MAKERERE UNIVERSITY

COLLEGE OF COMPUTING AND INFORMATION SCIENCES

SCHOOL OF COMPUTING AND INFORMATICS TECHNOLOGY

A CLINICAL DECISION SUPPORT SYSTEM (CDSS)

BY

GROUP 16

A Project Report submitted to the School of Computing and Informatics Technology

In Partial fulfillment of the requirements for the Award of a Degree of Bachelor in Information Systems and Technology of Makerere University Kampala

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DECLARATION

The following group members do hereby declare that this project report is original and has not been published and or submitted for any other degree award to any other university before.

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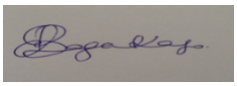
APPROVAL

This project has been submitted for examination with the approval of our following supervisor:

Signed …  …….

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DEDICATION

We would like to dedicate this project to our parents who have been our greatest supporters throughout our education

ACKNOWLEDGEMENT

First of all, we would like to express our sincere gratitude to Dr. Emily Bagarukayo, our supervisor, who assisted us throughout the developing of the project. She provided us with the necessary guidance throughout the project. We would also like to thank her for accepting to supervise us.

We would like to thank our colleagues, lecturers and mentors for the moral support and help that they provided us throughout our journey at the School of Computing and Informatics Technology.

We would like to express our utmost gratitude to the School of Computing and Informatics Technology and Makerere University for providing an environment in which we were able to implement this project.

Last but not least, we would like to thank our parents who invested in us both morally and financially, for their continued support and without whom, we would probably not be here today.

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ABSTRACT

The Quality of medical care in hospitals needs a lot of efforts to be improved; today these efforts are mainly focusing on increasing the practice of evidence-based medicine through the use of Clinical Decision Support System (CDSS). Proper use of clinical information is especially important in an effort to make sound clinical decisions and provide quality health services.

The purpose of this project was to develop the Clinical Decision Support System (CDSS), A web application to be used by medical workers to assist them in carrying out evidence based clinical decisions in hospitals. This will be used by hospitals to assist them during all phases of clinical decision. The app will be accessed via a web browser with internet connection.

Qualitative data collection techniques were used to gather information using questionnaires and interviews that were issued to a population sample size of 3 medical centers around central Kampala.

The findings revealed that there is need for clinical decision support system in the hospitals. The findings also revealed the system requirements such patient data management and real-time diagnosis which are needed to develop the system.

The output of this project is a fully functioning Clinical Decision Support System to be used by the medical workers online.

Keywords: Web Application, Clinical Decision Support System, Medical workers, Clinical decision.

TABLE OF CONTENTS

ABBREVIATIONS

API – Application Integration Interface

CDSS - Clinical Decision Support System

CSS – Cascading Styling Sheet

GUI - Graphical User Interface

HTML – Hyper Text Markup Language

IDE - Integrated Development Environment

OS - Operating System

RAD - Rapid Application Development

UI - User Interface

UCG - Uganda Clinical Guidelines

CHAPTER ONE: INTRODUCTION

1.1 Background to the problem

In Africa currently there are scanty experiences in the use of Clinical Decision Support Systems or ICT in healthcare services. While there is rapid development of mobile telecommunication infrastructure and use in Africa, ICT projects remain few and challenging. Most ICT projects have been applying SMS services using mobile phones when supporting maternal or HIV patient care and drug prescribing (Aranda-Jan, Mohutsiwa-Dibe, & Loukanova, 2014).

Traditionally in Uganda, data management and operations are mostly paper based across the country including clinical decision and patient data management. Doctors have physical files which contain patients' records to help them store and manage patient data. For clinical decisions, doctors usually rely mostly on written documents like the Uganda Clinical Guidelines (UCG) to get evidence based, practical and implementable guidance to help prescribe and provide the most cost effective and affordable treatment.

The Uganda Clinical Guidelines (UCG) is a document produced by the ministry of health Uganda which provides medical practitioners with evidence based, practical and implementable guidance to prescribe and provide the most cost effective and affordable treatment to the priority health conditions in the country (Ministry of Health, 2016). It provides clinical decision support by providing reliable reference for health workers on appropriate management of common health conditions.

