figure 4.2 is an illustration of the responses.

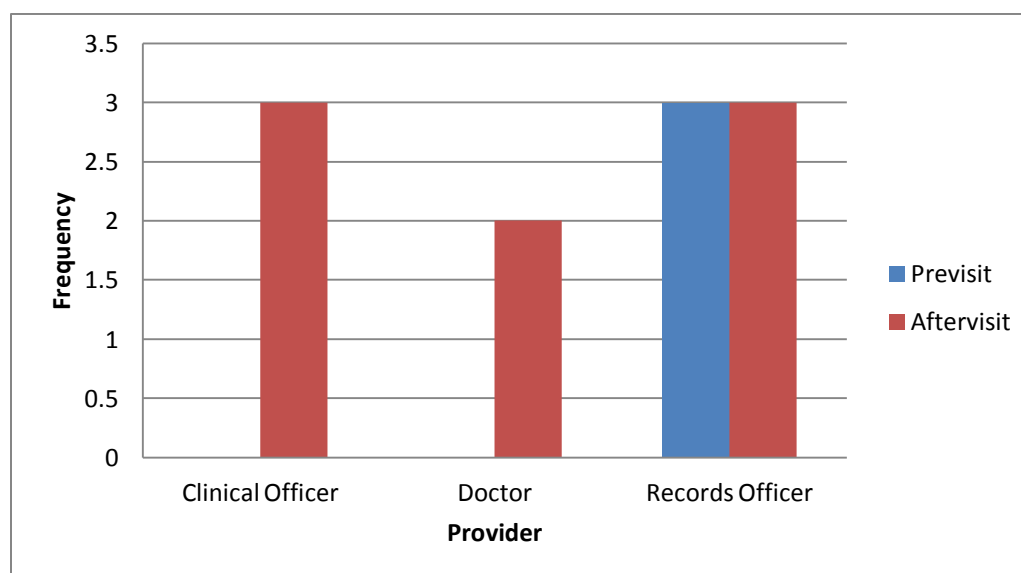


Figure 4.2: Types of Clinical Summaries.

Source: (Research Data: 2016)

As shown in Figure 4.2, all the 3 (100%) clinical officers and the 2(100%) doctors do provide after visit summaries and none of them (0%) provide pre-visit summaries while 100% of the records officers (3) provide both pre-visit and after visit summaries.

4.3.4 Kind of Information Contained in the Clinical Summaries

Whenever a patient visits a hospital, information about him/her is recorded for purposes of identification and medical diagnosis. Thus, the researcher sought to determine the kind of information contained in the summaries as provided by the clinical officers and doctors or as recorded by nurses. In addition, the study sought to determine the information given to a patient after every visit to Kabarak University Health Centre. Such information contained in the clinical summaries or that which is given to a patient after every visit form part of the functional requirements needed in designing the Mobile Phone Based Clinical Summaries model as per the aim and objective four of the study.

The response is as shown in Figure 4.3

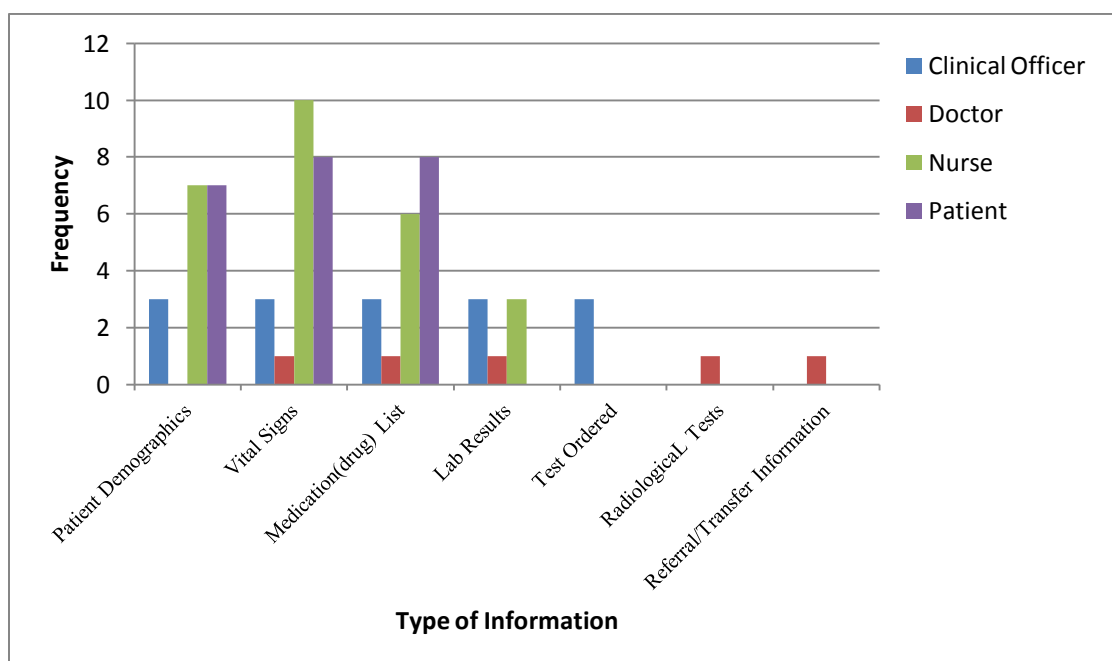


Figure 4.3: Kind of Information contained in Clinical Summaries/Patient Information recorded/given

Source: (Research Data: 2016)

The findings in Figure 4.3 showed that 3 (100%) clinical officers indicated that patient demographics, vital signs, medication list, lab results and test ordered is the information contained in the clinical summaries while 1 (50%) doctor listed vital signs, medication

list, lab results, radiological tests and referral/ transfer information as the pertinent information contained in the clinical summary. 7(70%) nurses indicated that they capture/record patient demographics in an episode of care. Likewise vital signs, medication lists and laboratory results information are captured/recorded by 10(100%), 6(60%) and 3(30%) nurses respectively. This variation in the number of nurses recording the different information is dependent on the stage in an episode of care he/she handles the patient (Figure 4.1) and the activities therein (Table 4.3) of which the study established that some of the activities performed are in violation of their roles and responsibilities (Table 2.2).

On the other hand, Figure 4.3 show that 7(70%), 6(60%) and 3(30%) patients indicated that they are normally given information about vital signs, medication list and lab results respectively after every visit to Kabarak University health center confirming the findings given by the providers (Figure 4.3)

4.3.5 Kind of Tests Normally Received by Laboratory Technicians from Providers

Before making any clinical decision on the prescription to make to a patient, a provider may want to know and understand the medical condition of the patient. Hence, the provider will require a laboratory technician to perform microbiology, chemistry, haematology and or transfusion medicine tests. All these tests are received by the 2 laboratory technicians except transfusion medicine which is received by 1 of them. From the findings it can be inferred that special skills are required to undertake certain laboratory tests.

4.3.6 Kind of Tests Results Generated by Laboratory Technicians

Based on the tests received (section 4.3.5), the laboratory technicians can generate positive, negative, indicative or predictive results. The research findings showed that 1of

the laboratory technician generated positive and negative results as per the tests performed but none of them generated either indicative or predictive results.

4.3.7 Recipients of the Test Results Generated by Laboratory Technicians

The researcher sought to know to whom the results are sent to by the laboratory technicians once generated. All the laboratory technicians indicated that doctors/clinical officers are the recipients of tests. However, 1 of the laboratory technicians indicated that the tests are received by patients. This is in violation of the roles and responsibility guidelines (Table 2.2) and the patient management process (**Appendix XV**) of Kabarak University Health Centre.

4.3.8 Kind of Information Recorded by Records Officer in an Episode of Care

Table 4.3 shows the activities performed by the three records officers sampled for the study at the specified stages of medical care. Hence the researcher wanted to specifically establish the kind of information recorded by the records officers while executing the said activities. From the study findings it was established that return visit date is the only information recorded by 2 of the 3 record officers while none of them has ever recorded information on medical prescription and test results. This can be attributed to the principle of capturing information at source as observed in the health industry to maintain data integrity and confidentiality (UNESCO, 2005).

4.3.9 Patients Vital Signs Recorded by the Nurses during Previous and Current Visit

The vital signs give the basic health condition about a patient and are required before the patient meets a clinician. The information about the vital signs will be used by the clinician in conjunction with the test results generated by the laboratory technicians to arrive at an appropriate diagnosis. And as shown in Table 4.3, one of the activities

performed by the nurses (N₂, N₃, N₇ and N₉) at the given stages of medical care is taking vital signs. Therefore, the researcher sought to establish from the patients, the vital signs normally taken and recorded by nurses during a current visit and all other previous visits to Kabarak University health centre. The response from the various patients is as shown in Table 4.4.

Table 4.4: Patients Vital Signs Recorded by the Nurses during the Previous and Current Visit

Vital Signs	Number	%(N=10)
Weight	7	70
Height	10	100
Temperature	9	90
Blood pressure	9	90
Blood sugar	1	10

NB: Table shows multiple responses

Source: (Research Data, 2016)

The findings from Table 4.4 showed that 7 (70%) patients indicated that their weight is normally taken and recorded while all the patients indicated that their heights are taken and recorded by the nurses. 9(90%) patients indicated that temperature and blood pressure are the vitals taken and recorded and only 1(10%) patient indicated that his/her blood sugar is normally taken and recorded by the nurses. Hence, this confirms the findings as established in Figure 4.3 wherein all the nurses record vital signs.

4.3.10 Provision of Information about Treatment to Patient after every Visit made to the Health Institution

All the patients indicated that they are given information about the treatment given after every visit to Kabarak University health centre. But the kind of information given varied from one patient to another as shown in Table 4.5.

Table 4.5: Information about treatment given to patient after every visit made to the health institution.

After Visit Information given	Number	%(N=10)
Vital Signs	3	30
Lab Results	2	20
Medication(drugs) list	2	20
Next visit date	5	50

NB: Table shows multiple responses

Source: (Research Data, 2016)

3 (30%) patients indicated that they are given information about their vital signs, 2 (20%) were given information about their lab results and medication list while 5(50 %) were given information about the next visit date (Table 4.5). Hence this findings show that patients are not provided with complete (holistic) information required to make informed decision about their health status when leaving Kabarak University health center after a treatment. Therefore, the adoption of Mobile Phone Based Clinical Summaries model will bridge this gap by enabling the health centre provide the patient with the required after visit information in a timely and convenient manner as well as allowing fast recording and dissemination of the patient health data at the facility.

4.4 Assessment of the Providers' and Patients' Use and Views of Clinical Summaries

Having determined the parameters that make up a clinical summary and the stages in an episode of care where these parameters are captured, the researcher sought to establish who are the users of the generated clinical summaries; assess their views on the impact of the clinical summaries in promoting better healthcare; determine protocols governing collection, storage and use of patient information contained in the clinical summaries and establish the formats used to record and communicate these information.

4.4.1 Users of Clinical Summaries

The researcher sought to know from the two categories of respondents (clinical officers and doctors) the users of the clinical summaries they specified (Figure 4.2) and the results are as depicted in Figure 4.4.

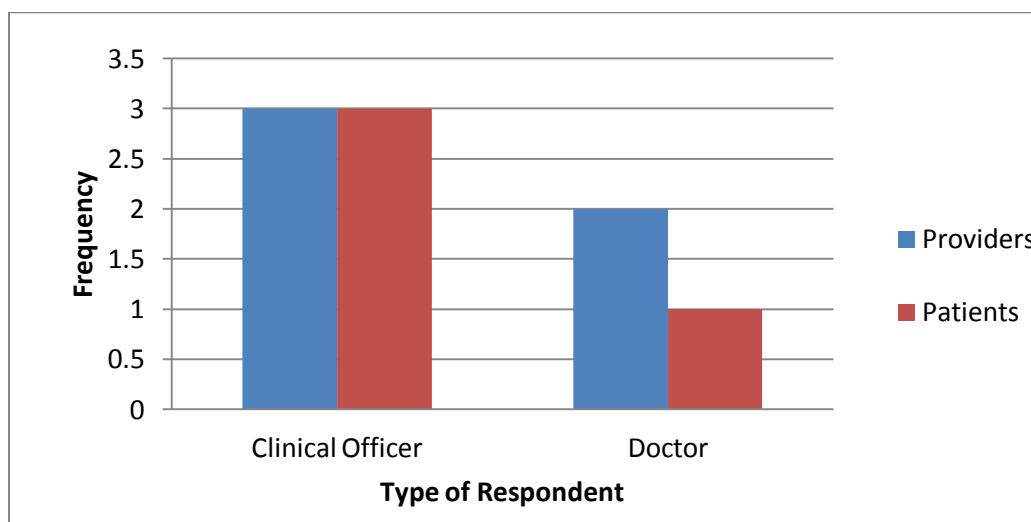


Figure 4.4: Users of Clinical Summaries.

Source: (Research Data: 2016)

As per the study findings, all the 3 clinical officers indicated that both the providers and the patients are the users of the clinical summaries (after visit summaries). Similarly, all the doctor(s) indicated that providers and patients were the users of the after visit summaries (Figure 4.4). Hence, this demonstrates that both categories of the respondents agree that both providers and patients are the users of the after visit summaries

4.4.2 Importance of Clinical Summaries in Improving Health Care Provision in Kabarak University

The study sought to get an insight of the significance of clinical summaries from the doctors and clinical officers since they are the providers who provide (Figure 4.2) and use (Figure 4.4) the summaries. Their varied responses are as shown in Table 4.6.

Table 4.6: Importance of Clinical Summaries in improving Health Care Provision in Kabarak University Health Centre

Respondent(Provider)	Importance
D ₁	<i>“Helpful for follow-up purposes.”</i> <i>“Useful in situation where review of treatments needed.”</i>
D ₂	<i>“Very important.”</i>
CO ₁	<i>”For planning and budgeting purposes.”</i>
CO ₂	<i>“Proper management of patients.”</i> <i>“Budget Projections.”</i>
CO ₃	<i>“It assists the facility to plan for better care and management of patients.”</i>

Source: (Research Data: 2016)

The findings in Table 4.6 showed that clinical summaries aid the facility in planning for better care and management of patients, budgeting, tracking and review of patients’ treatments. Clinical officers and doctors do engage the patients at the visit stage (Figure 4.1) of medical care hence the responses of D₁, CO₂ and CO₃ are in agreement with Hummel *et al.* (2012) who noted that the visit enables the provider to fill as much information from the examination rather than reconstructing the encounter when the patient has left.

4.4.3 Protocols that Govern the Collection, Storage and Use of Patient Information Contained in the Clinical Summaries

The researcher sought to establish the protocols that the providers adhere to during the process of collecting, storing and using patient health data as recorded in the clinical summaries and the findings are as shown in Table 4.7.

Table 4.7: Protocols That Govern the Collection, Storage and Use of Patient Information contained in the Clinical Summaries.

Respondent	Protocol(s) applied
D ₁	<ul style="list-style-type: none"> • <i>“We follow clinical protocols as required in the teachings.”</i>
D ₂	<ul style="list-style-type: none"> • <i>“None.”</i>
CO ₁	<ul style="list-style-type: none"> • <i>“Confidentiality.”</i>
CO ₂	<ul style="list-style-type: none"> • <i>“For proper management of patient report.”</i> • <i>“In order to maintain confidentiality of patient report.”</i>
CO ₃	<ul style="list-style-type: none"> • <i>“Confidentiality of patient report.”</i>
LT ₁	<ul style="list-style-type: none"> • <i>“SOP guidelines, EQC’s, IQC, national guidelines for reporting of different results.”</i>
LT ₂	<ul style="list-style-type: none"> • <i>SOP’s, EQC’s and IQC’s.</i>

Source: (Research Data, 2016)

The findings indicate that the health care providers (doctors, clinical officers and laboratory technicians) who handle the patient at the visit stage also handle the patient data collected as per the medical protocols stipulated by their profession. Hence, this is in agreement with Harman (2006) who noted that the information shared as a result of clinical relationship is considered confidential and must be protected. Moreover, this is in line with the UNESCO Universal Declaration on Bioethics and Human Rights (UNESCO, 2005) which states:

“...The privacy of the persons concerned and the confidentiality of their personal information must be respected.” (p.165).

4.4.4 Format used by Providers to Record Patient Information, Communicate Test Results, Medication Prescribed and Dispensed and provide Clinical Summaries for Patients

The researcher sought to find out the formats used by the providers at their respective stages of medical care to record, communicate test results, medication dispensed, and prescription and in the provision of clinical summaries for patients.

4.4.4.1 Formats used by Nurses to Record Patient Information

It was established from Table 4.3 that nurses perform activities like history taking and capturing vital signs. Hence the researcher further sought to establish the format(s) in which the given information is captured and the results are as shown in Table 4.8.

Table 4.8: Formats used by Nurses to Record Patient Information

Format	Number	% (N=10)
Handwritten	10	100
Pre-printed form	2	20
Electronic Medical Record Systems (EMR)	7	70

NB: Table shows Multiple Responses

Source: (Research Data, 2016)

The findings showed that all the nurses recorded the patient information in handwritten format, followed by Electronic Medical Record System at 70%(7) and lastly pre-printed form at 20% (2) (Table 4.8). This demonstrates that the formats used by the nurses to record the patient information fall under level 1 (handwritten), level 2 (pre-printed form) and level 3 (EMR) of the Healthcare Information Exchange and Interoperability Taxonomy (Table 2.4).

4.4.4.2 Formats used by Laboratory Technician to Communicate Test Results

Table 4.3 shows that laboratory technicians perform laboratory tests after which they give out the tests results to the clinician who originated the test. Hence the researcher sought to find out the format in which the given test results are conveyed to the clinician. The study findings indicated that all the laboratory technicians communicated the test results to the clinicians in a handwritten format and through Electronic Medical Records system. On the other hand, none of them communicate the results verbally, via email or SMS. Hence, the findings demonstrates that the formats used by the laboratory technicians to communicate the test results solely falls under level 1 (handwritten) and level 2 (Electronic Medical Records system) of Healthcare Information Exchange and Interoperability Taxonomy (Table 2.4).

4.4.4.3 Formats used by Pharmacist to Track Medication/Drugs Prescribed to a Patient

The pharmacists dispense prescribed drugs and advice the patient appropriately (Table 4.3). Thus the researcher further sought to establish the format used by the pharmacists to track the medication dispensed to patient(s). The research findings showed that all the pharmacists use Electronic Medical Records system to keep track of the medication/drugs dispensed, followed by handwritten medication list used by 1 of the 3 pharmacist while none of them use pre-printed checklist to track the medications. Hence this demonstrated that Electronic Medical Records system is the most preferred format to track drugs dispensed to patients. Further, the findings indicate that the formats used by the pharmacists mainly fall under level 3 (Electronic Medical Records system) followed by level 1 (Handwritten medication list) of the Healthcare Information Exchange and Interoperability Taxonomy (Table 2.4).

4.4.4.4 Formats used by Pharmacist to Communicate to a Patient on the Medication/Drug Dispensed

The researcher sought to find out if the pharmacists communicate to patients on the medication/drug they dispense and the format(s) of communication used in the process. It was found out that all the pharmacists communicate to patients on the medication/ drug dispensed. Further it was established that the entire sample of 3 pharmacists communicate verbally to patients while none use handwritten, SMS or email format to communicate to the patient on the test results. Thus, the findings demonstrate that the communication of results to patients is solely based on level 1 of the Healthcare Information Exchange and Interoperability Taxonomy (Table 2.4).

4.4.4.5 Formats used by Pharmacists to Communicate to Patient on Medication/Drug Dosage

The researcher sought to establish if the pharmacists communicate to patients about their medication/drug dosage and the format(s) used to convey the information. All the pharmacists indicated that they communicate to patients on the medication/ drug dosage. In addition, the research findings indicated that all the pharmacists communicate the dosage to patients verbally and in handwritten format while none of them use SMS or email. The used formats (Verbal and Handwritten) belong to level 1 of the Healthcare Information Exchange and Interoperability Taxonomy (Table 2.4).