However, since the Uganda Clinical Guidelines (UCG) is hard copy, many medical practitioners don't get access to this valuable document because of the high printing costs that hinder the government from providing it to everyone. Also, traditional hard copy information is not flexible as one cannot easily share it with others. It lacks important features like searching, filtering, sorting and more which can be provided by a digital system. It is also susceptible to data loss and damage in case of an accident.

This Clinical Decision Support Information System aims to solve those problems and enable medical practitioners to be able to get practical and implementable guidance, medical prescriptions and more information to help in clinical decision process.

Clinical decision support system technologies stand to transform healthcare for the better. If Clinical decision support system technologies are embraced and the proper software, hardware and IT infrastructure are put in place, the healthcare industry will stand to benefit greatly. It will increase patient quality and patient health outcomes.

Healthcare faces multiple problems, including high and rising expenditures, inconsistent quality, and gaps in service delivery and access. Because of this, health care services represent a major portion of the government spending in most countries. countries (Shaker & Samir, 2014).

The Quality of medical care in hospitals needs a lot of efforts to be improved; today these efforts are mainly focusing on increasing the practice of evidence-based medicine through the use of CDSS. Proper use of clinical information is especially important in an effort to make sound clinical decisions and provide quality health services (Dimitrios & Nailya, 2018).

1.2 Problem statement

Currently medical practitioners in Uganda lack a Clinical Decision Support Information System which can help provide them with up-to-date medical guidelines for reference and clinical decision support at work. This has created inefficiency in all hospital operations and on several occasions has resulted in loss of lives (Gasthony, et al., 2021). This research clearly states that the lack of enough skilled doctors and clinical support as major cause to death of pregnant women.

1.3 Objectives of the study

1.3.1 General objective

The main purpose of this study is to develop a Clinical Decision Support Information System to aid in clinical decision making.

1.3.2 Specific objectives

I. To identify the system requirements for the proposed clinical decision support system
II. To design the model for clinical decision support information system.
III. To implement the clinical decision support information system.
IV. To test and validate the clinical decision support information system.

1.4 Scope of the study

1.4.1 Geographical scope

This study investigated the clinical decision process in hospitals around Kampala district. A system was developed to enable medical workers around Kampala to access up-to-date medical guidelines for reference and clinical decision support at work. The System runs online to ensure ease of accessibility. The system is also expected to be applied in different hospitals at a later time.

1.4.2 Theoretical scope

The study focussed on the steps taken, methods and information used in the clinical decision-making process.

1.4.3 Functional Scope

The functional scope involves function and non-function requirements. The functional requirements describe what the system is expected to do or perform. The define intended behavior of the system such as;

i. It will provide basic information about each of the common diseases in the country like treatment, causes, remedies, prescription, advice etc.
ii. It will allow doctors to search through diseases and filter by medication, causes and types.
iii. It will make it easy for users to share data this will include features like downloading pdfs.
iv. The system will aid medical workers in diagnosing the patient's problem.

1.4.4 Time Scope

The research involved the use of data related to the topic under investigation for a period of 1- 2 months. This time range was suitable for arriving at correct conclusions.

1.5 Scope limitation

The clinical Decision support System is an online application without internet this system doesn't work. Diagnosis may lead to wrong results or no match found if patient gives wrong input and serious medical problems can't be solved using this system.

1. 6 Significance of the study.

Many medical professionals,patients, hospitals and other medical centers like pharmacies find it hard to get clinical support which is very crucial. This has led to problems such as giving out poor advice and failure to find the right causesof the disease. The results of this study will be beneficial is following ways.

i. The research will provide data needed to build the CDSS like system requirements.
ii. The research will also guide system developers to get a clear view of how doctors would like their system to function.
iii. The Clinical Decision Support System will help medical practitioners make informed medical decisions at work.
iv. The Clinical Decision Support System will help hospitals better handle their patient's data.
v. Data collected from the Clinical Decision Support System will be used for further analysis to guide on policy making in the health sector and the ministry of health.

CHAPTER TWO: LITERATURE REVIEW

2.1 Clinical Decision making.

Clinical decision making is a balance of known best practice awareness of the current situation and environment and knowledge of the patient. It is about joining the dots to make an informed decision (National Health Service, 2012).

2.2 Existing health facilities.

Among the health facilities Uganda has, are national referral hospitals, mental health facilities, regional referral hospitals, health centers II, III, IV, PNFP facilities and many more district hospitals. with quite many of these facilities the country faces a lot of challenges in providing sufficient health care.

2.3 Challenges faced when making clinical decision in health facilities.

Among the challenges faced by hospitals during clinical decision is that most medical workers actually do not have the necessary skills to make right decisions. This has negatively affected medical counselling and diagnosis (Joseph & Stella, 2013). It is common to find hospitals using more of trainees (who in most cases have partial ideas on treatment) than experienced health workers which puts patients' lives at risk. As a remedy, patients and students prefer consulting with experienced doctors who in most cases are not readily available and are so expensive for an average Ugandan. The time lag created delays patients, students and medical practitioners creating inefficiency in all hospital operations and on several occasions has resulted in loss of lives (Gasthony, et al., 2021).

2.4 Clinical Decision Support System.

Clinical decision support system is defined as software designed and embedded in general practice computers that provide intelligently filtered, evidence-adaptive knowledge or person-specific information, to directly support clinical decision-making at the point of prescribing medicines (National Health Service, 2012).

Since the beginning of computers, physicians and other healthcare professionals have predicted a time when machines would aid them in the clinical decision-making and other restorative procedures. CDSS provides clinicians, patients or individuals with knowledge

and person-specific or population information, intelligently filtered or presented at appropriate times, to foster better health processes, better individual patient care, and better population health (Ree & Pincock, 2020).

Computer-based CDSSs can be traced to the 1970s. At the time, they had poor system integration, were time intensive and often limited to academic pursuits. There were also ethical and legal issues raised around the use of computers in medicine, physician autonomy, and who would be at fault when using the recommendation of a system with imperfect 'explain ability'. Presently, CDSS often make use of web-applications or integration with electronic health records (EHR) and computerized provider order entry (CPOE) systems. They can be administered through desktop, tablet, smartphone, but also other devices such as biometric monitoring and wearable health technology. These devices may or may not produce outputs directly on the device or be linked into EHR databases (De Dombal, 1992).

A clinical decision support system (CDSS) is intended to improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information. A traditional CDSS is comprised of software designed to be a direct aid to clinical-decision making, in which the characteristics of an individual patient are matched to a computerized clinical knowledge base and patient-specific assessments or recommendations are then presented to the clinician for a decision (Berner, 2009).

Clinical decision support system enables clinicians, staff, patients, and other Healthcare professionals with knowledge and person-specific information, intelligently filtered and presented at appropriate times, to enhance health and health care.
Clinical decision support systems address activities ranging from the selection of medications or diagnostic to detailed support for optimal drug dosing and support for resolving diagnostic problems. Clinical decision support systems suggest default values for drug doses, and offer more sophisticated drug safety features such as checking for drug allergies.

Clinical Decision Support Systems (CDSS) provide clinicians with knowledge, intelligently filtered or presented at appropriate times, to enhance health and health care

(Berner, 2009) and can be seen as an effective pathway to improve patient safety providing, for instance, alerts for error reduction.

From the study conducted by Enrico, (2009), he concluded that clinical decision support systems are the best solution to support healthcare workers in the normal course of medical worker's duties, assisting with tasks that rely on the manipulation of data, knowledge and challenges of clinical decision support system to both practitioners and patients' outcomes.

There has been much research on the importance of clinical decision support systems in Uganda hospitals. However, few researchers have taken into account to the possibility of implementing a clinical decision support system. According to Rujumba, (2010), it was discovered that among the challenges faced by hospitals was that most workers actually do not have the necessary skills to make right decisions.

2.4.1 Benefits of clinical decision support system.

The CDSS as part of the Computerized Physician Order Entry has been found to alleviate adverse drug events and medication errors (Jesse & Jerry, 2008). CDSSs also have demonstrated to improve clinician performance, by way of promoting the electronic prescription of drugs, adherence to guidelines and to an extent the efficient use of time.

CDSSs perform a key role in providing primary care and preventative measures at outpatient clinics, e.g., by alerting caregivers of the need for routine blood pressure checking, to recommend cervical screening, and to offer influenza vaccination (Ahmadian, et al., 2011) .

CDSSs have helped healthcare organizations all over the world in acquiring higher standards of patient safety by adopting standardized clinical procedures governed by the clinical workflows encoded through these systems. Thus, reducing diagnostic and prescribing errors and drug doubling issues.