4.4.4.6 Situations where Pharmacists Changes a Patient's Drug Prescription

The researcher sought to establish if the pharmacists encounter situations where they are required to change a patient's drug prescription and if so, the format(s) they use to communicate such changes to episode provider and to the patient. All the pharmacists indicated that such situations do arise.

All the pharmacists indicated that they communicate verbally to both patients and encounter providers whereas two of the pharmacists also communicate in hand written and through the EMR to the encounter provider. It was evident that none of the pharmacist had used email to communicate such changes. The communication to patients only through verbal format is in agreement with the findings in section 4.4.4.2 which showed that pharmacists only communicate verbally to patients about their prescriptions. Further, this communication is based on level 1 (verbally) of the Healthcare Information Exchange and Interoperability Taxonomy (Table 2.4) as opposed to the communication of the same changes to episode providers which are based on levels 1 and 3.

4.4.4.7 Provision of Pre-visit and after Visits Summaries by Record Officers to Patients

As established from Figure 4.1(*Distribution of Providers as per stage of Medical care*) records officers handle the patients at the pre-visit and after-visit stages of medical care. Subsequently, the researcher sought to establish if at the specified stages of medical care the records officers provide pre-visit and after visit summaries, the formats used to provide the summaries, the frequency of provision of the summaries, whether the pre-visit summaries are updated, the parameters that they update and the frequency at which the updates are undertaken.

4.4.4.7.1 Provision of Pre-Visit Summaries

The researcher sought to establish whether Pre-Visit summaries are provided after every visit and the results are as shown in Table 4.9.

Table 4.9: Provision of Pre-visit Summaries

Respondent	Yes	No
Records Officer	3	0
Patient	6	4

Source: (Research Data, 2016)

The findings in Table 4.9 indicate that all the records officers (3) do provide pre-visits summaries to patients. On the other hand 60% (6) of the patients indicated that they are provided with pre-visit summaries while 40% (4) indicated that they are not provided with the pre-visit summaries.

4.4.4.7.2 Formats used by Record Officer to Provide Pre-visit Summaries

The researcher sought to establish the formats used by records officers to provide pre-visit summaries to patients. The findings show that only 1 of the respondents provide pre-visit summaries in handwritten and computer printed formats while none uses SMS or email in the provision of the pre-visit summaries. The two formats used (handwritten and computer printed) fall under level 1 and level 2 of the Healthcare Information Exchange and Interoperability Taxonomy (Table 2.4). The findings herein are in agreement with the findings from nurses (Table 4.12) that indicate a high usage of paper based formats. These formats as noted by Anokwa (2012) are tradeoffs for potential increases in functionalities.

4.4.4.7.3 Frequency of Provision of Pre-visit Summaries to Patients by Records Officers

The researcher sought to find out the frequency of provision of the pre-visit summaries (always, for specific type of care or never). The findings showed that all the records officers always provided summaries. Further, none has ever provided pre-visit summaries

based on the patient's type of care demonstrating that the pre-visit summaries are always provided irrespective of the type of care.

4.4.4.7.4 Update of Patient's Pre-visit Summaries and the Parameters Updated

The researcher sought to find out if the records officers normally update the pre-visit summaries. From the study findings, 2 of the 3 records officers update the summaries while 1 did not respond. Subsequently, the researcher sought to establish the parameters that they normally update. The findings indicated that none of the records officers update either the medical prescription or the test results while the two who responded indicated that they normally update return visit date. This is in conformity with the Revised Scheme of Service for Health Records and Information Management Personnel (GoK, 2012) which defines one of their roles as managing patient schedule

4.4.4.7.5 Frequency of Update of the Patient's Pre-visit Summaries

Having established that the pre visit summaries are updated and the respective parameters that are updated (section 4.4.4.7.4), the researcher thereafter sought to find out the frequency at which the pre-visit summaries are updated (always, for specific type of care or never).

The findings showed that all the records officers always updated pre-visit summaries and none has ever made updates for specific type of care or has never updated a pre-visit summary. Hence, the findings indicate that pre-visit are always provided (section 4.4.4.7.3) and updated concurring with the patient's response (Table 4.9) where 60% indicated that they are provided with pre-visit summaries

4.4.4.7.6 Patient need to be provided with previous Medical History before seeing the Doctor

Having found out that all the records officers provided pre-visit summaries to patients and that 40% of the patients indicated that they are not given previous medical history prior to being treated (Table 4.9), the researcher further sought to establish if patients would prefer to be given such information and the findings are as shown in Table 4.10.

Table 4.10: Provision of Previous Medical History Information to Patient prior to treatment

Response	Number of patients	% (N =10)
Yes	4	40
No	6	60

Source: (Research Data, 2016)

Table 4.9 showed that 40% of the patients indicated to not have received pre-visit summaries prior to being treated. Further, the findings in Table 4.10 show that 40% of the patients would prefer to be given their previous medical history information prior to seeing the doctor. Inferentially, these findings show that all patients would prefer to have their medical history prior to being treated.

4.4.4.7.7 Formats in which Patients are given previous Medical History

The researcher needed to know the formats in which the patients are given the information about their previous medical history. From the study findings one (1), three (3) and one (1) patients out of the sampled 10 indicated that they receive the information in handwritten, computer printed and verbal formats respectively while none of them receive the information via SMS or email. In addition, five (5) of the patients did not indicate their choice(s). Inductively, since 40% (Table 4.9) of the patients respondents had indicated to not have been provided with pre-visit summaries, it is thus implied that they had no access to their previous medical history. Consequently, majority of the

patients who indicated to have received previous medical history receive them in formats that fall under level 1 and 2 of the Healthcare Information Exchange and Interoperability Taxonomy (Walker *et al.*, 2005) as quoted by OECD (2010).

4.4.4.7.8 Patients Satisfaction with the Previous Medical History Details given

Further the researcher sought to know if the patients are satisfied with the previous medical history information as provided. The findings (Table 4.11) indicate that 60% of the patients were satisfied while 40% were not.

Table 4.11: Patients Satisfaction with the previous medical history details given

Response	Number of patients	% (N =10)
Yes	6	60
No	4	40

Source: (Research Data, 2016)

The findings in Table 4.11 reflect the pattern identified in Table 4.9 and Table 4.10 where patients expressed desire to be informed of their medical status prior to being treated. It can thus be deduced from the three Tables (4.9, 4.10 and 4.11) that the 40% of the patients who are not satisfied with the information provided were actually not provided with any information prior to being treated hence the dissatisfaction.

4.4.4.7.9 Patients Satisfaction with the Formats used to Provide Previous Medical History Information

In addition, the researcher sought to establish if the patients are satisfied with the formats (section 4.4.4.7.7) used in the provision of the previous medical history. The study findings revealed that 5 of the 10 patients were satisfied with the formats used to provide information about the previous medical history while 5 patients did not respond. This

corresponds to the findings in section 4.4.4.7.7 where five (5) of the patients did not indicate their choice(s).

4.4.4.7.10 Provision of after Visit Summaries

The researcher sought to find out if records officers provide patients with after visit summaries, the format(s) used and the frequency of provision. The findings in Table 4.12 shows that all records officers provide the patients with after visit summaries. Further, all the patients indicated that they are provided with information about the treatment provided. The conclusive findings imply that the records officers fulfil their role of ensuring that patients leave the facility with the required information after being attended to

Table 4.12: Provision of After Visit Summaries

Respondent	Yes	No
Records Officer	3	0
Patient	10	4

Source: (Research Data, 2016)

4.4.4.7.11 Formats used by Record Officer to Provide after Visit Summaries

Having established that the records officers do provide after visit summaries to patients (Table 4.12) the researcher further sought to find out the format(s) used. The findings revealed that 1 of the 3 record officers provide the summaries in handwritten and computer printed formats respectively whereas none of them use SMS or email. Comparatively, the responses are similar to those of pre-visit summaries (section 4.4.4.7.2)

4.4.4.7.12 Frequency of Provision of after Visit Summaries to Patients by Records Officer

In addition, the researcher sought to find out the frequency of provision of the after-visit summaries (always, for specific type of care or never). The findings showed that all the record officers always provided after-visit summaries and none has ever provided for specific type of care or has never provided. These findings are similar to those in section 4.4.4.7.3 indicating that pre-visit and after-visit are always provided irrespective of the type of care.

4.4.4.7.13 Formats in which Patients are given Information about Treatment Provided

The researcher sought to know the formats in which the patients are normally given information about their treatment and the findings are as depicted in Table 4.13.

Table 4.13: Formats in which Patients are given Information about Treatment Provided

Format	Number of patients	%(N=10)
Handwritten	4	40
Computer Printed	5	50
Verbal	3	30

NB: Table shows multiple responses

Source: (Research Data, 2016)

The findings show that 4, 5 and 3 of the patients are given the information in handwritten; computer printed and verbal formats respectively (Table 4.13). Thus, the findings demonstrate that the formats in which the patients are given information about the treatment provided fall under level 1 (handwritten, verbal) and level 2 (Computer Printed) of the Healthcare Information Exchange and Interoperability (Walker *et al.*, 2005) as quoted by OECD (2010).

4.4.4.7.14 Patients Satisfaction with the Information given about the Treatment Provided

Further the researcher sought to find out if the patients are satisfied with the information given about their treatment. The study findings show that 9 out of 10 are satisfied with the information given while only 1 patient is not satisfied.

4.4.4.7.15 Patients Satisfaction with the Formats used to provide the Information about the Treatment Provided

In addition, the researcher sought to establish if the patients are satisfied with the formats normally used to provide them with information about the treatment provided. From the study findings 8 of the patients are satisfied with the formats while 2 are not. Similarly, section 4.4.4.7.14 showed that 90% of the patients were satisfied with the information provided after every episode of care. The near conclusive satisfaction with information provided and its format is in agreement with the trend exhibited by the patients in the provision of pre-visit summaries (Table 4.9 and 4.11) and section 4.4.4.7.5. It is therefore evident that patients would like to be empowered to participate in their health care.

4.4.4.7.16 Promptness in which the Patient is given Information about Treatment Provided

The efficiency of a system is determined by its ability to provide timely information and thus in the study the researcher sought to find out the promptness at which the patient are normally given information about the treatment provided.

Out of the 10 patients, 5 indicated to receive the information immediately, 2 in less than an hour and 1 within a day. However, 2 (20%) of the patients did not indicate any level of promptness. It is evident that majority of the patients receive the information within an hour after care which is agreement with Texmed (2013) who posits that such information should be availed to the patient within 24 hours after provision of care. However, Table

4.13 shows that the information is received in handwritten, computer printed or verbal formats. Information in such formats is error prone, susceptible to delays, redundant and expensive (OECD, 2010). Thus to counter the aforementioned challenges, the conceptual model (Figure 5.7) which is based on level 4 of the Health Care Information Exchange and Interoperability Taxonomy (Table 2.4) will be developed

4.5 Challenges with the Current System of Recording Clinical Summaries at Kabarak University Health Centre

The researcher sought to establish the challenges inherent in the current system with a view to recommending solution(s) to the concerns raised by the health care providers.

The study objective was thus prodded using the following research questions:

- i. What type of systems do you use to keep the information captured in an episode of care?
- ii. If manual, how do you aggregate the patient information captured?
- iii. How long does it take to aggregate the information?
- iv. Which sections have been computerized?
- v. What challenges do you face when using the system specified?

4.5.1 Type of Systems used to keep Information Recorded in an Episode of Care

The study sought to analyse existing systems as guided by the clinical summaries conceptual model (Figure 2.2) and to this end responses were sought from records officers and informatician (I₁). The findings are as illustrated in tables 4.14 and 4.15 respectively.

Table 4.14: Type of systems used by Records Officer to keep information Recorded in an Episode of Care

Type of System	Number	%(N= 3)
Manual	3	100
Computerised	2	66.7
Mobile	0	0

NB: Table shows Multiple Responses

Source: (Research Data, 2016)

The findings in Table 4.14 show that the manual and computerised systems are the two main types of systems used at Kabarak University Health Centre with 100% (3) and 66.7% (2) responses respectively. Conversely, none of the record officers has ever used a mobile system to record information in an episode of care. This is in agreement with the findings hitherto which demonstrate that Kabarak University Health Centre employs a manual and an EMR in its provision of healthcare. Further, it is evident that the limited uptake of technology is as identified by the Kenyan Ministry of Health as a major challenge in application of ICTs in Health Care (GoK, 2009).

Table 4.15: Modules implemented Kabarak University Health Centre EMR

Respondent	Modules implemented in the EMR
I ₁	<i>“Reception & Scheduling”</i>
	<i>“Patient Management”</i>
	<i>“Clinical & Nursing”</i>
	<i>“Pharmacy”</i>
	<i>“Laboratory Management”</i>
	<i>“Reporting”</i>
	Features in the Reception and Scheduling Module
	<i>“Patient appointment booking and honouring”</i>
	Features in the Patient Management Module
	<i>“Patient Registration”</i>
<i>“Patient Workflow”</i>	
<i>“Billing and Finance”</i>	
Features in the Clinical and Nursing Module	
<i>“Diagnosis entry”</i>	
Features in the Pharmacy Module	

	<p>“Receive Drug Prescription”</p> <p>“Drug Dispensing”</p>
	Features in the Laboratory Module
	<p>“Receive Lab request from doctors”</p> <p>“Capture Lab Test Results”</p> <p>“Bill for Tests”</p> <p>“Send results to doctors”</p>
	Features in the Reporting Module
	<p>“Monthly Ministry Reports”</p> <p>“Patient Medical Reports”</p> <p>“Insurance Reports”</p> <p>“Financial Reports”</p>

Source: (Research Data, 2016)

Table 4.15 show that the Kabarak University EMR consist of six modules, thus

- *Reception & Scheduling*

The Reception and Scheduling Module performs patient appointment, booking and honouring the appointments. This shows that the module only performs one function of the Health Information and Data functions of a fully functional EHR system (Table 2.5).

- *Patient Management*

The module has three features namely patient registration, patient work flow and finance (Table 4.15) showing that the module falls in the Health Information and data section of a fully functional EHR system (Table 2.5).

- *Clinical & Nursing*

This module supports diagnosis entry which can entail clinical orders entry and medical history recording. Therefore, it means that the clinical and nursing module falls under the visit stage of an episode of care (Table 4.3) implying that the EMR captures the parameters (Figure 4.3) necessary to generate a clinical summary as per objective four of the study.

- *Pharmacy*

The module is used to receive prescription orders from the clinical and nursing module and dispense medications/drugs thereby prescribed (Table 4.15). This confirms the findings in sections 4.4.4.3 and 4.4.4.5 where all the pharmacists indicated that they use an EMR to track and communicate medication prescriptions and dosage.

- *Laboratory Management*

The module is used by laboratory technicians and is thus applied at the visit stage of an episode of care (Table 4.3). This ascertains the findings established in section 4.4.4.2 where all the laboratory technicians indicated that they communicate test results through the EMR.

- *Reporting*

The module *generates* “*Monthly Ministry Reports*”, “*Patient Medical Reports*”, “*Insurance Reports*” and “*Financial Reports*” (Table 4.15). The Monthly Ministry Reports are consumed vertically by the Ministry of Health. The Patients Medical Reports is a brief reporting aggregate statistics (**Appendix XIV**) which are relevant to the Health Centre Management. Since Insurance and Financial Reports are equally management reports, it is evident that the EMR concentrates on aggregates rather than horizontal information to providers and patients which enriches an episode of care. Thus, the need to develop the Mobile Phone Based Clinical Summaries model to bridge this gap

4.5.1.1 System’s Ability to Aggregate Patient Information

The researcher sought to know whether the system(s) specified in Table 4.14 perform aggregation of patient information. All the 3 records officers indicated that the system aggregates the information. Further, the study sought to establish how the system specified aggregates patient information and the responses are as shown in Table 4.16.

Table 4.16: How the System Aggregates Patient Information

Respondent	Type of System Selected	How it aggregates
RO ₁	<ul style="list-style-type: none"> • Manual 	<i>“It aggregates because of the flexibility of patient information which can be retrieved anytime thus patient continuity of care.”</i>
RO ₂	<ul style="list-style-type: none"> • Computerised • Handwritten (Manual) 	<i>“It aggregates the patient information because it helps in easy retrieval of patient information/records.”</i>
RO ₃	<ul style="list-style-type: none"> • Computerised • Handwritten (Manual) 	

Source: (Research Data, 2016)

The findings show that the record officers use both manual and computerised system. Whereas RO₁ uses only manual system, RO₂ and RO₃ use both manual and computerised systems.

4.5.1.2 Sections that have been computerized

As per the scope of the study, the Mobile Phone Based Clinical Summaries model shall be implemented in the records/reception sections of the Kabarak University health facility. Thus, the study sought to find out the sections within the facility that have been computerised so as to establish the technical and economic feasibility of the developed model.

The findings show that records is the only section that has been computerised with 2 of the records officers indicating so. Conversely, none of the records officers indicated computerization of the pharmacy, laboratory or consultation sections. However, Table 4.8 indicates that 70% of the nurses record patient information through an EMR while all the laboratory technicians communicate results through an EMR (section 4.4.4.2). Further, all the pharmacists use an EMR to track medications prescribed to a patient (section 4.4.4.3) while 2 of the 3 pharmacists communicate changes in drug prescription to the episode provider through an EMR (section 4.4.4.6). These findings imply that all the sections (records, pharmacy, laboratory and consultation) are computerised as confirmed by the informatician (Table 4.15) but that the record officers are only modular aware of their module in the EMR. Therefore, it is evident that an EMR exists hence making it feasible to operationalize the Mobile Phone Based Clinical Summaries model.

4.5.1.3 The Length of Time it takes the System to Aggregate Patient Information

The study sought to establish the length of time it takes the system to aggregate the patient information for example medical prescription, test results and return visit date.

This is because such information is captured by the different healthcare providers and hence the efficiency of the system and eventual feedback to the patient will be measured by the length of time it takes to aggregate/consolidate the collected information. From the study findings all records officers revealed that the system consolidates the information immediately concurring with findings in section 4.4.4.7.16 where 50% of the patients indicated that they receive the information immediately. Hence the findings are in agreement with Sepucha *et al.* (2004) who observed that electronic systems can provide clinicians with real-time information, which can lead to improved clinical decisions.

4.5.2 Challenges with the Current System of Recording Clinical Summaries at Kabarak University Health Centre.

Kabarak University Health Centre is administratively divided into private and public sections and the providers do serve patients in either of the sections or both as shown in Table 4.17. The study sought to establish the challenges with the current system of recording clinical summaries from nurses, laboratory technicians, records officers and informatician. Their individual responses are as shown in Table 4.17.