CDSS have improved the quality of care to considerable levels with this extra support provided to clinicians (who are already struggling to cope with current healthcare demands). This has made it possible for clinical experts to allocate more time in providing direct patient care

2.5 Review on related Clinical Decision Systems.

2.5.1 Existing systems.

There are majorly two systems used in clinical decision in health facilities in Uganda. That is the traditional manual system and the Health Management Information System (HMIS) provided by the government.

Traditional manual system.

The current system of medical diagnosis and drug prescription in most hospitals is manually undertaken (Agbeko, 2022). Diagnosis is the first step towards receiving medical care It does not involve quite a number of steps before receiving this medication and among is, a patient making their way to the hospital.

Due to larger numbers which flock in such health facilities long queues are evident of which they follow the First Come First Serve (FCFS) procedure, one has to be in the position to get into the line and wait to be attended to.

At this stage a patient usually undergoes card verification and clearance ,the registers into the hospital system by filling through the" patient forms "which signifies that the person is now registered with that particular hospital, this step also gives a person access to own a hospital folder which contains records basing on information about the diagnoses and drug prescriptions recommended by the physicians, after which he or she waits in another room so as to meet consultation officer who allocates the respective physician. the physician carries on different tests so as to determine what the problem or disease is.

It is a wide spread practice of staff members retrieving files containing personal information pertaining various patients. This form is then sent to the doctor who peruses through it before examining the patient and carrying out the appropriate therapy. the patient is then referred to the laboratory unit for a test (if need be) or directly to the pharmacy unit to obtain the prescribed drugs.

Any treatment proffered to the patient by the doctor must be recorded in the patient's folder to aid in the future diagnosis. It is such a long and tedious procedure that not only leaves the medical attendants so exhausted after attending to many patients but also to the patients who seek diagnosing from attending towards the whole procedure.

Limitations to the Traditional manual system.

Manual documentations of patient's records: The existing systems is heavily dependent on manual methods of operation, for example, entering, storing and retrieval of patient's data in physical files. This implies that information is not greatly recorded due to insufficiency by human beings. Patients have to wait for quite a long time before being referred to for diagnosis because of long queues.

i. **Error in diagnosis:** Most often wrong diagnosis is given for ailments (sickness) particularly by physicians whose medical backgrounds don't extend to other particular fields.
ii. **Deterioration in patients condition due over delays**: Many patients end up having more complications due to longer processes which involves over waiting to be examined by the physicians .in regards to these other unfamiliar complications do rise up that have at most times led to death
iii. **Limited accessibility:** Accessibility in the current system is narrow as it extends only where these health facilities for example hospitals are situated, that means remotely accessed areas for example deep within the rural areas (villages) there is no possibility of locating one thus not being in position to acquire these services.

Clinical Decision Support Systems in use today.

There are a number of Clinical Decision Support systems used across the globe, these include the famous MYCIN and Quality Management Representative (QMR) systems which were developed in early 1970s to help clinicians choose anti bacteria for different diseases (Martin, 2004) in the United States of America.

However, in Uganda the government through the ministry of health developed the Health Management System (HMIS) to be used in hospitals.

Health Management Information System (HMIS).

Health Management Information System is an integrated system used by Ministry of Health Uganda, development partners, and stakeholders to collect relevant and functional information on a routine basis to monitor the Health Sector Strategic and Development Plan (HSSDP) indicators to enable planning, decision making, monitoring, and evaluation of the health care delivery system. It is designed to assist managers to undertake evidence-based decision making at all levels of the health care service delivery system (Strategic Information, 2018). This system is currently employed in most government health facilities to collect and analyze data during clinical decision process. It handles data

collection, management and storing in the health facilities.it also provides health workers with detailed analysis of the patient's data using visualizations and detailed reports.

Limitations of Health Management Information System (HMIS).

1. **It requires government permission to access it.** This system is developed by the ministry of health Uganda thus for private hospitals to use it they require to ask for authorization from the government which is lengthy.
2. **Limited control of the system.** The users have limited control of the data since the main authority is with the ministry of health
3. **It doesn't provide live diagnosis.** The system doesn't provide real-time diagnosis. It rather provides information management of patient information

2.5.2 Comparison of the reviewed systems with the proposed system.

FEATURES (Operational features)	**TRADITIONAL MANUAL SYSTEM**	**HEALTH MANAGEMENT INFORMATION SYSTEM (HMIS)**	**PROPOSED SYSTEM (CLINICAL DECISION SUPPORT SYSTEM)**
Learnability (Easy to learn to how use)	Not easy to learn, involves many unguided procedures.	Not easy to learn. requires many clicks to perform a certain function.	Easy to learn, less procedures involved and a simple instructing graphical user interface.
Reliability (Ease to base / count on the workability of a system given a task)	Less reliable. It is prone to human errors during data entry.	it is reliable can work on large numbers efficiently.	It is reliable can work on large numbers efficiently.