Table 4.17: Challenges with the Current System of Recording Clinical Summaries at Kabarak University Health Centre

Respondent	Challenges	Section
N ₁	<ul style="list-style-type: none"> • <i>“Receiving false information which alters the diagnosis.”</i> • <i>“Poor handwriting, difficult to comprehend.”</i> • <i>“System failure.”</i> • <i>“Power shortage.”</i> 	Both
N ₂	<ul style="list-style-type: none"> • <i>“Storage of records: - No electronic capturing on data storage and retrieval.”</i> 	Public
N ₃	<ul style="list-style-type: none"> • <i>“No computers for capturing the patients records for future reference.”</i> 	Public

Respondent	Challenges	Section
N ₄	<ul style="list-style-type: none"> • <i>“Faulty information:- some patients may lie about information.”</i> • <i>“Delay in system for electronic medical record system.”</i> 	Both
N ₅	<ul style="list-style-type: none"> • <i>“Language barrier.”</i> • <i>“Difficult patients.”</i> • <i>“Holding vital information.”</i> 	Both
N ₆	<ul style="list-style-type: none"> • <i>“Language barrier.”</i> • <i>“Children who cannot speak.”</i> • <i>“When net is low.”</i> 	Both
N ₇	<ul style="list-style-type: none"> • <i>“Accessibility of patients records-i.e. when there is no internet.”</i> • <i>“Language barrier.”</i> • <i>“Uncooperative patient.”</i> 	Both
N ₈	<ul style="list-style-type: none"> • <i>“Comatosed patients.”</i> • <i>“Language barrier.”</i> • <i>“Non cooperative patients.”</i> • <i>“In recording-lack of books, low net.”</i> 	Both
N ₉	<ul style="list-style-type: none"> • <i>“Time consumption when using both.”</i> 	Both
N ₁₀	<ul style="list-style-type: none"> • <i>“Language barrier.”</i> 	Public
LT ₁	<ul style="list-style-type: none"> • <i>“When there is no power or internet we are not able to use electronic medical record system.”</i> 	Both
LT ₂	<ul style="list-style-type: none"> • <i>“When the internet services are low thus creating problems when reporting the results.”</i> 	Both
I ₁	<ul style="list-style-type: none"> • <i>“No reliable or credible source of ICD-10 Listings”</i> • <i>“Disjointed modules within the system resulting in manual uploading of data in CSV”</i> • <i>“User activity leading to wrong entries”</i> • <i>“Poor Network connectivity leading to downtimes”</i> • <i>“Power loss causes outages, - the fall back is the manual system”</i> • <i>“Difficulty maintaining stock levels due to disparate systems”</i> • <i>“Non-clear policy on private devices”</i> 	Both
RO ₁	<ul style="list-style-type: none"> • <i>“Patient’s ignorance on the return dates, that is either they come before or after their dates. It may not be considered by the patient as of importance.”</i> 	Public

Respondent	Challenges	Section
RO ₂	<ul style="list-style-type: none"> • “Power shortage.” • “Lack of network.” 	Private
RO ₃	<ul style="list-style-type: none"> • “Power shortage.” • “Network problem.” 	Private

Source: (Research Data, 2016)

From the findings in Table 4.17, the researcher inferentially classified the challenges encountered by the specified respondents thus:

- *Communication challenges* as demonstrated by N₁ as “*poor handwriting which is difficult to comprehend*” and by N₅, N₆, N₇ and N₈ as “*language barrier*”, “*children who cannot speak*”. This is in agreement with Raymond and Dold (2002) as quoted by Burton *et al.* (2004) who observed that paper based systems supporting clinical care have high rates of failure in retrieval and illegibility and that human memory based medicine is increasingly unreliable.
- *Technological challenges* which are brought about by power failure as demonstrated by N₁, LT₁, RO₂ and RO₃ and confirmed by I₁ “*Power loss causes outages, - the fall back is the manual system*” or network connectivity as indicated by N₄, N₆, N₇, N₈ LT₁, RO₂ and RO₃ and corroborated by I₁ “*Poor Network connectivity leading to downtimes*”. There is also lack of computers for data capture and storage as indicated by N₂ and N₃ in agreement with the HIS Policy of 2009 which notes that there exists limited availability of requisites skills, equipment and IT illiteracy inhibiting integration of Information Technology to health information. In addition, other technical challenges indicated by I₁ included “*Disjointed modules within the system resulting in manual uploading of data in CSV*” and “*Difficulty maintaining stock levels due to disparate systems*”

These challenges explain the findings in Table 4.16 where despite computerization (section 4.5.1.2) the respondents indicated that they still use the manual system. It is

evident from I₁, RO₂, RO₃ and N₁ that power outages lead to the unavailability of the EMR hence the fallback by the respective respondents to the manual system.

- *Integrity information* as demonstrated by N₁ where they receive “*false information which alters the diagnosis*” or “*some patients who provide false information*” as indicated by N₄.
- *Confidentiality/privacy* as demonstrated by N₅ as “*holding vital information*”. This could imply that the health care provider may be concerned about legal liability (Burton *et al.*, 2004), in the event that he/she divulges the information that is within his/her confines.
- *Ignorance/lack of information to make right decision* as indicated by RO₁ as “*patient ignorance on return dates*”.
- *Challenges of mining information* from patients as demonstrated by N₇ and N₈ as “*uncooperative patients*”. This shows that a patient may not be willing or fears to divulge some information to the nurse and this concurs with Burton *et al.* (2004) who noted that patients’ have concerns about information sharing and possible loss of privacy.
- *Policy Level Challenges* as demonstrated by I₁ “*No reliable or credible source of ICD-10 Listings*”. This shows that Kabarak University Health Centre is yet to benefit from the domestication of ISO-Health Informatics Standards (ISO Catalogue, 2005) and adopted by KeBs. Further, existing policies are lacking in clarity as indicated by I₁ “*Non-clear policy on private devices*”.

4.6 Establishment of the Requirements needed for the Design and Development of a Mobile Phone Based Clinical Summaries Model

Figure 4.4 established that the users of clinical summaries at Kabarak Health Centre are both the providers and patients. Further, Table 4.14 in conjunction with section 4.5.1.2

indicates that providers at the health centre have enabling ICTs to consume mobile phone based clinical summaries albeit the challenges (Table 4.17). The study thus sought to establish the patient's level of preparedness to use the mobile phone based clinical summaries. Hence to achieve this, the researcher sought to answer the following research questions in relation to the study objective:

- i. Do you own a mobile phone or tablet?
- ii. What type of mobile phone/tablet do you own?
- iii. Is the mobile phone/tablet owned shared or private?

4.6.1 Patient Ownership and/or use of Mobile Phone or Tablet

The use of the Mobile Phone Based Clinical Summaries model will require that the patient(s) has a mobile phone, hence the researcher sought to find out the number of patients who own a mobile phone. The findings are as shown in Table 4.18.

Table 4.18: Patient Ownership and/or use of Mobile phone or Tablet

Response	Number of patients	%(N=10)
Yes	7	70
No	0	0
No response	3	30
Total	10	100

Source: (Research Data, 2016)

The findings (Table 4.18) show that majority of the patients (70%) own and use mobile phones while 30% were indifferent. However, since 3 patients did not respond it is implied that a 100% of the patients who gave a substantive answer own and use a mobile phone. This reflects the current mobile penetration in Kenya which stands at 88.1% of the total population (CAK, 2016) hence implying that it is feasible to implement the model.

4.6.2 Type of Phone/Tablet owned by the Patient

Further, the researcher sought to specifically establish the type of phone/tablet owned by the patients. This is because the specifications of the device will determine the viability of implementation/use of the Mobile Phone Based Clinical Summaries model. Out of the 7 respondents who own a mobile phone or tablet (Table 4.18), 6 gave their responses. From the responses none of the patients owns a PDA or a basic phone while only 1 owns a feature phone and 5 own a smart phone or a tablet. Therefore, given that 83.3% of the respondents who gave a substantive answer own smart phones/tablets, it means that it will be technically feasible to implement and use the Mobile Phone Based Clinical Summaries model even for patients living in remote places.

4.6.3 Nature of Ownership of the Mobile Phone or Tablet

Having established the patient phone ownership and the type of mobile phone/tablet owned by the patient it was important to find out if the given phone/tablet is individually owned (private) or shared with other users. The nature of ownership is important because it determines how the patients keep his/her health records confidential hence upholding his/her privacy. The findings are as shown in Table 4.19.

Table 4.19: Nature of Ownership of the Mobile Phone or Tablet

Nature of ownership	Number	%(N=10)
Private	6	60
Shared	0	0
No Response	4	40
Total	10	100

Source: (Research Data, 2016)

The findings in Table 4.19 show that 6 patients who represent 85.7% of the patients who own mobile phones (Table 4.18) own the phones privately while 1 (14.3%) were indifferent of their nature of ownership. Thus, providing an assurance that once the Mobile Phone Based Clinical Summaries model is in use by the patient the information disseminated to him/her by the health care providers shall remain confidential, unless he/she consents otherwise. Hence, this shall be in conformity with article 9 of the UNESCO Universal Declaration on bioethics and Human rights (UNESCO, 2005).

Subsequently as per the aim of the study and the responses as per objectives 1, 2, 3 and 4 of the study, the researcher designed and developed a Mobile Phone Based Clinical Summaries model as the end product of study.

4.7 Chapter Summary

This chapter presents, analyzes and interprets the findings of the study. It discusses parameters that compose a clinical summary, assessment of the providers' and patients' use and views of clinical summaries, challenges with the current system of recording clinical summaries at Kabarak University Health Centre and the design and development of a Mobile Phone Based Clinical Summaries model. The next chapter details the design, development and deployment of the model in accordance with the requirements gathered and analyzed.

CHAPTER FIVE

MODEL DESIGN AND DEVELOPMENT

5.0 Chapter Overview

Kabarak University Health Centre employs a hybrid system consisting of a paper based system and an Electronic Medical Records system to manage its health information. The health centre however generates clinical summaries in paper format with findings indicating the main users of these summaries to be both providers and patients. These findings place the health centre at low levels of the Health Information Exchange and Interoperability taxonomy. From these evidences, this chapter designs a Mobile Phone Based Clinical Summaries model for Kabarak University as per objective four (4) of the study, the scope of the study and as guided by systems theory and the SDMX-HD standard, and by using the findings to the generate the model's functional and non-functional requirements.

According to Treeratanapon (2012) in Pāvāloaia (2013), mobile applications are software applications that are usually designed to be ran on smart phones and tablet computers. Hence, the study adopted the Mobile Application Development Life Cycle (MADLC) framework which consists of five phases namely; identification, design and development, prototyping, testing, deployment and maintenance phases (Vithani and Kumar, 2014) as it allows users with no prior experience of a system learn the new system and improve on it while being developed through prototyping. Further, the study adopted Model Driven Software Development (MDSD) methodology which defines four stages namely; abstraction, tagging the model, separation of code, tagging the code (Stahl *et al.*, 2006) in designing and developing the interfacing REST API model for use by Kabarak University Health Care Providers since it will provide for abstraction of the underlying EMR enabling separate development of the model and ensuring interoperability.

5.1 Model Requirements Specifications

Requirement specifications are a precise description of the functions and capabilities a software system should exhibit and constraints it should operate within. According to Sommerville (2010), requirements specifications are grouped into two groups: functional and non-functional (business) requirements.

5.1.1 Functional Requirements

Sommerville (2010) defines system functional requirements as statements describing services the system should provide. They define how a system should operate in particular situations and react to particular inputs. The following functional requirements were identified for the Mobile Phone Based Clinical Summaries model:

- a. The model should provide a friendly web-based interface for Healthcare informaticians to create a template defining parameters that compose a clinical summary.
- b. The model is expected to provide healthcare providers with actionable clinical summaries through a friendly mobile graphical interface.
- c. The model is expected to provide patients with non-actionable clinical summaries through a friendly graphical interface.

5.1.2 Business Requirements

These are requirements that relate to the fundamental business of an organization (Holt and Perry, 2010). Business (non-functional) requirements represent the constraints on the system and its functionalities; performance constraints; compliance with standards, (Sommerville, 2010). The study identified the following non-functional requirements.

- a. The model should comply with WHO (2004) and the government of Kenya Standards and guidelines for EMRs (2010) on health information management for interoperability.
- b. The model should seamlessly integrate with existing EMR
- c. The model will be reliably accessible to users through mobile networks irrespective of their geographical location.
- d. The model should be scalable

5.2 The Mobile Phone Based Clinical Summaries model Application Development Process

5.2.1 Model Requirements

In this phase, the requirements needed for the subsequent phases were gathered from providers and patients at Kabarak University Health Centre and analysed as per study objectives one, two and three. As per objective one of the study, the researcher sought to establish and analyze the parameters that make up a clinical summary as shown in Figure 4.3 and depicted in sections 4.3.5, 4.3.6, 4.3.8, Table 4.4 and Table 4.5. Objective two of the study sought to assess the Providers' and Patients' use and views of clinical summaries and the requirements gathered and analyzed are as depicted in Figure 4.4, Tables 4.6 to 4.13 and sections 4.4.2 to 4.4.4. Finally, objective three sought to establish the challenges with the current system of recording clinical summaries at Kabarak University Health centre and the requirements gathered and analyzed are as shown in Tables 4.15 to 4.16 and seen in sections 4.5.1.2-3.

In the view of the challenges established with the current system of recording clinical summaries, the providers and patient use and views of clinical summaries, a Mobile Phone Based Clinical Summaries model for health care providers at Kabarak University

Health Centre was designed and developed taking into account the clinical summary parameters. The steps involved in generating and using a clinical summary are as outlined:

- i. The patient enters the Kabarak University Health Centre
- ii. An encounter is generated through the following processes
 - Rooming: This will yield the vital signs
 - Diagnosis
 - Test ordered
 - Prescription
- iii. The generated encounter is subsequently recorded in the EMR
- iv. An electronic After Visit Summary (AVS) that will be consumed by the provider(s) is generated.
 - The provider will review the AVS; specifically lab test results, medication prescribed and dispensed.
- v. In the next visit (pre-visit), the reviewed AVS will be availed by the provider (Records Officer) to the provider (Doctor or Clinical Officer). The AVS can then be used to update the encounter and inform the current visit (revisit).

The aforementioned processes are as illustrated in the Mobile Phone Based Clinical Summaries model Use Case Diagram as shown in Figure 5.1.

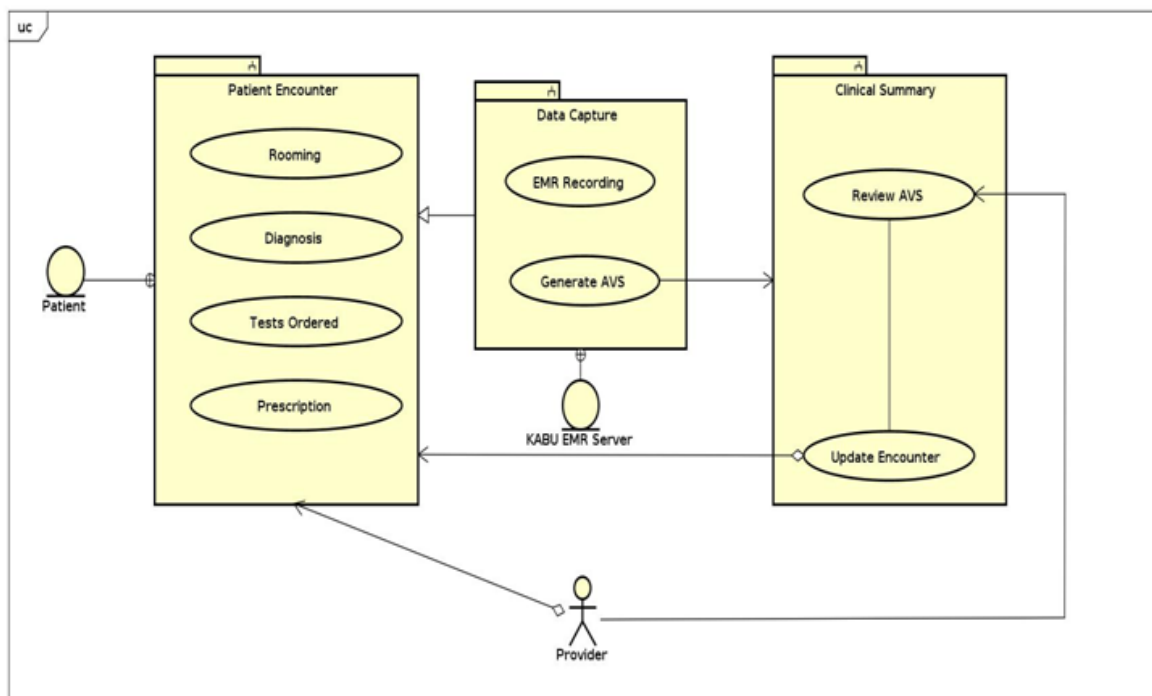


Figure 5.1: Mobile Phone Based Clinical Summaries Model Use Case Diagram
 Source: (Author, 2016)

5.2.2 User Experience (UX) Mock-up Design

The requirements analysis modelled as a use case (Figure 5.1) were extended to include the providers and model developer UX expectations. This consisted of defining the Mobile Phone Based Clinical Summaries model application general layout as per the expectations. This was implemented using Evolus Pencil v2.0.5 and the layouts were Patient List UX (Figure 5.2), Summary Page UX (Figure 5.3) and Use Case UX (Figure 5.4).

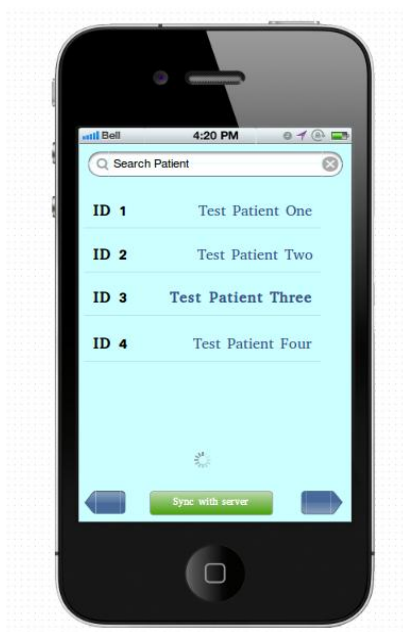


Figure 5.2: Patient List UX
 Source: (Author, 2016)

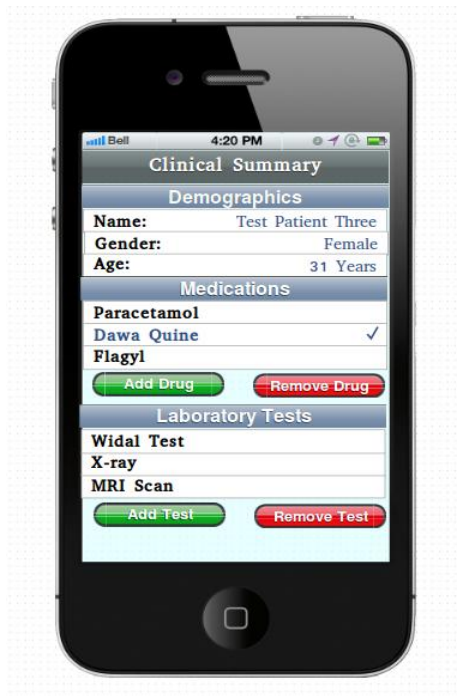


Figure 5.3: Summary Page UX
 Source: (Author, 2016)

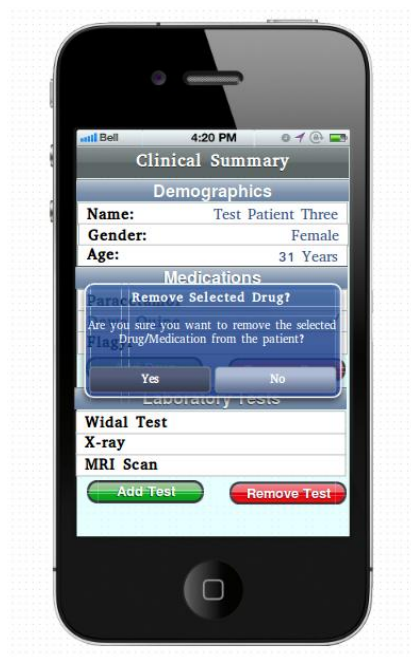


Figure 5.4: Use Case UX
Source: (Author, 2016)

5.2.3 Design and Development of the Mobile Phone Based Clinical Summaries Model for Health Care Providers at Kabarak University Health Centre

Having captured the dynamic functional requirements of the model in Figure 5.1, the next step was to provide the design overview of the target model. This was accomplished by use of the model's class diagram as shown in Figure 5.5 which shows the relationship between the seven classes and their respective attributes that compose the clinical summaries model.

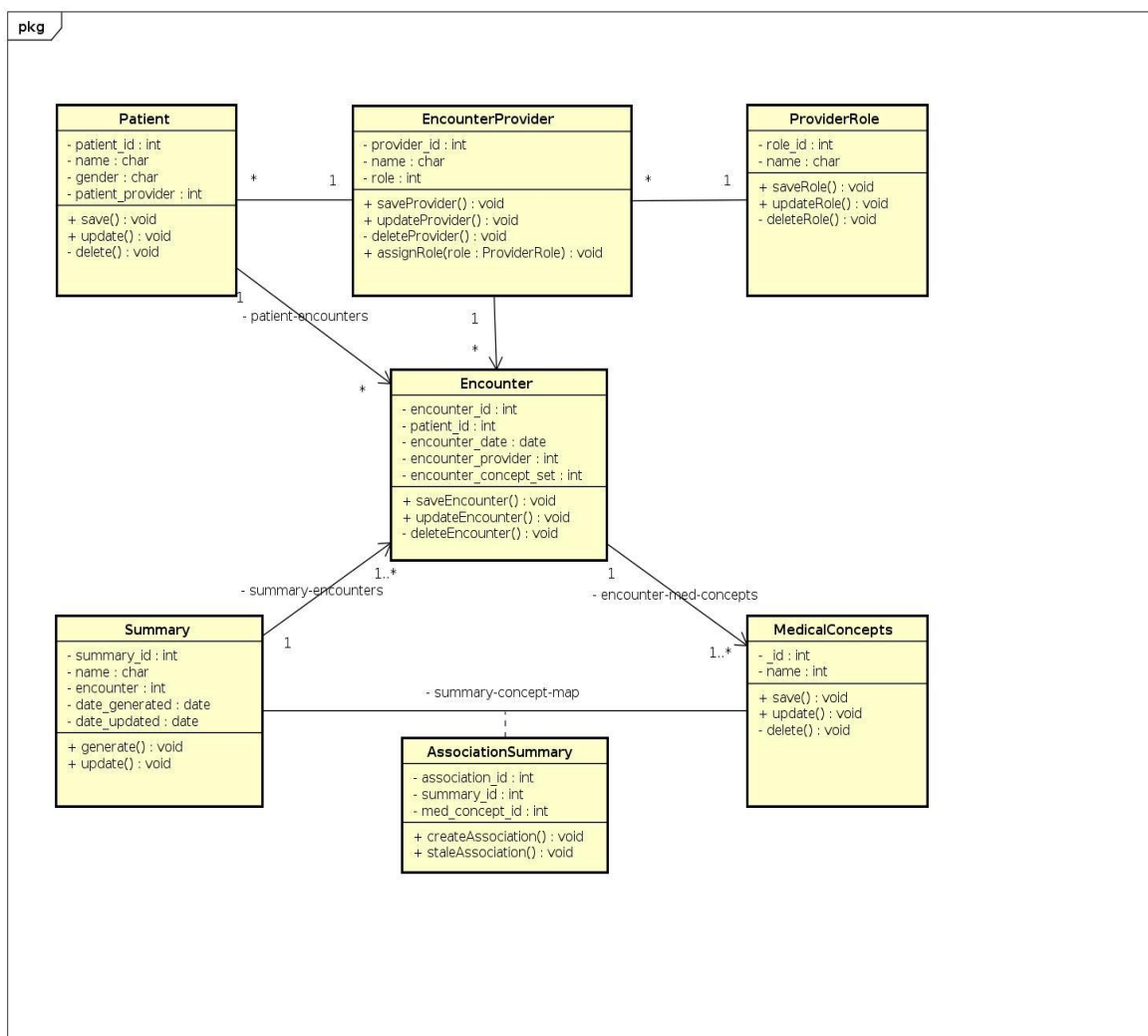


Figure 5.5: Mobile Phone Based Clinical Summaries Model Class Diagram
Source: (Author, 2016)

5.2.4 Entity Relationship Diagram (ERD)

The logical structure of the clinical summaries model server side module database is as shown in Figure 5.6.

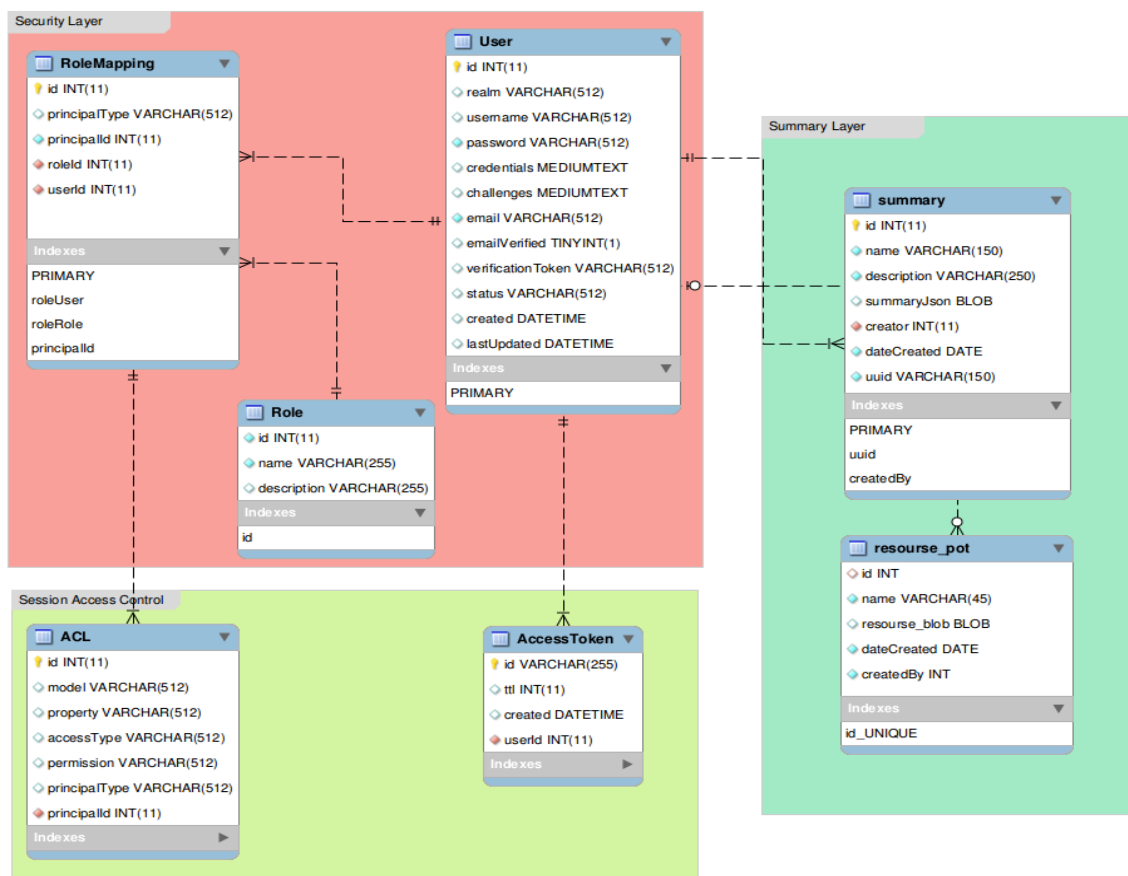


Figure 5.6: Mobile Phone Based Clinical Summaries Model ERD Diagram
Source: (Author, 2016)

The model database is composed of three schematic layers and a total of seven entities as shown in Figure 5.6. The database will be exposed through REST protocol as conceptualized in Figure 5.7 and its implementation is as illustrated in **Appendix XVII**.

5.3 Prototyping and Testing

In the design of server side and mobile application modules prototyping was done. Figure 5.7 illustrates conceptual design block diagram implementing communication between the Mobile Phone Based Clinical Summaries model and the Kabarak University Health Centre EMR as described in Table 4.15.

Communication between the mobile application and the server interface module as well as the server interface module to the Kabarak University Health Centre EMR was guided by the SDMX-HD standard (Figure 2.4) and the specified model non-functional requirement (b). The SDMX-HD DSD as depicted in Figure 5.7 defined the communication by creating medical concepts and observations as the key components of a patient encounter. Each of these components adopted DSD/MSD and defined a *UUID*, a name and meta-data, (<https://wiki.openmrs.org/display/docs/SDMX-HD>). For transparency between the components, REST protocol (Figure 5.7) was used to create the communication channel.

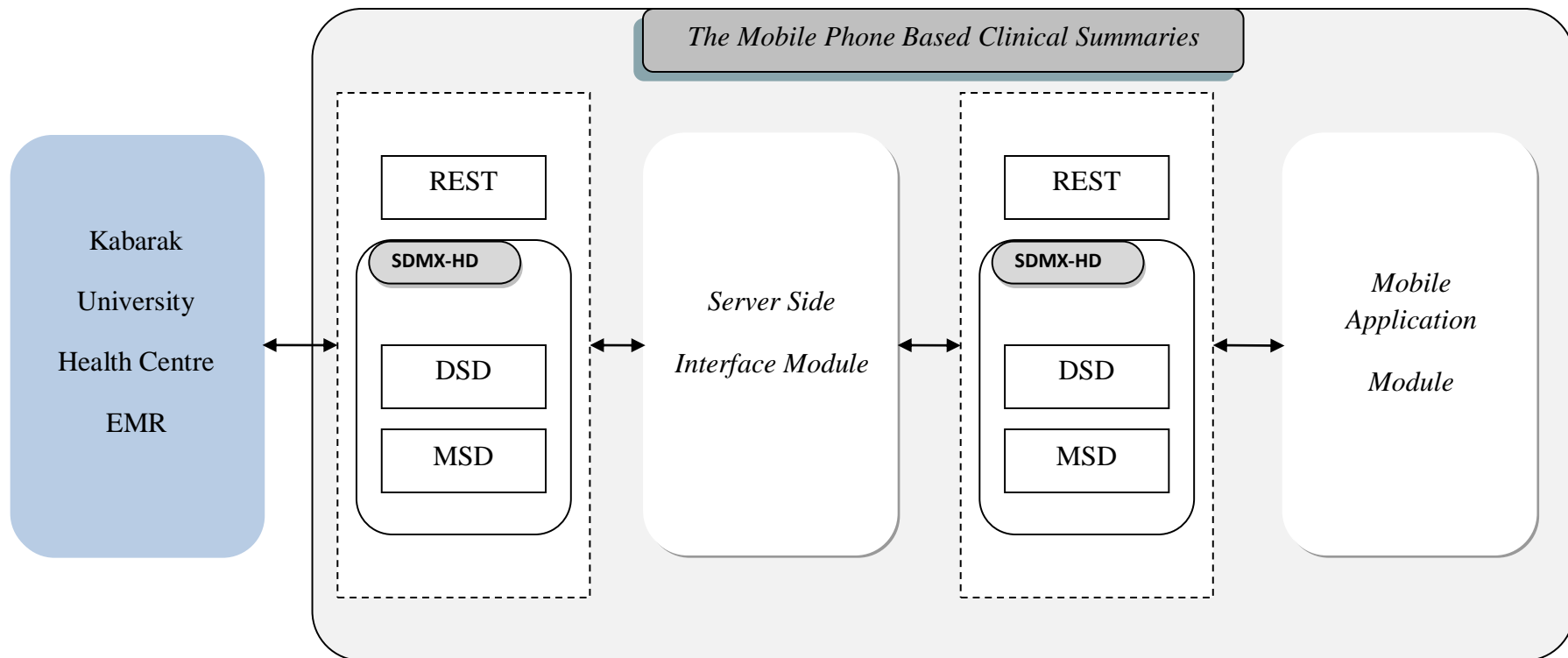


Figure 5.7: The Conceptual Design Block Diagram Implementing Communication between Mobile Phone Based Clinical Summaries Model and the Kabarak University Health Centre EMR
 Source: (Author, 2016)

5.3 1 Server Side Prototyping

The development of the Server Side Interface Module (Figure 5.7) entailed REST Resource Configuration, RESTful Login, RESTful GET, RESTful POST and RESTful POST Validation and the interfaces are as demonstrated in Figures 5.8, 5.9, 5.9, 5.10 and 5.11 respectively. The server side module was implemented using StrongLoop API (http://strongloop.com), a highly extensible open source framework that enables creation of dynamic end-to-end REST APIs accessible both locally and remotely via native clients and thus ensuring that the model is reliably accessible to users as guided by the model's third (c) non-functional requirement.

5.3.1.1 REST Resource Configuration

It exposes clinical summaries as REST resources with URI/summaries as shown in Figure 5.8.

The screenshot displays the StrongLoop API Explorer interface. At the top, there is a header with the logo 'StrongLoop API Explorer', a 'Token Not Set' indicator, an input field for 'accessToken', and a 'Set Access Token' button. Below the header, the main content area is titled 'ServerInterfaceBE'. Underneath, there is a section for 'summary' with options to 'Show/Hide', 'List Operations', and 'Expand Operations'. The interface lists various REST operations for the 'summary' resource, each with a colored icon representing the HTTP method and a description of the operation's purpose.

Method	URI	Description
PATCH	/summaries	Patch an existing model instance or insert a new one into the data source.
GET	/summaries	Find all instances of the model matched by filter from the data source.
PUT	/summaries	Patch an existing model instance or insert a new one into the data source.
POST	/summaries	Create a new instance of the model and persist it into the data source.
PATCH	/summaries/{id}	Patch attributes for a model instance and persist it into the data source.
GET	/summaries/{id}	Find a model instance by {id} from the data source.
HEAD	/summaries/{id}	Check whether a model instance exists in the data source.
PUT	/summaries/{id}	Patch attributes for a model instance and persist it into the data source.
DELETE	/summaries/{id}	Delete a model instance by {id} from the data source.
GET	/summaries/{id}/exists	Check whether a model instance exists in the data source.
POST	/summaries/{id}/replace	Replace attributes for a model instance and persist it into the data source.
GET	/summaries/change-stream	Create a change stream.
POST	/summaries/change-stream	Create a change stream.
GET	/summaries/count	Count instances of the model matched by where from the data source.

Figure 5.8: Rest Resource Configuration
Source: (Author, 2016)

5.3.1.2 RESTful Login

RESTful login allows RESTful authentication to the underlying application. On successful authentication, a session based token is generated and used for all subsequent REST calls to the API. Figure 5.9 illustrates the REST response detailing the token id, time to live(ttl), date and time the token was created and the user (userId) who are the Clinical Summary providers shown in Figure 4.1

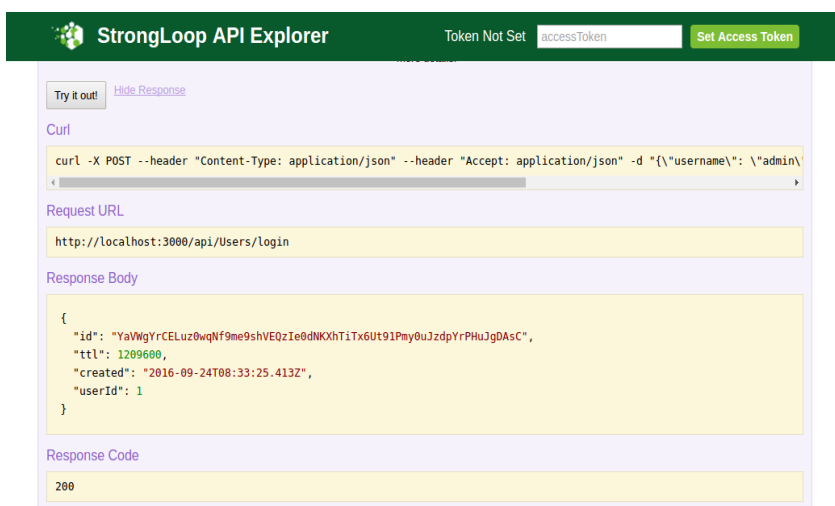


Figure 5.9: RESTful Login

Source: (Author, 2016)

5.3.1.3 RESTful GET

It RESTfully retrieves data from the underlying database as illustrated in Figure 5.10.

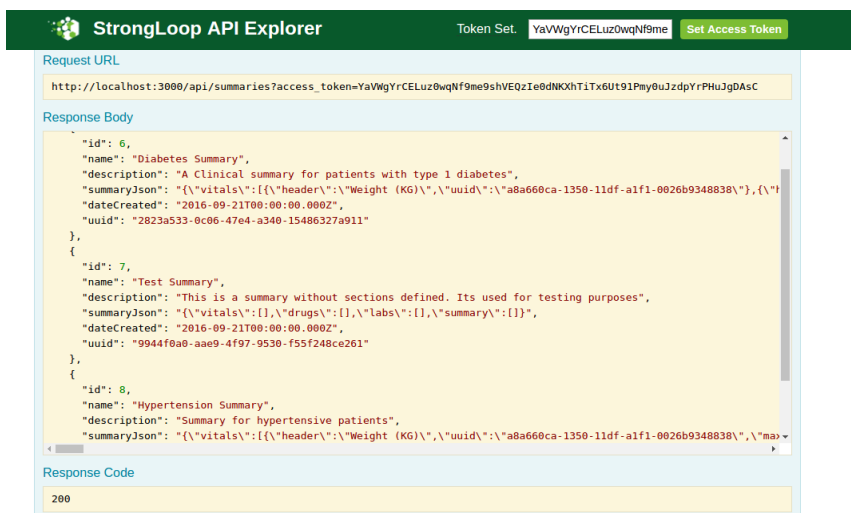


Figure 5.10: RESTful GET

Source: (Author, 2016)

5.3.1.4 RESTful POST

RESTful POST command is used to save or update a Clinical Summary statelessly to the underlying database and with validation as shown in Figure 5.11 and Figure 5.12 respectively.

Figure 5.11: RESTful POST

Source: (Author, 2016)

5.3.1.5 RESTful POST Validation

RESTful validation ensures that data being saved to the underlying database passes integrity constraints applied at business logic level and at the database level. Figure 5.12 indicates a POST command failing while attempting to persist a clinical summary template without a name. The property name of a clinical summary template is required by the database schema as defined in Figure 5.5 and Figure 5.6.

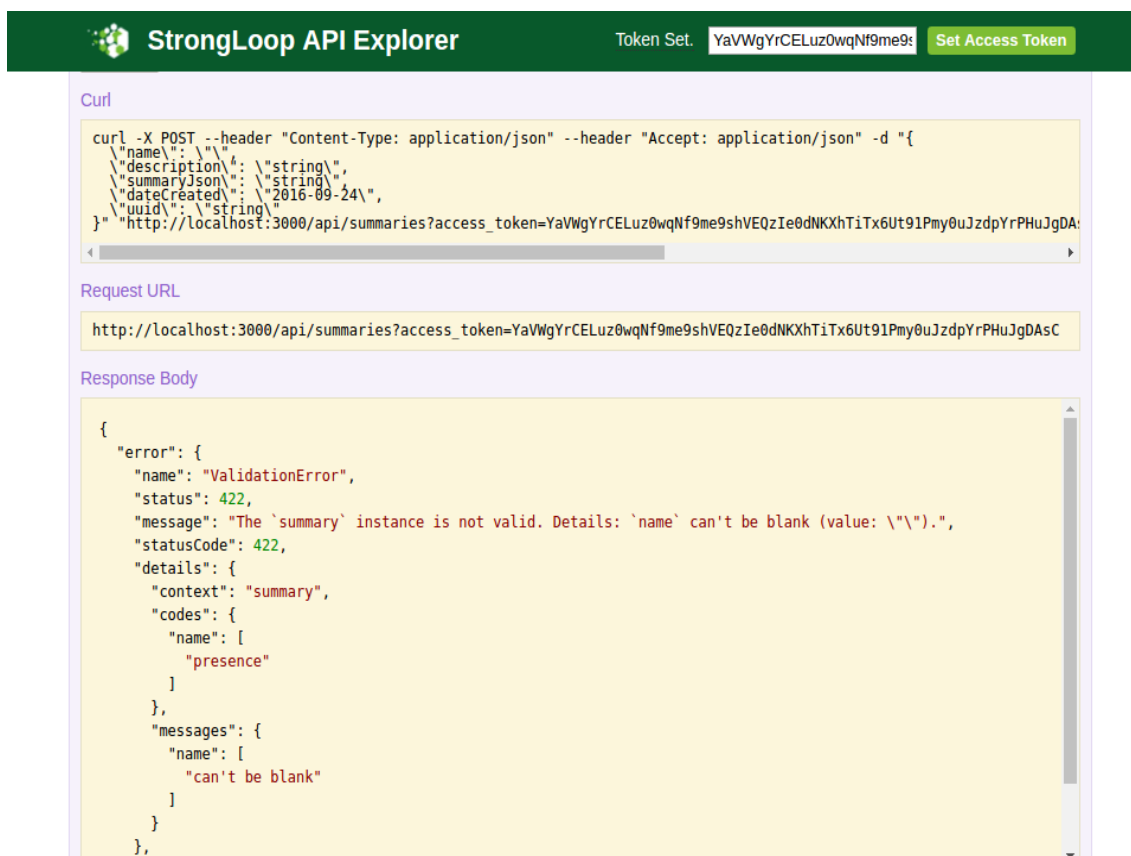


Figure 5.12: RESTful POST Validation

Source: (Author, 2016)

5.3.2 Server Module Web Based Interface

The server side module presents a user with an interface to create a clinical summary template. The template is downloaded to a mobile phone device to generate a clinical summary from patient's encounter data. The module was designed in angularJs and bootstrap and Figures 5.13 to 5.19 illustrates the module's interfaces and its implementation is as depicted in **Appendix XVIII**.