Performance/ Speed	Slow as a result of manual operation.	Moderately slow.	It is faster, less memory needed to accommodate the system.
Accessibility (Ease to acquire access to the system)	Easily accessed during day, less accessible at night.	Requires government authorization. Not all hospitals can use it.	It is easy to acquire, runs on the web, can accessed by everyone.
Utility (Extent to which the system provides expected functionality).	Low utility, there is limited trained personnel/staff to attend to large numbers of patients.	Low utility as system does not. provide automated diagnosis.	High utility in form of prescription, diagnosis, as it uses. Intermedia API to determine the most probable disease.

Table 1 Comparison of the reviewed systems with the proposed system

2.6 Implementation of the clinical decision support information system.

CDSS is "an active knowledge system that generates case specific advice, based on two or more items of patient data" or "an active intelligent system capable of assisting the medical professionals by making specific recommendations and decisions based on the analysis of patient specific information and related medical facts" (Chen & Skjelvik, 2009). From a system architecture perspective, a CDSS implementation as a diagnostic tool is essentially an expert system built to present helpful information and advice to the clinician or physician at the point-of-care. The main responsibilities of a CDSS are to support decision making, improve the overall patient quality of service and increase patient diagnostic and prognostic capabilities to the best available level, eliminate unnecessary mistakes and cost, and increase productivity (Garcia & Klein, 2014). The

expanding medical knowledge, patient information, diagnostics, diseases and treatment methods, by necessity, is becoming a science of information (Peiffer-Smadja, et al., 2020). CDSS are designed to assist clinicians and other healthcare professionals in diagnosis as well as decision-making. CDSS uses healthcare data and a patient's medical history to make recommendations. By using a predefined set of rules, CDSS intelligently filters knowledge from complex data and presents at an appropriate time. By adopting CDSS, healthcare can become more accessible to large populations.

CHAPTER THREE: METHODOLOGY

This section describes and shows the methods and steps that were used to obtain data to design the system.

3.1 Research Design

The study involved a cross sectional research design employing both qualitative and quantitative methods. Qualitative methods are methods used to manage qualitative data for understanding and explaining social phenomena. Quantitative methods emphasize objective measurements and statistical, mathematical and numerical analysis of quantitative data.

The study was carried out within a short period of time of 1-2 months to determine the effectiveness of the system. The information was collected from doctors and nurses in Kampala hospitals and medical centers and any other related written information was obtained from the internet about the clinical decision process. Using this approach, we managed to get the system requirements needed which we used to develop the Clinical Decision Support System.

3.2 Data Collection

Both primary and secondary data was collected, through questionnaires, interviews and research from the internet respectively, in order to get a clear understanding about the issues concerning clinical decision.

Interview

Interviews were conducted to specific medical staff about how they conduct the clinical decision support process and we got to know how the system could aid them to conduct their activities better.

We scheduled an interview with the four different doctors and nurses in hospitals around Kampala hospitals. Interview questions were open and closed questions which was aimed to collect system requirements.

Questionnaire

Self-administered questionnaires were randomly administered to four medics in different hospitals around Kampala to eliminate sampling bias and reduce the sampling error. This enabled us collect information from a larger sample.

We handed out questionnaires to different doctors and nurses in hospitals around Kampala hospitals. The questions included open and closed questions which was aimed to collect system requirements.

Observation

Observation was carried out to observe the process, procedures involved in clinical decisions. This enabled us get first-hand information.

We set up an appointment with different hospitals to observe the process, procedures involved in clinical decisions for example, diagnosis, and lab testing. This helped us to proper understand the system requirements.

3.3 Data analysis

Data analysis is a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making.

We carried out data analysis after collecting data from the respondents in following steps;

a) Editing Data. We scrutunized the completed research instruments to identify and minimise as far as possible, errors, incompleteness, incosistencies.
b) Data coding. We translated the raw data into values suitable for computer entry and statistical analysis.
c) Data entry. We entered the data into computer and also carried out data verification to eliminate typing mistakes.
d) Statistical analysis and making conclusions from our data to get the system requirements.