5.3.2.1 Login Page

The login page allows the provider to input his/her authentication credentials as shown in Figure 5.13. After supplying his/her credentials and clicking the 'Sign In' button, the page authenticates against the underlying database by making REST POST login commands (Figure 5.9).

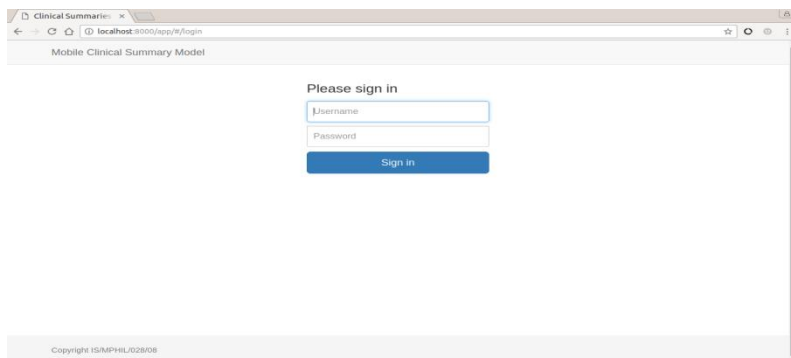


Figure 5.13: Login Page
Source: (Author, 2016)

5.3.2.2 Landing Page

The landing page is the main interface/dashboard to the Clinical Summary Server Side Module (Figure 5.14) and allows the privileged user to manage the Clinical Summary templates by:

- i. Creating new clinical Summary Template.
- ii. Updating an existing Clinical Summary Template.
- iii. Deleting a Clinical Summary Template.

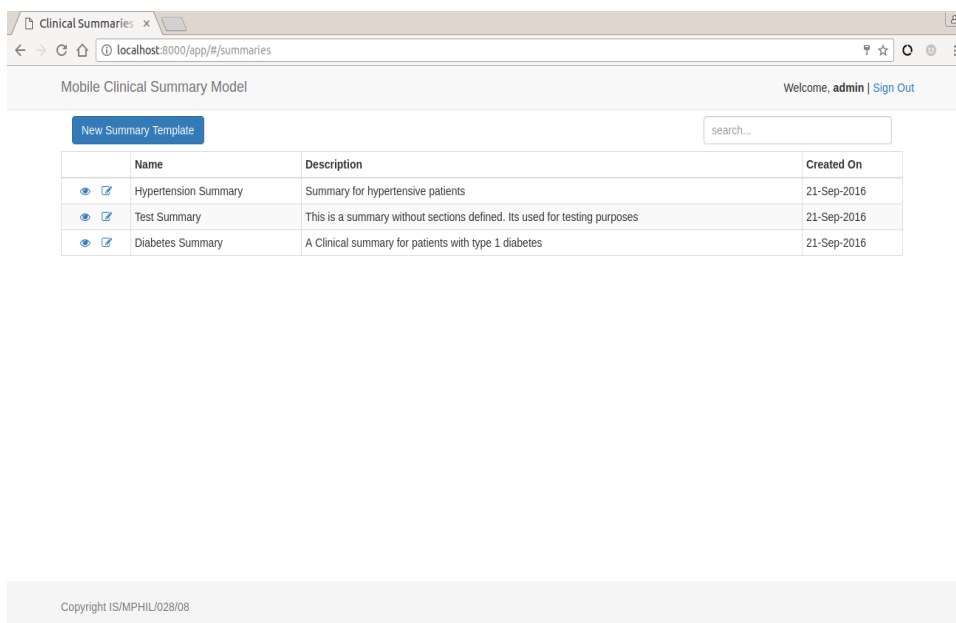


Figure 5.14: Landing Page
Source: (Author, 2016)

5.3.2.3 Create Summary Template

On clicking the New Summary Template button on the Landing Page (Figure 5.14) the window shown in Figure 5.15 appears enabling the user to create a new Clinical Summary Template based on medical criteria by:

- i. Specifying the name of the Clinical Summary Template
- ii. Providing description for the Summary Template.
- iii. Specifying Clinical Summary Parameters to include in the Template as capture by the functional requirements in Figure 4.3

Figure 5.15: Create Summary Template
Source: (Author, 2016)

5.3.2.4 Update Summary Page

The Update Summary Page allows the user to modify or delete an existing Clinical Summary Template as shown in Figure 5.16 and Figure 5.17 respectively. When a clinical summary template is deleted the associated generated clinical summaries on mobile devices are not affected until new clinical summaries are generated with a new template.

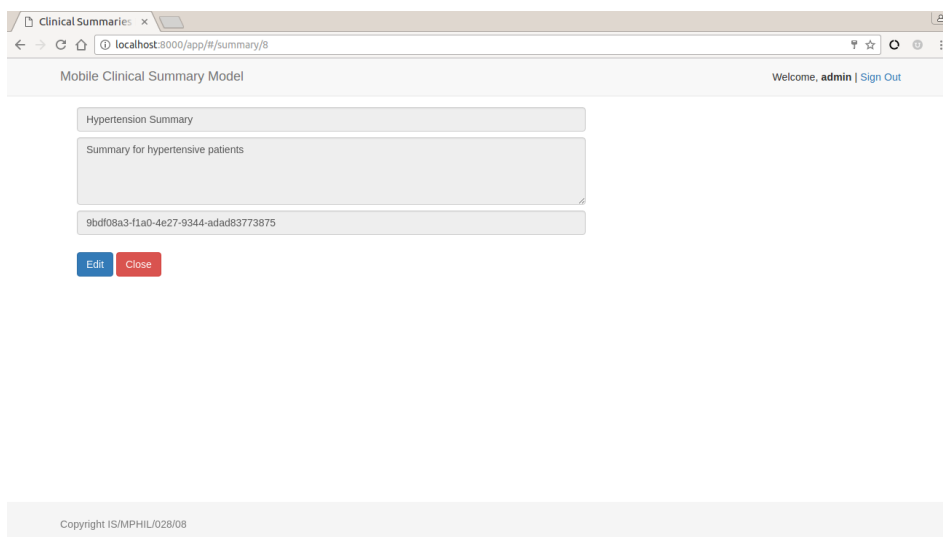


Figure 5.16: Edit Summary Page
Source: (Author, 2016)

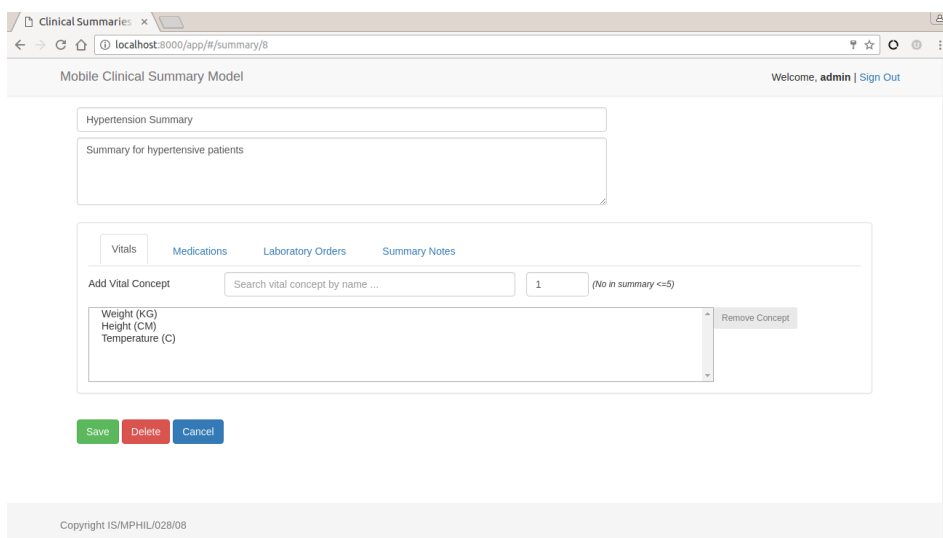


Figure 5.17: Edit Summary Page Two
Source: (Author, 2016)

5.3.2.5 View Summary

The view summary page presents the user with a graphical view of an existing Clinical Summary Template without modifying it as shown in Figure 5.18. The template is displayed as a JSON tree with foldable nodes for readability. Further, using the same view, the user is able to get a wholesome look (all nodes folded) of the template or a detailed view where all nodes are expanded.

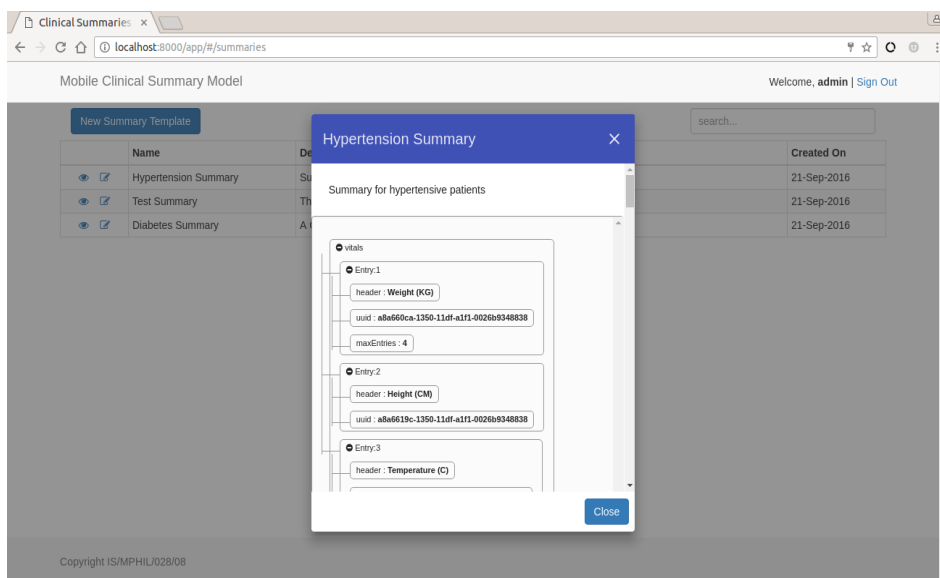


Figure 5.18: View Summary
Source: (Author, 2016)

Appendix XIX shows the sample implementation code for the creation (Figure 5.15), view (Figure 5.18), update and deletion (Figure 5.16) of a clinical summary template.

5.3.3 Mobile Application Prototyping and Testing

This entailed the design and development of the Mobile Application Module of Figure 5.7. The module consumes the Clinical Summary Template created in Figure 5.15 so as to generate a Clinical Summary for a selected patient. As per the scope of the study, the mobile application prototype is for use by providers and patients. The sample code for the implementation of the mobile application module is as illustrated in **Appendix XX**.

Software testing is used to determine if a software product is running as expected. This is achieved by applying some defined test data to the product by test users or by the developers of the product. A test data set mainly has valid and invalid cohorts which are used to verify and validate the product. The model was subjected to some test data (**Appendix XXI**) and found to work as expected. The respective testing screenshots are as shown in Figures 5.19 to 5.25.

5.3.3.1 Mobile Interface for Viewing Patient Information and Meta Data (Summary Notes)

Objective one of the study sought to determine the parameters that compose a clinical summary and hence the purpose of the mobile interface is to enable the providers review patient information/parameters (Figure 4.3) as per the given stage of medical care (Figure 4.1 and Table 4.3). These included patient demographics, vital signs, medications, laboratory orders and Meta-data (Summary Notes) as depicted in Figure 5.19.

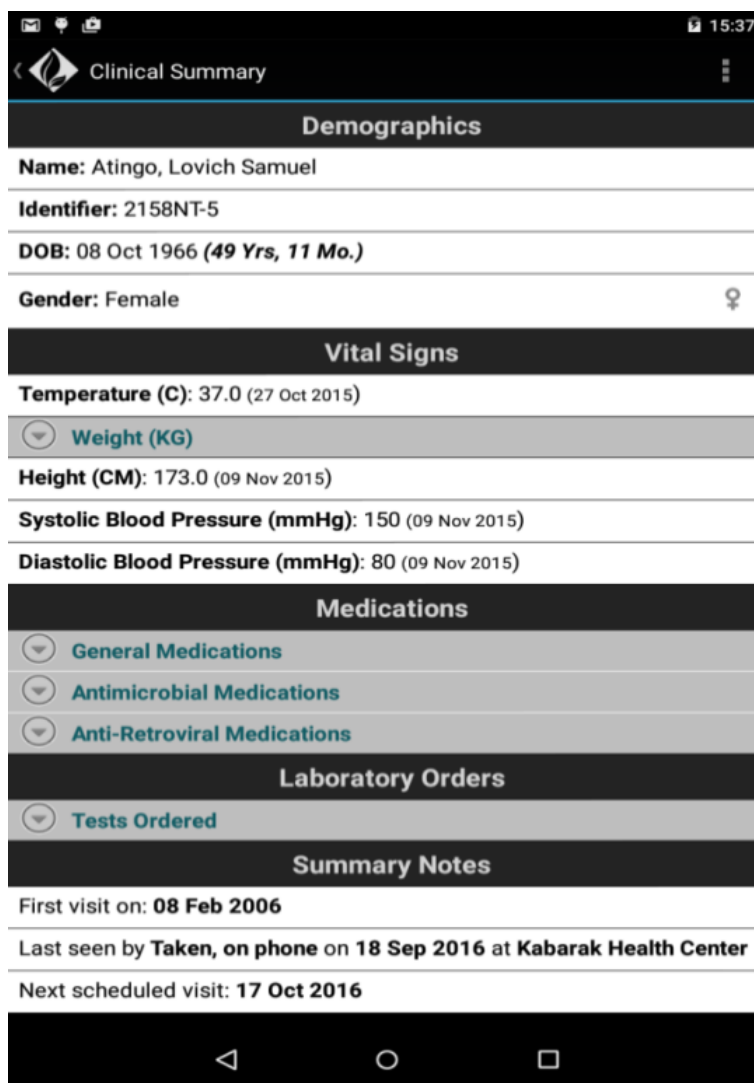


Figure 5.19: Mobile Interface for viewing Patient Information and MetaData (Summary Notes)

Source: (Author, 2016)

Providers should only capture information in the stage they are responsible as per their roles and responsibilities as opposed to the current system used by Kabarak University Health Centre where for example Nurse (N₄) performs “*Clinical diagnosis*” and Nurse (N₁₀) “*Make diagnosis and prescribe medication and give it*” and “*Do laboratory tests if necessary*” as shown in Table 4.3. The aforementioned roles should only be done by Clinical Officers and Doctors.

5.3.3.2 Vital Signs Recorded

As shown in Table 4.3, Nurses (N₂, N₃, N₇, N₉) are responsible for taking patients vital signs and during the testing of the model the vital signs captured by a Nurse for **test patient** - *Atingo, Lovich Samuel* as shown in Figure 5.20 were temperature(C), four instances of patients weight(KG), height(CM) systolic and diastolic blood pressure.

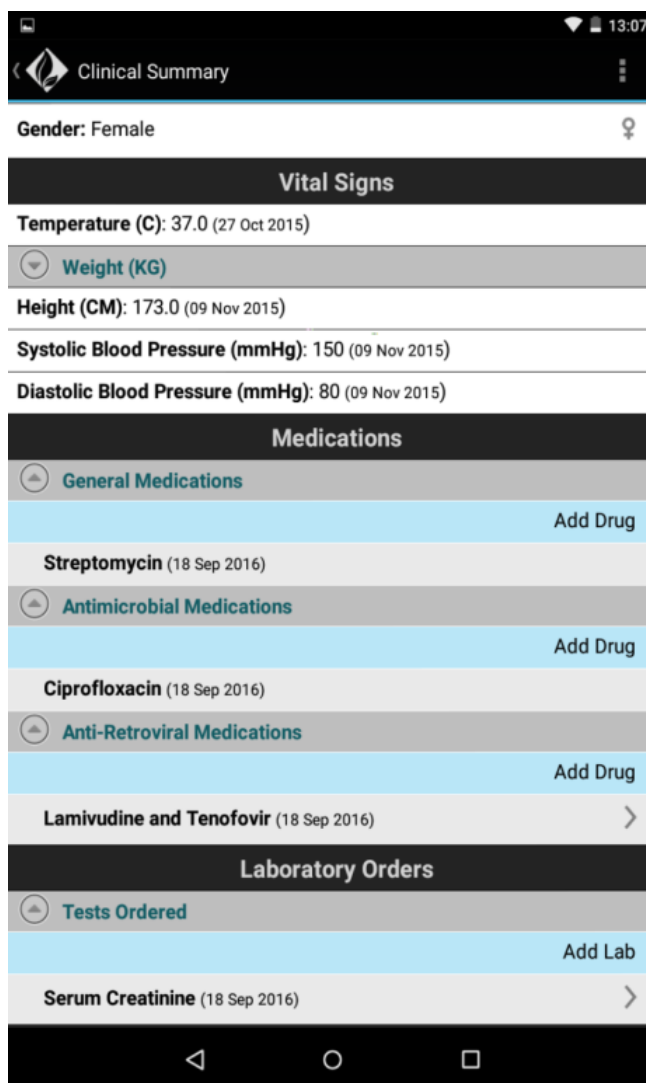
The screenshot displays a mobile application interface for a patient's clinical summary. The top bar shows the time as 13:04 and the title 'Clinical Summary'. Below this, the 'Demographics' section lists the patient's name as 'Atingo, Lovich Samuel', identifier '2158NT-5', date of birth '08 Oct 1966 (49 Yrs, 11 Mo.)', and gender 'Female'. The 'Vital Signs' section shows a temperature of 37.0°C (27 Oct 2015) and a weight history table with values 74.0, 75.0, 65.0, and 45.0 KG. Blood pressure readings are also shown as 150/80 mmHg (09 Nov 2015). The 'Medications' section is currently collapsed, and the 'Laboratory Orders' section shows 'Tests Ordered'.

Weight (KG)	Date
74.0	09 Nov 2015
75.0	27 Oct 2015
65.0	07 Oct 2015
45.0	24 Aug 2015

Figure 5.20: Vital Signs Recorded
Source: (Author, 2016)

5.3.3.2 Medications Recorded as Per Providers Prescription

Medication prescriptions are performed by doctors and clinical officers during the visit stage of medical care as shown in Table 4.3 and Figure 5.21 is a test window showing the categories of medications that have been added as per the vital signs and, or laboratory tests ordered. The test window also shows that a provider with the right privileges can review drug/medications by adding new ones or removing current prescription.