3.4 Design Methods

In this section, process modeling, functional modeling and data modeling were looked at so as to create models for the data to be stored in the database.

3.4.1 Process Modeling

In process modeling, we focused on the visual presentation and documentation of information flow within the Application. This involved use of data flow diagrams (DFDs) that show inputs, outputs ad data stores of the application. We also used use case diagrams to model the system interactions between users and the system.

3.4.2 Data modeling

The research team used the Entity Relationship Modeling which involved identifying the important data entries and the relationships between the data to be represented in the model.

3.5 Implementation

This section describes the different choices of web frameworks, programming languages and possible methods that were used in building the web application. Realization of the project was done using a number of implementation tools and technologies which include Visual studio Code, Django,Python as defined below;

3.5.1 Rapid Application Design

Rapid Application Development (RAD) is a software development process model that is based on prototyping without paying a lot of attention to the planning but instead pay more attention to the development tasks. RAD was used during prototyping of the application.

3.5.2 Visual Studio Code

Visual Studio Code is a code editor developed by Microsoft used in application development. This was used to write the application's code. Visual Studio code provides the main interface for coding the application and also helps to indicate the errors in coding. Additionally, it helps to identify things to test and run the application conveniently and helps build the files needed for the android mobile application.

3.5.3 Python

Python is a widely used object-oriented general purpose programming language that is used in the distributed environment of the internet. It is one of the most popular programming language for web applications. This was used to develop the logic of the backend of the application. Python is versatile and can save time and money in the longer run thus reduced need to tailor it for use on different devices.

3.5.4 JavaScript

JavaScript is a widely used general purpose programming language that is used in web development. This was used to develop the logic of the frontend of the application together with VueJs. JavaScript was used to make the app dynamic.

3.5.5 MySQL

MySQL is an open-source and free Database Management System that helps teams create scalable databases. It is a platform developed by Oracle for creating databases for all types of applications. This was used to store the application's data

3.5.6 Infermedica

Infermedica Infermedica is an artificial intelligence (AI) powered platform which collects, analyzes and employs medical knowledge and provides advanced reasoning technology to identify patients' conditions. It is an AI-powered health care platform that helps doctors deliver efficient, safe, and reliable care to their patients.

We integrated in infermedica via their API so as to deliver real time diagnosis to patients.

3.6 Frameworks

We used open-source frameworks to avoid additional overhead costs that are required for purchasing a license. This was accompanied by choosing popular frameworks whose structure or language has been written. This study therefore adopted the use of popular web development frameworks.

3.6.1 Django

Django is a high-level Python web framework that encourages rapid development and clean pragmatic design. We used Django to develop the application backend system and handle database connections and transactions in the application.

3.6.2 VueJs

VueJs.is an open-source model view view-modal frontend JavaScript framework for building user interfaces and single-page application. We used VueJs to build the user interface components the frontend. VueJs makes prototyping easier as it provides a lot of tools out of the box.

3.7 Testing

3.7.1 Unit testing

The individual units and modules of the application were tested to evaluate whether the features operate as expected. Each unit of the application was examined to ensure that it

performs the tasks it is meant to and discover any errors in the code to verify that certain application parts are working well.

3.7.2 Integration and system testing

This was done after the different modules of the application were placed together to come up with a complete application. This type of testing was majorly aimed at the different modules that are compatible and that they can be integrated to come up with a complete working application.

3.8 Validation

This was done by comparing the functionalities of the application to the expectations of the application that were described in the planning phase.We achieved this through;

i. Carrying out system inspections with group members to verify system functionalities against system requirements.
ii. Carrying out peer reviews of the system together as a group.

CHAPTER FOUR: FINDINGS, SYSTEMS ANALYSIS AND DESIGN

4.1 Introduction

This section shall describe the system study, analysis, and design of the clinical decision support system application.

The data collected from the research study was analyzed basing on the research questions and objectives. The various answers obtained were analyzed to provide a deeper understanding of the requirements necessary for the system. Attached via the appendix section, are the questionnaires that were used to guide the research.

4.2 System Analysis

System analysis is the process of gathering and interpreting facts, identifying the problems and decomposition of the system into its components with the purpose of analyzing and presentation of results from the field.