*Figure 5.21: Medications Recorded as Per Providers Prescription
Source: (Author, 2016)*

5.3.3.3 Updating a Clinical Summary

Figure 5.22 shows a provider reviewing a clinical summary for a patient; updating the summary by adding a new Antimicrobial drug/medication. Once the provider synchronizes the mobile clinical summary to the server module, a records officer will be able to update the underlying encounter to indicate the added medications. This is in line with findings in section 4.4.4.6

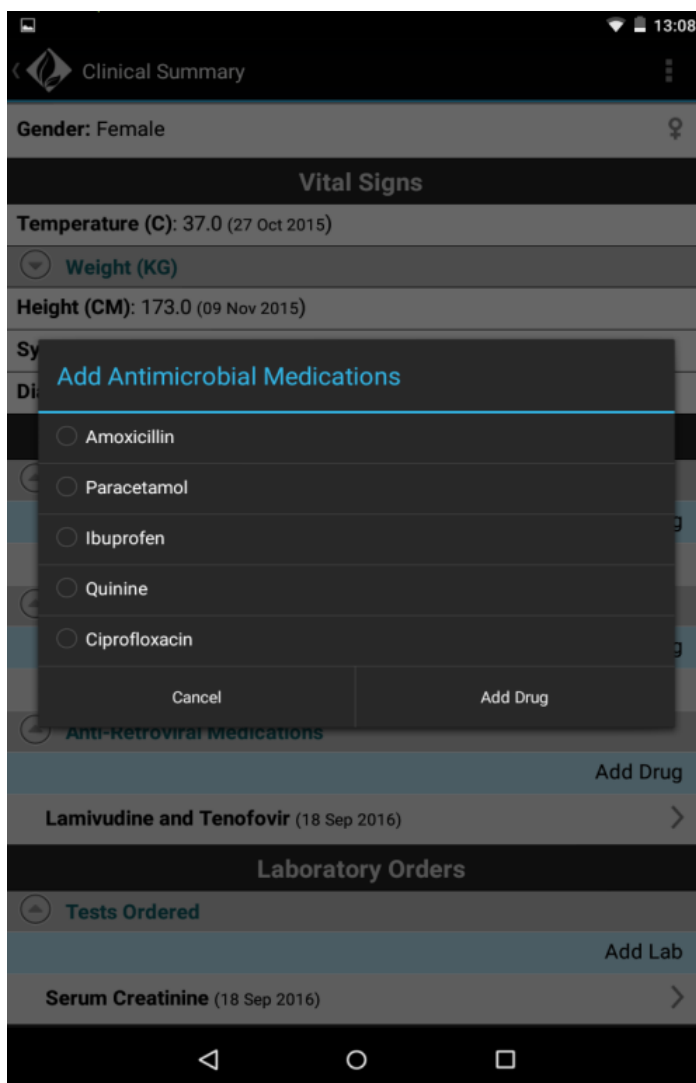


Figure 5.22: Addition of a New Antimicrobial Medication.
 Source: (Author, 2016)

5.3.3.4 Removal of a Medication Added

The purpose of this process/window (Figure 5.23) is to enable a doctor or a clinical officer review and change prescriptions previously administered to a patient. For example, the drug prescribed may be out of stock. This was in line with objective two of the study which sought to assess the providers' and patients' view of clinical summaries. The study did establish that Clinical Summaries are *“Helpful for follow-up purposes”* and are *“Useful in situation where review of treatments is needed”* as indicated by doctor

(D₁) (Table 4.6). Thus, during model testing, the drug/regimen chosen for removal was “*Lamivudine and Tenofovir*” as shown in Figure 5.23.

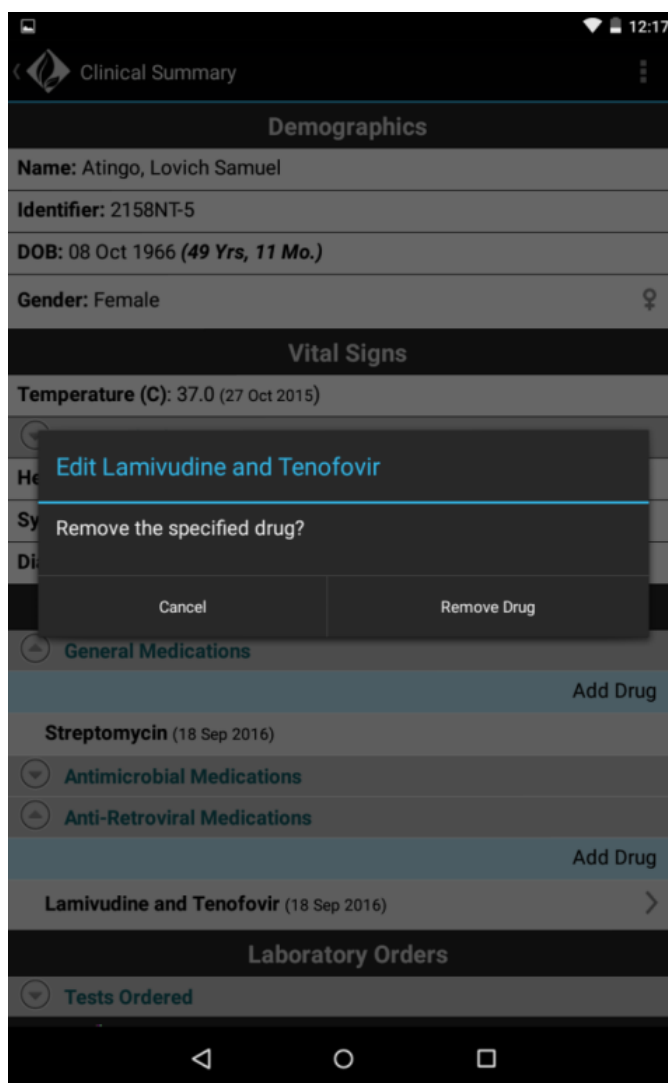


Figure 5.23: Removal of a Medication Added
Source: (Author, 2016)

5.3.3.5 Interface for reviewing Tests Ordered

The model functional requirements gathered (Table 4.3) showed that: Doctor (D₁) “*sends the patient for lab investigation*” whereas the Laboratory technician (for example LT₁) “*Perform laboratory tests and give quality results to the clinicians for patient management.*” This is in agreement with Kabarak University Patient Management Process Guidelines (Kabarak University, 2015) and hence, the Mobile Phone Based

Clinical Summaries model provides in its interface a section for reviewing laboratory tests ordered with option of updating the tests by adding new tests or changing previous ordered tests, Figure 5.24.

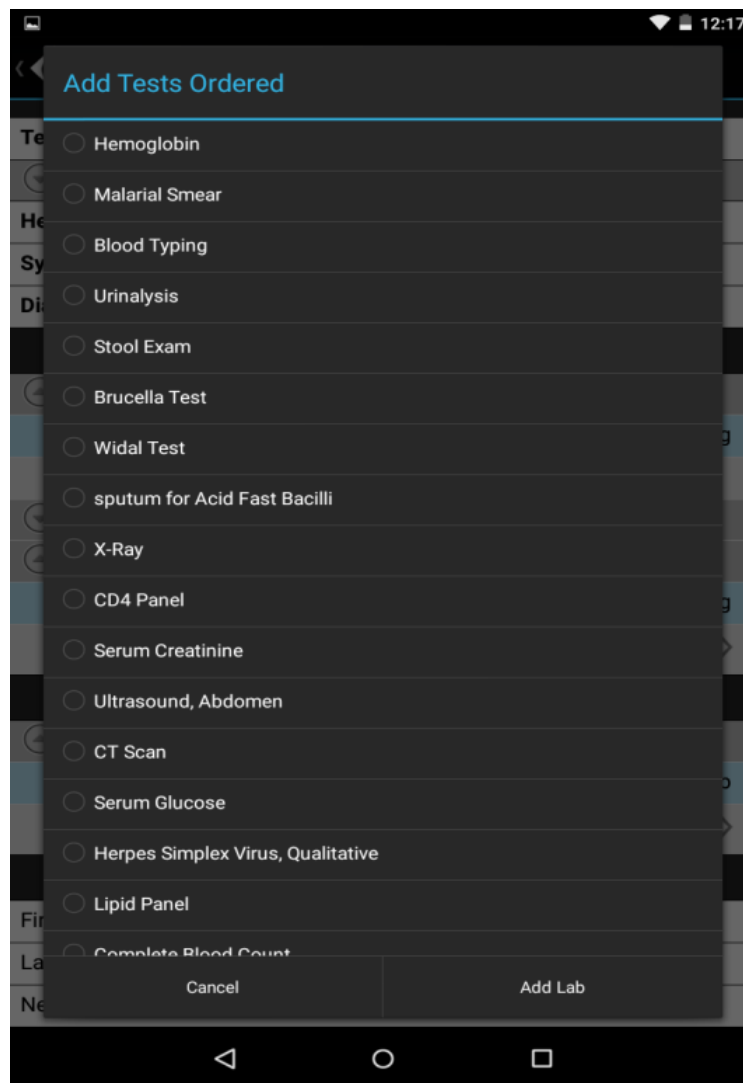


Figure 5.24: Interface for reviewing Tests Ordered
Source: (Author, 2016)

5.3.3.6 Laboratory Orders Listings

Subsequently, the laboratory orders window (Figure 5.25), show the tests (labs) that have been carried out in a test encounter of 18th September 2016 at Kabarak Health Centre and as a result of the process of selecting the tests ordered (Figure 5.24).

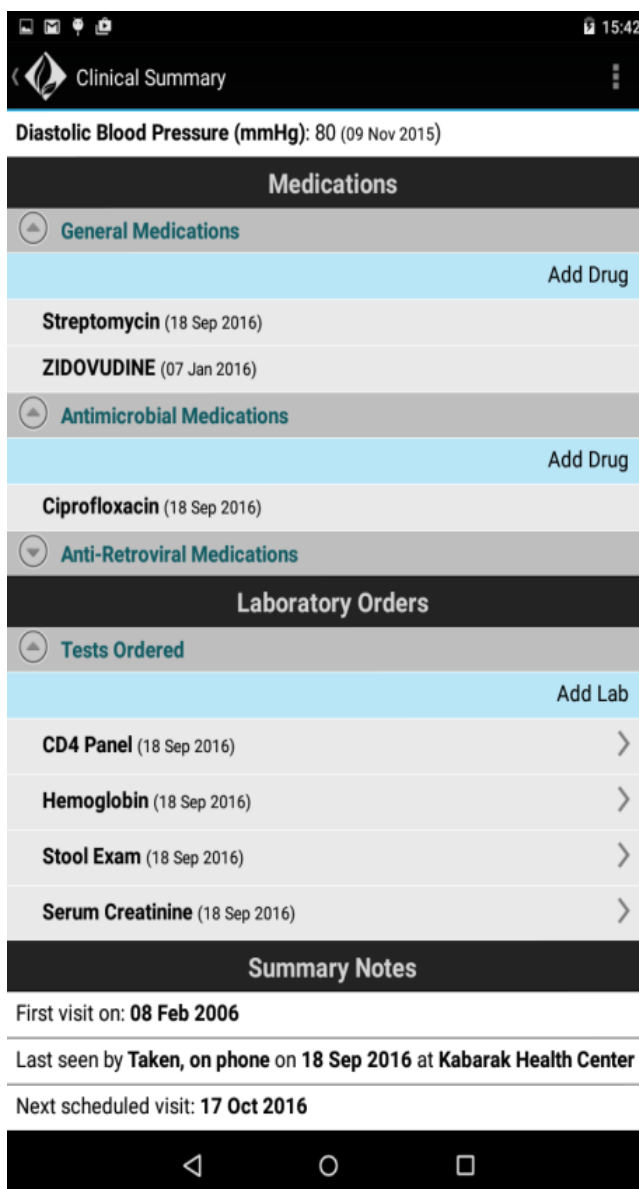


Figure 5.25: Laboratory Orders
Source: (Author, 2016)

5.4 The Model Hardware and Software Requirements

The minimum requirements that were needed to capture and analyze the user requirements, design and deploy the Mobile Phone Based Clinical Summaries model are as summarized in Table 5.1.

Table 5.1: The Model Hardware and Software Requirements

No	Requirements/Specifications	Purpose
1	Android API 19 and above	Model deployment environment
2.	SPSS v.17	Statistical Analysis of quantitative data gathered
3.	Evolus Pencil V 2.0.5	UX Design
4.	Astah Professional-Student Licence	UML Design
5.	JDK v1.6 and above	Java Development Kit
6.	IntelliJ iDEA 2016.2	Java IDE
7.	AngularJS Framework v1.5.8	Server Side Model Development
8.	MySQL	Creation of the server side model database
9.	SQLite	Mobile Side Database
10.	GreenDao	Mobile Side ORM for Database
11.	StrongLoop/Loopback API	Provision of REST Services
12.	Nodejs v3.4.5	Servlet-design and implementation of Model Controllers
13.	Java Server Pages (JSP) and HTML	Web-based user Interface
14.	Server or Desktop (Intel Core i3@2.4GHz, 2GB RAM)	Requirements analysis, design and deployment hardware platform
15.	Ubuntu Linux v16.04	Requirements analysis, design and deployment system software platform

5.5 Chapter Summary

The chapter presented the design and development of the Mobile Phone Based Clinical Summaries model for Providers and Patients. The process encompassed model requirements specifications, model application development process and prototyping and testing. The next chapter presents the study summary, conclusion and recommendations.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

6.0 Chapter Overview

The study aimed to evaluate the clinical summaries system used by Kabarak University Health Centre with a view to designing and developing a Mobile Phone Based Clinical Summaries model for Healthcare Providers. The study was carried out at Kabarak University Health Centre, and targeted 82 respondents. 34 of the target respondents were sampled for the study. The study adopted a mixed research approach, and case study research method. Purposive, stratified and simple random sampling techniques were employed. Interview schedules, questionnaires and documentary analysis were the data collection instruments.

6.1 Summary of Findings

The study aimed to evaluate the clinical summaries system used by Kabarak University Health Centre with a view to designing and developing a Mobile Phone Based Clinical Summaries model for Health Care Providers. The study findings were based on the four objectives defined for the study:

6.1.1 Parameters that Compose a Clinical Summary

The findings showed that the parameters that compose a clinical summary are dependent on the stages of Medicare that a patient goes through in an episode of care and the activities that providers perform at the respective stages (rooming, pre-visit, visit and after-visit) of care as indicated in Figure 4.1 and Table 4.3 respectively. Further, the after-visit summaries (AVS) are provided by all of the doctors and clinical officers but none of them provide pre-visit summaries. However, all of the records officers do provide both the AVS and pre-visit summaries. Subsequently, it was established that the

parameters that compose a Clinical Summary (Figure 4.3) included: patient demographics recorded by nurses and given to patients; vital signs recorded by clinical officers, doctors, nurses and given to patients; medication (drug) list (prescriptions) generated by clinical officers doctors and nurses. However, as demonstrated by the roles and responsibilities of health care providers in Kabarak University Health Centre (Table 2.2), nurses are not supposed to be providing medication prescription to patients. Laboratory results are recorded by clinical officers, doctors and nurses; tests ordered are recorded by clinical officers only while radiological tests and referral/transfer information is recorded by doctors only.

Moreover, in determining the parameters that compose a clinical summary, the study established that the tests normally received by the laboratory technicians included microbiology, chemistry, haematology and transfusion medicine. From the tests received, they generate positive and negative results. Upon completion of generation of results, all the laboratory technicians pass the said results to doctors/clinical officers and 1 of them give the results to patients while none of them give the results generated to nurses, pharmacist or record officers (section 4.3.7).

In an episode of care, the record officers only update return visit date while none of them updates medical prescription and test results as part of pre-visit summary (section 4.3.8). The vital signs (Table 4.4) recorded by nurses included weight, height, temperature, blood pressure and blood sugar. Further the study sought to find out from the patients the information given to them after every visit to Kabarak University Health Centre as contained in the AVS. The findings showed (Table 4.5) that out of 10 patients, 3 received vital signs, 2 receive laboratory results, 2 receive medication (drugs) list and 5 receive information about the next visit date.

6.1.2 Assessment of Providers' and Patients' Use and View of Clinical Summaries

In probing this objective, the study sought to determine the users of the clinical summaries; the importance of clinical summaries in improving health care provision in Kabarak University Health Centre; protocols that govern the collection, storage and use of patient information contained in clinical summaries; formats used by the providers to record patient information, communicate test results, medication dispensed and prescribed and provide clinical summaries to patients.

6.1.2.1 Users of the Clinical Summaries

The study established from the doctors and clinical officers that both patients and providers are the users of clinical summaries (Figure 4.4).

6.1.2.2 The Importance of Clinical Summaries in improving Health Care Provision at Kabarak University Health Centre

The findings from doctors and clinical officers (Table 4.6) showed that clinical summaries help them when they are; reviewing treatments, planning and budgeting and planning for better care and management of patients. Thus, the findings were in agreement with Hummel *et al.* (2012) who observed that a visit enables providers to fill as much information from the examination rather than reconstructing an encounter when a patient has left.

6.1.2.3 Protocols that Govern the Collection, Storage and use of Patient Information contained in Clinical Summaries

The findings in Table 4.7 demonstrated that there are clinical protocols that guide health care providers when handling patient information as contained in the clinical summaries so as to uphold privacy and confidentiality of the patient. This is in line with UNESCO Universal Declaration on Bioethics and Human Rights (UNESCO, 2005). The protocols

included confidentiality, SOP guidelines, EQC's, IQC and the national guidelines for reporting different results (Table 4.7)

6.1.2.4 Formats used by the Providers to Record Patient Information, Communicate Test Results, Medication Dispensed and Prescribed and Provide Clinical Summaries to Patients

The study findings in Table 4.8, Table 4.13, sections 4.4.4.2-6, 4.4.4.7.2, 4.4.4.7.7 and 4.4.4.7.11 showed that the formats used by the various providers in recording patient information, communicating test results, medication prescribed, medication dispensed and its dosage and in the provision of clinical summaries are handwritten, verbal, pre-printed form/checklist and/or Electronic Medical Records System (EMR). These formats fall into level 1, 2 or 3 of the Health Information Exchange and Interoperability Taxonomy (Walker *et al.*, 2005 as quoted by OECD (2010)). However none of the providers and patients has used email and/or SMS which also fall under level 3 of the taxonomy like the EMR. Further, none of the formats used fall under level 4 of the taxonomy which supports standardized exchange of machine –interpretable data with no human intervention in the extraction and conversion of content.

6.1.2.5 Patients Satisfaction with Information provided and its Formats

From the study findings it was established that 90% and 80% of the patients were satisfied with the information provided and its formats respectively as seen in sections 4.4.4.7.14-15.

6.1.3 Challenges with the Current System of Recording Clinical Summaries at Kabarak University Health Centre

In order to establish the challenges with the current system of recording clinical summaries, the study sought to determine: the type of system used to capture the information in an episode of care, how the records officers aggregate the patient

information in a manual system, the length of time it takes to aggregate the information, the sections that have been computerized and the challenges the records officers face when using the system.

6.1.3.1 The Types of Systems used to Capture Information in an Episode of Care

The findings in Table 4.16 revealed that both manual and computerised systems are under use by Kabarak University Health Centre while a mobile phone based system has never been used by the records officers to record/capture patient information in an episode of care.

6.1.3.2 Aggregation/Consolidation of Patient Information by the System

The study findings showed that the systems in use by the Kabarak University Health Centre do consolidate all patient information recorded in the different stages of care (Table 4.3) as depicted by the responses in Table 4.16.

6.1.3.3 Sections that have been computerized

The study findings showed that records, consultation, laboratory, and pharmacy sections have been computerised as shown from the 66.7 % response (section 4.5.1.2), 70% usage of EMR by the nurses (Table 4.8), 100% communication of laboratory test results through the EMR (section 4.4.4.2), 100% tracking of medication through the EMR by the pharmacist (section 4.4.4.3) and 2 out of 3 pharmacist communicating prescription changes through the EMR (section 4.4.4.6). The aforementioned findings are confirmed by the findings provided informatician (Table 4.15). Therefore, the computerisation of all the sections makes the implementation of the Mobile Phone Based Clinical Summaries as conceptualized in Figure 5.7 technically feasible.

6.1.3.4 The Length of time it takes to Aggregate/Consolidate the Patient Information

The findings indicated that the system used by Kabarak University Health Centre aggregates the patient information immediately (Table 4.16). Thus the findings were in agreement with Sepucha's *et al.* (2004) observations who observed that electronic systems can provide clinicians with real-time information.

6.1.3.5 Challenges with the Current System of Recording Clinical Summaries at Kabarak University Health Centre

The challenges encountered by the providers in recording clinical summaries at the University Health Centre include:

- Communication challenges such as poor handwriting which is difficult to comprehend (Table 4.17).
- Technological challenges brought about by power failure, poor network connectivity, lack of computers for data capture and storage, disjointed EMR modules and disparate systems (Table 4.17).
- Provision of false information by patients which alters diagnosis (Table 4.17)
- Confidentiality/privacy issues arising from the fact that the providers hold vital information (Table 4.17)
- Patients' ignorance for example by ignoring return dates (Table 4.17).
- Patients being uncooperative in provision of information (Table 4.17).
- Policy challenges such as unclear policy on private ICT devices (Table 4.17).
- Reporting Challenges being generation vertical management reports rather than horizontal patient centred reports (Table 4.15)

6.1.4. Design and Development of the Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.

The researcher sought to design the Mobile Phone Based Clinical Summaries model for Health Care Providers and Patients at Kabarak University Health Centre as per the functional requirements elicited from objectives one, two, three and the study assumptions. The study established that all providers at Kabarak University Health Centre have access to ICTs in their offering of health services to patients (Tables 4.8 and 4.15 as well as sections 4.4.4.2-3 and 4.4.4.6). Further, the study findings established that majority of the patients own and use mobile phones (70%) (Table 4.18), majority of whom own a smart phone or tablet (83.3%) and 16.7% owning a feature phone (section 4.6.2). In addition, the study findings showed that all the patients who responded indicated that the phones specified in section 4.6.2 are privately owned (Table 4.19). This demonstrates that the electronic clinical summaries that will be generated by the model developed are highly likely to be consumed by the providers and patients while maintaining patient confidentiality owing to the private ownership of mobile phones.

Subsequently, based on the aforementioned functional requirements gathered during the study, the researcher designed and developed a Mobile Phone Based Clinical Summaries model for use by Kabarak University Health Care Providers and Patients as guided by Systems theory, Health Level Seven (HL7) and Statistical Data eXchange-Health Domain (SDMX-HD) standards based on the REST light weight protocol. The study further adopted the Mobile Application Development Life Cycle (MADLC) framework in the development on the mobile module of the model and the Model Driven Software Development (MDSD) methodology for the development of the server side module and the REST APIs.

The developed model falls under level four of the Healthcare Information Exchange and Interoperability Taxonomy as put forth by Walker *et al.* (2005) and quoted by OECD (2010) (Table 2.4) and the Mobile Phone Based Clinical Summaries model Conceptual Design Block Diagram illustrating communication between the model and the Kabarak University Health Centre EMR (Table 4.15) is as illustrated in Figure 5.7

6.2 Conclusion

The study was guided by the following four objectives: to determine parameters that compose a clinical summary; to assess providers' and patients' view and use of clinical summaries; to establish the challenges with the current system of recording clinical summaries at Kabarak University Health centre and to design and develop a Mobile Phone Based Clinical Summaries model For Health Care Providers and Patients at Kabarak University Health Centre. The study was premised on the assumptions that the current system used by Kabarak University health centre in providing clinical summaries to providers has gaps and limitations that need to be addressed and that the health centre embraces ICTs in its provision of health services.

Therefore, the following conclusions were drawn based on the respective objectives: The study established that that the patient parameters that make up a clinical summary are dependent on the stages of medical care that a patient goes through in an episode of care. The resulting parameters were patient demographics, vital signs, medication lists, test ordered, radiological tests, laboratory results and referral/transfer information.

The assessment of the providers 'and patients' view and use of clinical summaries upon which the parameters are contained revealed that clinical summaries enabled the providers to review treatments and plan for better care and management of patients. The summaries are either in handwritten, verbal, pre-printed form/checklist and/or Electronic

Medical Records System (EMR) formats which fall under levels 1, 2, and 3 of the Health Information Exchange and Interoperability Taxonomy. This provision of clinical summaries in different formats implies that the summaries suffer from the inherent challenges of data incompatibility owing to the requirement of human intervention. However, level four of the taxonomy ensures that the clinical summaries are exchanged using a uniform messaging format irrespective of the EMR platform hence ensuring interoperability implying that the care providers will disseminate the results emanating from an episode of care in an effective and efficient manner leading to better health care and patient satisfaction.

Further, the challenges with the current system of recording clinical summaries at Kabarak University Health Centre were dependent of the type of systems used to capture the patients parameters in an episode of care which inherently determined the format upon which the providers and the patients communicate. This would subsequently determine the effectiveness and efficiency of care provision and thus patient satisfaction. Hence, the study established that the current system has limitations and gaps (Table 4.17) inhibiting adoption of clinical summaries.

Therefore, based on the findings established from objectives one, two and three, a Mobile Phone Based Clinical Summaries model for use by Kabarak University Healthcare Providers and Patients was designed and developed as guided by Systems Theory (Friedman & Allen, 2011), HL7 and SDMX-HD standards (WHO, 2009) and based on the REST protocol (Kumari, 2015). The model effectively ensures that the formats used in the transmission of Kabarak Health Centre patient level data are based on level four formats as per the Health Information Exchange and Interoperability Taxonomy. In addition, the model ensures that the providers are assigned roles and

responsibilities based on their professional job descriptions and the stage(s) they handle the patients in an episode of care. This implies that for example, a nurse will not make diagnosis and prescribe medication as demonstrated by the study findings. Hence, this ensures that confidentiality and privacy is upheld by the providers in handling the patient as prescribed by the medical protocols and Article 9 of the UNESCO Universal Declaration on Bioethics and Human Rights (2005). Further, by providing non-actionable summaries on patient's mobile phones, the model empowers the patients by allowing them to participate in their own care as envisioned by Markle Foundation (2012).

Finally, the model is cost effective and efficient to use by the providers and patients and will enable them to monitor and evaluate the health performance of the patients wi

6.3 Recommendations

From the findings and conclusion of the study the following recommendations were made:

6.3.1 Realization of Roles and Responsibilities of Health Care Providers

Privacy and confidentiality are some of the greatest constraints on a health system. The study thus recommends that Kabarak University Health Centre employs measures to realize segregation of the duties and responsibilities of the various care givers.

6.3.2 Application of ICTs in Health Information Exchange and Consumption

The study established that the clinical summaries at Kabarak University Health Centre are available in formats which fall under level 1 and 2 of the Health Information Exchange and Interoperability Taxonomy. Clinical summaries presented in these formats are prone to illegibility and misplacement. Hence, to overcome the aforementioned

challenges the study recommends that the health centre adopts systems which provide clinical summaries in level 3 and 4 formats of the Health Information Exchange and Interoperability Taxonomy.

6.3.3 Adoption of the Mobile Phone Based Clinical Summaries Model

The study established that Kabarak University Health Centre avails clinical summaries to both providers and patients in verbal and paper based formats (manual system) even though it employs an EMR in recording and storage of patient related data. The developed model if adopted will utilize the EMR to provide better, up to date, timely and actionable clinical summaries hence enhancing effectiveness and efficiency in patient management while realizing privacy and confidentiality of patient health data. In addition the model eliminates human errors in the generation of clinical summaries by operating autonomously. The model can further be enhancing to include clinical decision support to even empower the providers at the health centre.

6.4 Further Areas of Research

The study was premised on the assumption that there exist gaps in the use of clinical summaries to better provision of health care by placing information at the hands of those who really need it: health care providers and patients. The findings of the study sustained this assumption which the study sought to address by developing the Mobile Phone Based Clinical Summaries model. However, the study findings shows that there are other factors beyond the scope of this study that affect the use of clinical summaries in health care provision and may also impact on the use of the model if adopted. It is therefore suggested that;

- i. A study be undertaken on the impacts of electrical power availability and reliability in the adoption of ICTs in the health sector in Kenya since the study evidences this as a major challenge.
- ii. The clarity and level of applicability of existing policies on health information management should be investigated and addressed.
- iii. A study should be conducted to evaluate the impacts of language as a barrier to access of quality health care services.
- iv. Finally, in order to optimally benefit from the implementation of the developed model, investigation should be undertaken on the impacts of Personal Health Records System (PHR) on the adoption, uptake and consumption of clinical summaries.

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APPENDICES

Appendix I: Letter of Introduction



MOI UNIVERSITY
DEPARTMENT OF INFORMATION TECHNOLOGY

Tel. 0722 836 972 / 0723 391 800
Fax No. 053-43047,43360
Email: dit@mu.ac.ke / hodit@mu.ac.ke

P.O. Box 3900
Eldoret - 30100
Kenya

Our Ref:.....IS/MPHIL/28/08.....

14th October 2015

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: SAMUEL THAIYA MBUGUA (IS/MPHIL/28/08)

The above named is a bona fide student of Moi University pursuing **Master of Science (MSc)** in **Information Technology** Degree at our Information Technology Department.

As a partial fulfillment of this degree, he will be required to conduct a research study. The title of his research is "**A Mobile Phone Based Clinical Summaries System for Health Care Providers: A Case of Kabarak University Health Centre**"

We would be grateful if you could be kind enough to allow him to conduct his research study in your organization. Any assistance accorded to him will be highly appreciated.

Please do not hesitate to contact the undersigned for any further information.

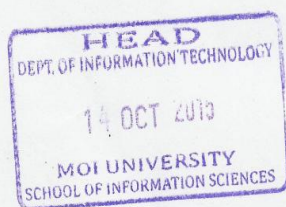
Thank you.

Yours sincerely,

DR. IRENE MOSETI

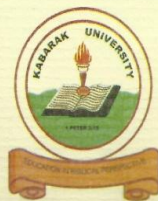
Head,

DEPARTMENT OF INFORMATION TECHNOLOGY



IM/cam

Appendix II: Letter of Approval



Office of the Registrar (Administration & Human Resources)

Private Bag - 20157
KABARAK, KENYA
Email: Registrar@kabarak.ac.ke

Tel: 254-51-343509
Fax: 254-51-343529
www.kabarak.ac.ke

5th January 2016

Mr. Samuel T. Mbugua
Moi University
School of Information Science
P.O. Box 3900 - 30100
ELDORET

Dear Mr. Mbugua,

RE: APPLICATION TO UNDERTAKE RESEARCH

This is to acknowledge receipt of your letter dated 4th January 2016 on the above subject.

I am pleased to inform you that your request to undertake your research in Clinical Summaries and selected Kabarak Health Clinic for a period of one year has been approved. We would also appreciate if you would share with us your research findings.

Thank you for choosing to undertake your research thesis at Kabarak University.

Yours sincerely,

Prof. Ronald K. Chepkilot
REGISTRAR (ADMIN. & HR)

C.C. Deputy Vice Chancellor (A & R)
Registrar (A & R)

RKC/ccb

Kabarak University Moral Code

As members of Kabarak University family, we purpose at all times and in all places, to set apart in one's heart, Jesus as Lord. 1 Peter 3:15

Appendix III: Questionnaire for Doctors

The questionnaire is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.”

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by answering the following questions.

1. At what stage of medical care do you normally handle a patient?(*tick all that apply*)
 Huddle Rooming Pre-visit Visit After-visit
2. What activities/diagnosis do you perform at the given stage(s)? _____

3. What types of clinical summaries do you provide?
 Pre visit Summaries After Visit Summaries
 Others, Specify _____
4. What kind of information is contained in the summaries stated in (4) above?
 Patient Demographics Vital Signs Medication List Lab Results
 Tests Ordered Others, Specify _____

5. Who are the users of the clinical summaries specified in (4) above
 Providers Patients Both
6. How important are clinical summaries in improving healthcare provision at Kabarak University Health centre and its community? _____

7. Are there any protocols that govern the collection, storage and use of the patient information contained in the clinical summaries? _____

Thank you for participating

Appendix IV: Interview Schedule for Doctors

The interview is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “*A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.*”

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by responding to the following questions.

1. At what stage of medical care do normally handle a patient?
2. What activities/diagnosis do you perform at the given stage?
3. What types of clinical summaries do you provide?
4. What kind of information is contained in the summaries specified in (3) above?
5. Who are the users of the clinical summaries specified in (3) above
6. How important are the clinical summaries in improving healthcare provision at Kabarak University Health centre and its community?
7. Are there any protocols that govern the collection, storage and use of the patient information contained in the clinical summaries?

Appendix V: Questionnaire for Clinical Officers

The questionnaire is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.”

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by answering the following questions.

1. At what stage of medical care do you normally handle a patient?(*tick all that apply*)
 Huddle Rooming Pre-visit Visit After-visit
2. What activities/diagnosis do you perform at the given stage(s)? _____

3. What types of clinical summaries do you provide?
 Pre visit Summaries After Visit Summaries
 Others, Specify _____
4. What kind of information is contained in the summaries stated in (4) above?
 Patient Demographics Vital Signs Medication List Lab Results
 Tests Ordered Others, Specify _____

5. Who are the users of the clinical summaries specified in (4) above
 Providers Patients Both
6. How important are clinical summaries in improving healthcare provision at Kabarak University Health centre and its community? _____

7. Are there any protocols that govern the collection, storage and use of the patient information contained in the clinical summaries? _____

Thank you for participating

Appendix VI: Questionnaire for Nurses

The questionnaire is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.”

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by answering the following questions.

1. At what stage of medical care do you normally handle a patient?(*tick all that apply*)

Huddle Rooming Pre-visit Visit After-visit

2. What activities/diagnosis do you perform at the given stage(s)? _____

3. What kind of patient information do you normally capture/record?

Patient Demographics

Vital Signs

Medication List

Lab Results

Tests Ordered

Others, Specify _____

4. In what format(s) do you record the information specified in 3 above?

Handwritten

Pre-printed form

Electronic Medical Record System

Others, Specify _____

5. What challenges do you face in capturing/recording the information specified in 3 above? _____

Thank you for participating

Appendix VII: Questionnaire for Pharmacist

The questionnaire is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.”

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by answering the following questions.

1. At what stage of medical care do you normally handle a patient?(*tick all that apply*)

Huddle Rooming Pre-visit Visit After-visit

2. What activities/diagnosis do you perform at the given stage(s)? _____

3. How do you keep track of the medications/drugs prescribed to a patient?

Handwritten medication list

Pre-printed medication checklist

Electronic Medical Records System

Others, Specify _____

4. Do you communicate to the patient on the medication/drug dispensed?

Yes No

- a. If Yes, in what format?

Verbally

Handwritten

SMS

E-mail

Others, Specify _____

- b. If No, why?

5. Do you communicate to the patient on the medication/drug dosage?

Yes No

a. If Yes, in what format?

Verbally

Handwritten

SMS

E-mail

Others, Specify _____

b. If No, why?

6. Are there situations where you change a patient's drug prescription?

Yes No

7. If yes, how do you communicate such changes to:

a. The episode provider?

Verbally

Handwritten

Electronic Medical Records System

E-mail

Others, Specify _____

b. The patient?

Verbally

Handwritten

SMS

E-mail

Others, Specify _____

Thank you for participating

Appendix VIII: Questionnaire for Laboratory Technician

The questionnaire is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.”

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by answering the following questions.

1. At what stage of medical care do you normally handle a patient?(*tick all that apply*)

Huddle Rooming Pre-visit Visit After-visit

2. What activities/diagnosis do you perform at the given stage(s)? _____

3. What kind of tests do you normally receive from providers?

- MicroBiology (Mycology, Virology, Parasitology, Serology)
 Chemistry (Routine testing, Therapeutic drug monitoring)
 Hematology (Coagulation, Full Haemogram, Body Fluid Analysis)
 Transfusion Medicine (Compatibility Testing, Component Preparation)
 Others, Specify _____

4. What kind of test results do you generate?

- Positive Results
 Negative Results
 Indicative Results
 Predictive Results
 Others, Specify _____

5. Who is the recipient of the results in (4) above?

Doctor/Clinical Officer

Nurse

Pharmacist

Records Officers

Patient

Others, Specify _____

6. In what formats do you communicate the test results?

Verbal

Handwritten

Pre-printed checklist

Electronic Medical Records System

Email

SMS

Others, Specify _____

7. What are the guiding protocols in disseminating test results? _____

8. What challenges do you encounter in disseminating test results? _____

Thank you for participating

Appendix IX: Questionnaire for Records Officer

The questionnaire is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on "A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre."

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by answering the following questions.

1. At what stage of medical care do you normally handle a patient?(*tick all that apply*)

Huddle Rooming Pre-visit Visit After-visit

2. What activities/diagnosis do you perform at the given stage? _____

3. What kind of information do you record in an episode of care?

Medical Prescription Test Results Return Visit Date

Others, Specify _____

4. (a) What type of system do you use to keep the information captured in (3) above?

Manual Computerised Mobile

Others, Specify _____

- (b) Do the systems in 4(a) above aggregate the patient information?

Yes No

(i) If yes, how? _____

(ii) If no, why? _____

- (c) If computerized, which sections?

Records Pharmacy Lab Consultation

Others, Specify _____

5. How long does it take to aggregate the information?

Immediately Less than 1hr 1-2hrs Within a day

Other, Specify _____

6. Do you provide pre- visit summaries to patients(s)?

Yes No

a) If Yes,

(i) In what format(s) do you provide the summaries?

Handwritten Computer Printed SMS Email

Others, Specify _____

(ii) How often?

Always

For specific type of care Specify _____

Never

b) If No, why? _____

7. Do you update patient's pre-visit summaries?

Yes No

a) If Yes,

(i) What parameters do you update?

Medication Prescription Test Results Return Visit

Others, Specify _____

(ii) How often do you update?

Always

For specific type of care Specify _____

Never

b) If No, why? _____

8. Do you provide after visit summaries to patients?

Yes No

a) If Yes,

(i) In what format(s) do you provide the summaries?

Handwritten Computer Printed SMS Email

Others, Specify _____

(ii) How often?

Always

For specific type of care Specify _____

Never

b) If No, why? _____

9. What challenges do you encounter when using the format(s) of presentation specified in 6(a)(i) and 8(a)(i) above? _____

Thank you for participating

Appendix X: Provider Questionnaire – Definition of Terms

Huddle:

The purpose of the huddle is to mentally prepare the clinical team, synchronize staff expectations, and assemble the information and equipment needed for the visit. This step of mental preparation for each patient on the day's schedule is designed to improve the team's efficiency in making clinical decisions during the limited time the patient is in the clinic.

Rooming:

The health care staff gets basic information before patient meets the provider (e.g. the doctor). The second purpose of this step is to gather as much information as possible for the visit and record it before the provider and patient use that information to make clinical decisions.

Pre-Visit:

The patient is assisted to review the previous episode, medications lists and other prescriptions. Patients and clinical assistants identify medications that the patient is, or may be taking, thereby speeding up the medication list verification process.

Visit:

The goal for the visit should be for the provider to fill in as much of the information from the examination (completing the history, review of systems, assessment, and plan) as possible during the encounter and to complete the chart note in the exam room.

After-Visit:

The patient has seen the doctor, has labs taken and medications dispensed. The patient may be given a summary of the current episode of care

Pre-Visit Summary:

A reference summary (e.g. medical card) detailing records captured in the last episode of care. It may contain a list of medications dispensed – with dosages, any other medications the patient is under prescribed or not etc.

After-Visit Summary:

A summary (e.g. medical card) detailing care provided today, generated (and or not) given to a patient after an episode of care. The card may contain lab results, medications dispensed, indicators, return visit date etc.

Appendix XI: Questionnaire for Patients

The questionnaire is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “A *Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.*”

The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by answering the following questions.

1) What made you choose Kabarak University Health Centre?

2) Is this your first time at this health institution?

Yes No

3) For every visit you make to this health institution, are you normally given information about your previous medical history prior to being treated?

Yes No

4) If Yes,

a) What information are you normally given?

b) In what format are you given?

Printed form Handwritten SMS E-mail

Others, Specify _____

c) Are you normally satisfied with the details given?

Yes No

d) Are you normally satisfied with the format used in giving the information? Yes No

5) If No, would you like to be provided with such information before seeing the doctor? Yes No

6) During the current visit (and all previous) do the nurses take and record any of the following information (*vital signs*)? (*tick all that apply*)

Weight Height Temperature

Blood pressure Blood sugar

Others, Specify _____

7) After every visit you make to this health institution, are you normally given information about the treatment provided?

Yes No

8) If Yes,

a) What information are you normally given?

Vital signs (*as indicated in question 6 above*)

Lab results

Medication (drugs) list

Next visit date

Others,

Specify _____

b) In what format are you given this information?

Printed form Handwritten SMS E-mail

Others,

Specify _____

c) Are you normally satisfied with the information given?

Yes No

d) If no, what additional information would you like to be provided with?

e) Are you normally satisfied with the format used in giving this

Yes No

f) How promptly is this information given to you?

Immediately Less than 1 hr 1-2hrs Within a day

Others, Specify _____

9) If No, what information would you like to be provided with after every visit?

Vital signs (*as indicated in question 6 above*)

Lab results

Medication (drugs) list

Next visit date

Others, Specify _____

10) How would like to receive this information?

Printed form Handwritten SMS E-mail

Others, Specify _____

11) Do you own and/or use a mobile phone or tablet?

Yes No

12) If Yes;

a) What type (refer to the attached picture sheet)?

PDA (Personal Digital Assistant)

Basic Phone (Voice and SMS Only)

Feature Phone (Have internet connection)

Smart Phone or tablet (with GPS, camera, touch screen)

b) Is it shared or private?

Private

Shared

Thank you for participating

Appendix XII: Patients Questionnaire – Device Type Reference

A palmtop digital device that functions as a personal organizer and also provides e-mail and internet access.



Basic Phone

A phone that provides only voice and SMS features.



Feature Phone

A feature phone adds more features to a basic phone. It has internet and simple gaming applications. It has a physical keyboard and a small screen.



Smart Phone and Tablet

Latest mobile phones and tablets with rich features such as built-in cameras, GPS, and touch screens.



Smart Phone

Tablets



Appendix XIII: Interview Schedule for Informaticians

The interview is being administered by Mr. Samuel Mbugua. I am a Master of Science in Information Technology student in the School of Information Sciences, Moi University undertaking a Masters Research degree on “*A Mobile Phone Based Clinical Summaries Model for Health Care Providers and Patients at Kabarak University Health Centre.*”

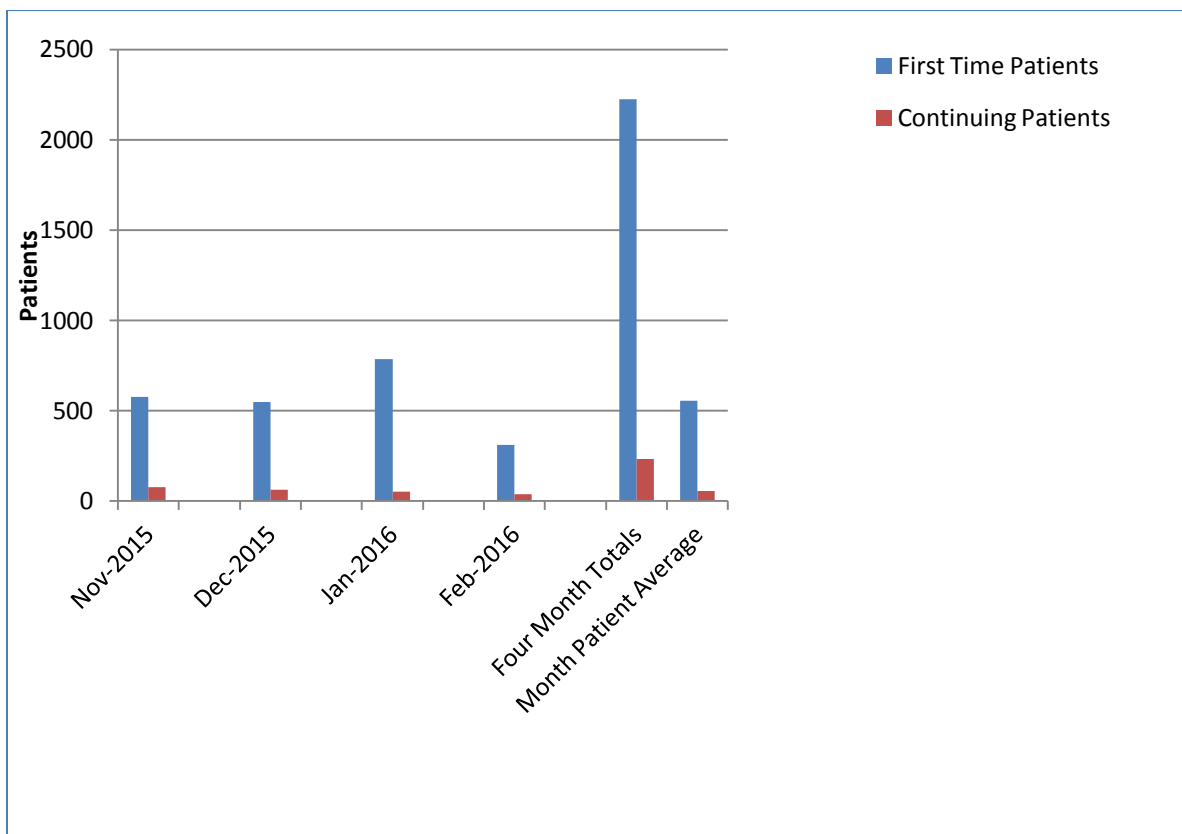
The purpose of this task is to gather information on clinical summaries system for my thesis.

You are requested to spare a few minutes of your time schedule to help by responding to the following questions.

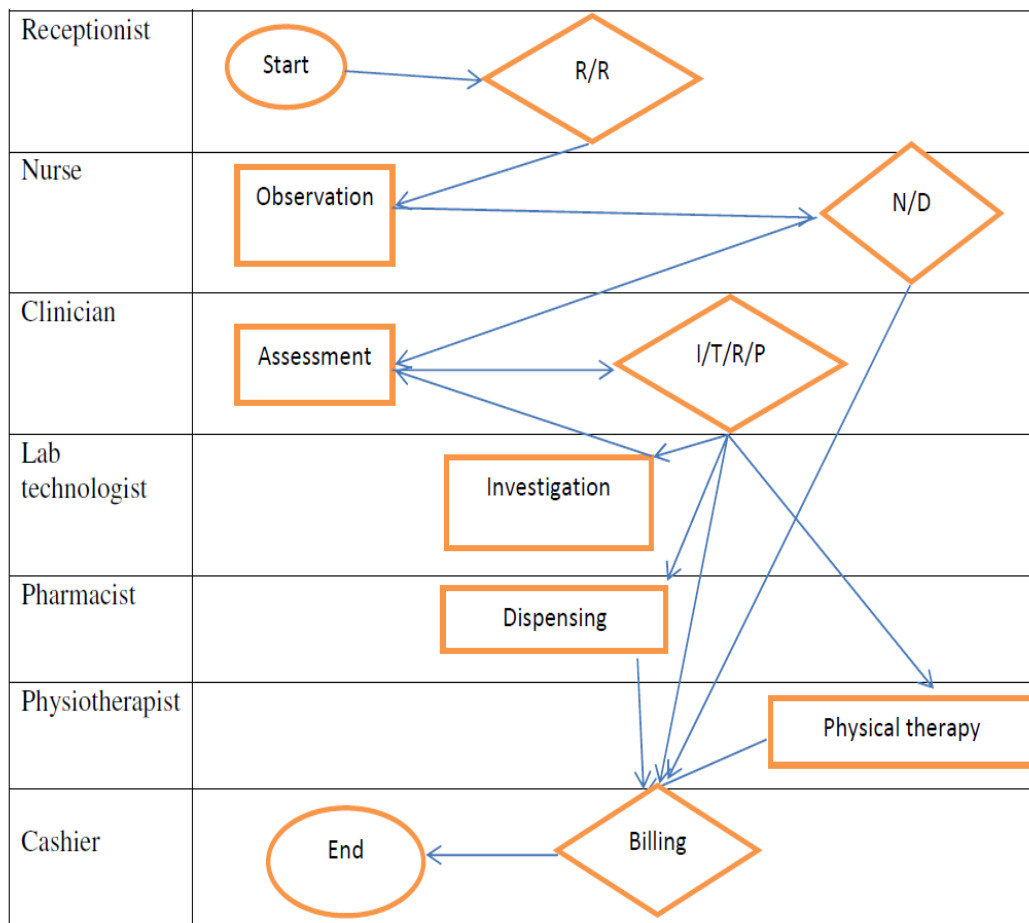
1. What is your role in the implementation of Kabarak University Health Centre Electronic
2. If developer, what roles did you play in the development of the EMR?
3. What features does KABU Health Centre EMR have?
4. What challenges do you face in administration and management of KABU EMR?

Appendix XIV: Kabarak University Health Center Monthly Patient Loads for the Period November 2015 – February 2016

Kabarak University Health Center Monthly Patient Loads			
	First Time Patients	Continuing Patients	Total
Nov-2015	576	77	653
Dec-2015	549	63	612
Jan-2016	787	53	840
Feb-2016	313	39	352
Four Month Totals	2225	232	2457
Month Patient Average	556.25	58	614.25



Appendix XV: Patient Management Process



KEY:

R/R: Receiving and Recording

N/D: Nurse Desk

I/T/R/P: Investigations/ Treatment/ Referral/ Physiotherapy

Appendix XVI: Krejcie and Morgan Sample Size Table

Table for Determining Sample Size from a Given Population

<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

Note.—*N* is population size.
S is sample size.

Appendix XVII: Sample REST code for the implementation of the Mobile Phone Based Clinical Summaries model ERD

```

{
  "name": "summary",
  "plural": "summaries",
  "base": "PersistedModel",
  "idInjection": true,
  "options": {
    "validateUpsert": true
  },
  "properties": {
    "id": {
      "type": "number",
      "required": true
    },
    "name": {
      "type": "string",
      "required": true
    },
    "description": {
      "type": "string",
      "required": true
    },
    "summaryJson": {
      "type": "string"
    },
    "dateCreated": {
      "type": "date",
      "required": true
    },
    "uuid": {
      "type": "string",
      "required": true
    }
  },
  "validations": [],
  "relations": {},
  "acls": [
    {
      "accessType": "*",
      "principalType": "ROLE",
      "principalId": "$authenticated",
      "permission": "ALLOW"
    },
    {
      "accessType": "EXECUTE",
      "principalType": "ROLE",
      "principalId": "$everyone",
      "permission": "ALLOW",
      "property": "listProjects"
    },
    {
      "accessType": "*",
      "principalType": "ROLE",
      "principalId": "$everyone",
      "permission": "DENY"
    }
  ],
  "methods": {}
}

```

Appendix XVIII: Sample Code for the Implementation of the Server Module Web Based Interface

```

var serverInterface = angular.module('serverInterface', ['ui.bootstrap', 'ngRoute',
'ngSanitize', 'uuid4',
'ngMaterial', 'material.svgAssetsCache']);

serverInterface.constant('REST_URI', 'http://localhost:3000/api/');
serverInterface.config(['$routeProvider', '$compileProvider', function ($routeProvider,
$compileProvider) {
    $compileProvider.aHrefSanitizationWhitelist(/^\/s*(https?|ftp|mailto|file):/);

    $routeProvider.when('/summary/:id', {controller: SummaryCtrl, templateUrl:
'partials/summary.html'});
    when('/createSummary/', {controller: SummaryCtrl, templateUrl:
'partials/summary.html'});
    when('/summaries', {controller: SummariesCtrl, templateUrl:
'partials/summaries.html'});
    when('/login', {controller: LoginCtrl, templateUrl: 'partials/login.html'});
    otherwise({redirectTo: '/login'});
}]);

serverInterface.factory('$summaries', function($http, REST_URI, $window) {
    var getVitals = function() {
        return $http.get("resources/vitals.json");
    };
    var getNotes = function() {
        return $http.get("resources/notes.json");
    };
    var getDrugs = function() {
        return $http.get("resources/drugs.json");
    };
    var getLabs = function() {
        return $http.get("resources/labs.json");
    };
    var getSummaries = function(search) {
        if (search === undefined || search === '')
            return $http.get(REST_URI + "summaries?access_token=" +
$window.sessionStorage["authorization"]);
        else
            return $http.get(REST_URI + "summaries?filter[where][or][0][name][regex]=" +
search + "&filter[where][or][1][description][regex]=" + search);
    };
    var getSummary = function(id) {
        return $http.get(REST_URI + "summaries/" + id + "?access_token=" +
$window.sessionStorage["authorization"]);
    };
    var saveSummary = function(summary) {
        if (summary.id != null && summary.id != undefined) {
            // we are updating an existing summary through list
            return $http.put(REST_URI + "summaries/" + summary.id + "?access_token=" +
$window.sessionStorage["authorization"], summary);
        } else {
            // we are creating a new instance through REST
            return $http.post(REST_URI + "summaries?access_token=" +
$window.sessionStorage["authorization"], summary);
        }
    };
    var deleteSummary = function(id) {
        return $http.delete(REST_URI + "summaries/" + id + "?access_token=" +
$window.sessionStorage["authorization"]);
    };

    return {
        getVitals: getVitals,
        getNotes: getNotes,
        getDrugs: getDrugs,
        getLabs: getLabs,
        getSummaries: getSummaries,
        getSummary: getSummary,
        saveSummary: saveSummary,
        deleteSummary: deleteSummary
    }
}]);

```

Appendix XIX: Sample code for the CRUD operations on the model's Summary Template

```

function SummaryCtrl($scope, $routeParams, $location, $summaries, uuid4) {

    // initialize search objects
    $scope.search = {vitals: '', drugs: '', drugsGroup: '', labs: '', labsGroup: '',
notes: ''};
    $scope.selected = {vital: '', drug: '', lab: '', note: ''};
    $scope.specialFields = {vitalMaxEntries: 1, editable: false};

    // initialize the summary objects
    $scope.summary = {};
    $scope.summaryVitals = [];
    $scope.summaryDrugs = [];
    $scope.summaryLabs = [];
    $scope.summaryNotes = [];

    // initialize the view to be read only
    $scope.mode = "view";

    $summaries.getVitals().then(function (response) {
        $scope.vitals = response.data["vitals"]["fields"];
        $scope.vitalsGroup["header"] = response.data["vitals"]["header"];
    });

    $summaries.getNotes().then(function (response) {
        $scope.notes = response.data["summary"]["fields"];
        $scope.notesGroup["header"] = response.data["summary"]["header"];
    });

    $summaries.getDrugs().then(function (response) {
        $scope.drugs = response.data["drugs"]["fields"];
        $scope.drugsGroup["header"] = response.data["drugs"]["header"];
    });

    $summaries.getLabs().then(function (response) {
        $scope.labs = response.data["labs"]["fields"];
        $scope.labsGroup["header"] = response.data["labs"]["header"];
    });

    $scope.id = $routeParams.id;
    if ($scope.id === undefined) {
        $scope.mode = "edit";
    } else {
        $summaries.getSummary($scope.id).then(function (response) {
            $scope.summary = response.data;
            var summaryString = JSON.parse($scope.summary.summaryJson);
            if (summaryString != null && summaryString != undefined) {
                if (summaryString["vitals"] != undefined)
                    $scope.summaryVitals = summaryString["vitals"];
                if (summaryString["drugs"] != undefined)
                    $scope.summaryDrugs = summaryString["drugs"];
                if (summaryString["labs"] != undefined)
                    $scope.summaryLabs = summaryString["labs"];
                if (summaryString["summary"] != undefined)
                    $scope.summaryNotes = summaryString["summary"];
            }
        });
    }
    $scope.save = function (summary) {
        summary.uuid= uuid4.generate();
        summary.summaryJson = createJson();
        summary.dateCreated = new Date();
        $summaries.saveSummary(summary).then(function () {
            $location.path("/summaries");
        });
    };
    var createJson = function () {
        var summaryJsonString = {};
        summaryJsonString["vitals"] = $scope.summaryVitals;
        summaryJsonString["drugs"] = $scope.summaryDrugs;
        summaryJsonString["labs"] = $scope.summaryLabs;
        summaryJsonString["summary"] = $scope.summaryNotes;
        return angular.toJson(summaryJsonString);
    };
};

```

Appendix XX: Sample code for the implementation of the Mobile Application Module

```

/**
 * Create labs section
 */
private void createLabOrdersSection() throws JSONException {
    String headerText =
    ((JSONObject)summaryJson.get("labs")).get("header").toString();
    cwacMergedAdapter.addView(mHelper.createSectionHeaderView(headerText));

    JSONArray labs = ((JSONObject) summaryJson.get("labs")).getJSONArray("fields");

    for (int i = 0; i < labs.length(); i++) {
        // we expect max four fields header,uuid, editable, list
        JSONObject lab = labs.getJSONObject(i);
        Boolean editable = !StringUtils.isEmpty(lab.optString("editable")) &&
        Boolean.parseBoolean(lab.optString("editable"));

        try {
            View v =
            mHelper.createInnerSectionHeaderView(lab.getString("uuid"), lab.getString("header"));

            cwacMergedAdapter.addView(v, true);
            List<SummaryObservation> obsList = new
            ArrayList<SummaryObservation>();
            Observation oboso = new Observation();
            SummaryObservation summaryObservation = new
            SummaryObservation(oboso, false, getString(R.string.general_add_lab),
            lab.getString("uuid") + ":" + lab.getString("header"));
            obsList.add(summaryObservation);

            Concepts concepts =
            obsCtrl.getConceptWithObservations(mPatient.getUuid(), lab.optString("uuid"));
            if (concepts != null && concepts.size() > 0) {

                concepts.sortByDate();
                List<Observation> observations =
            concepts.get(0).getObservations();
                for (Observation obs : observations) {
                    if (!StringUtils.isEmpty(obs.getValueAsString()) &&
                    !StringUtil.equals(obs.getValueAsString().toUpperCase(), "NO")
                    &&
                    !StringUtil.equals(obs.getValueAsString().toUpperCase(), "YES")) {
                        summaryObservation = new
            SummaryObservation(obs, editable, null, getString(R.string.general_add_lab));
                        obsList.add(summaryObservation);
                    }
                }
            }

            // our adapter instance
            SummaryObservationAdapter adapter = getSummaryObsAdapter(obsList);

            cwacMergedAdapter.setAdapter(adapter);
            sackOfAdapters.put(v.getTag().toString(), adapter);

            cwacMergedAdapter.setActive(adapter, false);
        } catch (ObservationController.LoadObservationException e) {
            e.printStackTrace();
        }
    }
}

```

Appendix XXI: Sample Test Data

```

{
  "summary": {
    "header": "Summary Notes",
    "nextVisit": {
      "header": "Next visit on",
      "uuid": "a8a666ba-1350-11df-af1-0026b9348838"
    }
  },
  "demographics": {
    "header": "Demographics"
  },
  "vitals": {
    "header": "Vital Signs",
    "fields": [
      {
        "header": "Temperature (C)",
        "uuid": "a8a65fee-1350-11df-af1-0026b9348838"
      },
      {
        "header": "Weight (KG)",
        "uuid": "a8a660ca-1350-11df-af1-0026b9348838",
        "maxEntries": "4"
      }
    ]
  },
  "drugs": {
    "header": "Medications",
    "editable": true,
    "fields": [
      {
        "header": "General Medications",
        "uuid": "a89ae56a-1350-11df-af1-0026b9348838",
        "list": {
          "a8b0f4a4-1350-11df-af1-0026b9348838": "Malaria Prophylaxis",
          "a8a43750-1350-11df-af1-0026b9348838": "Losartan"
        }
      },
      {
        "header": "Anti-Retroviral Medications",
        "uuid": "a899cf5e-1350-11df-af1-0026b9348838",
        "list": {
          "a8afbf9e-1350-11df-af1-0026b9348838": "Atazanavir",
          "a89cc876-1350-11df-af1-0026b9348838": "Lamivudine and Tenofovir"
        }
      },
      "editable": true
    ]
  },
  "labs": {
    "header": "Laboratory Orders",
    "uuid": "a89c2cae-1350-11df-af1-0026b9348838",
    "fields": [
      {
        "header": "Tests Ordered",
        "uuid": "a89c2268-1350-11df-af1-0026b9348838",
        "list": {
          "4c51bcf6-f39f-11e3-b0ca-101f74f2794b": "Hemoglobin",
          "4c51cc62-f39f-11e3-b0ca-101f74f2794b": "Malarial Smear",
          "4c56c8b2-f39f-11e3-b0ca-101f74f2794b": "Serum Potassium"
        }
      },
      "editable": true
    ]
  }
}

"patient": {
  "patient.uuid": "9090900-asdsa-asdsannidj-qwnkika",
  "patient.medical_record_number": "Test-4",
  "patient.birthdate": "1996-02-07",
  "patient.name": "Atingo, Lovich Samuel",
  "patient.sex": "M"
}

```