Data was collected from four medical workers in health centers around central Kampala.The health centers visited were;

1. Pearl medical center – Kansanga
2. Mukwaya general hospital – Ggaba
3. Godnet medical center – Kiruddu road
4. Buziga family health care

Questionnaires and interview guides were used to collect data from medical centers above which was then later analyzed.

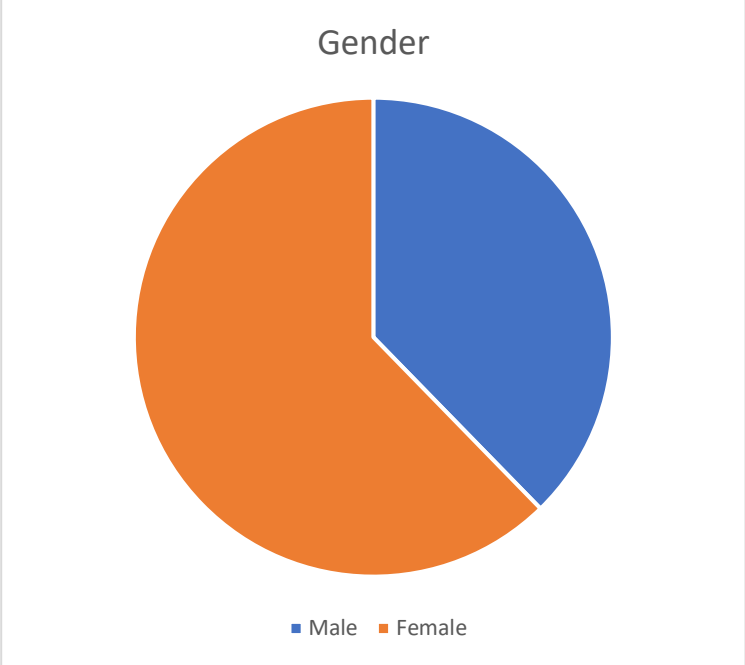
4.2.1 Data analysis and interpretation of results

Data analysis as the process of cleaning, transforming and modeling of data so as to discover useful information for business decision making.

This section presents and discusses the findings that were obtained from the field study research.

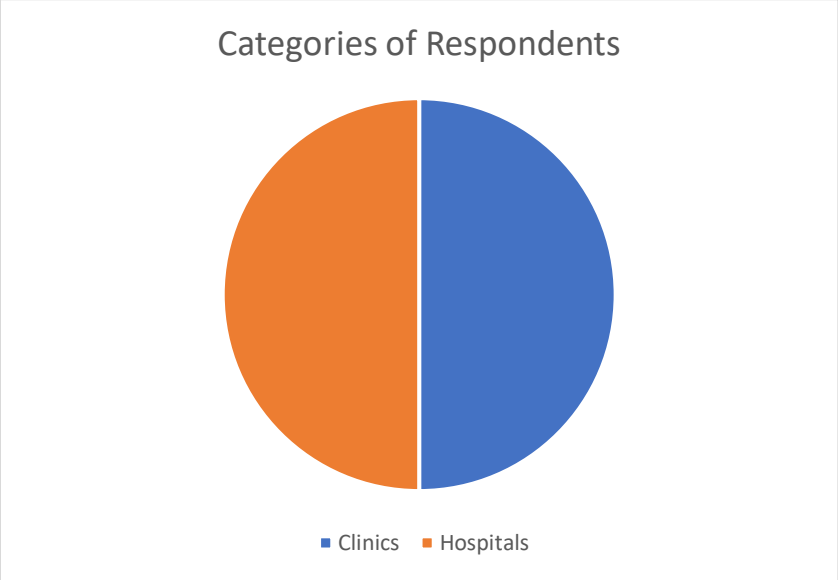
4.2.1.1 Respondents that took part in the survey

The figure below shows the composition of respondents that took part in the survey. 62.3% of the respondents that took part in the survey were female and 37.7% were male. This shows there was more interest from the females than male in the survey.



4.2.1.2 Categories of the respondents that took part in the survey

The figure below shows the categories of the respondents that took part in the survey. 50% of the respondents worked in Clinics, and the 50% worked in hospitals.



4.2.1.3 Challenges faced during clinical decisions

When respondents were asked the challenges faced during clinical decision process, they outlined a number of issues which included;

i. Lack of skilled doctors or personnel to carry out the diagnosis.

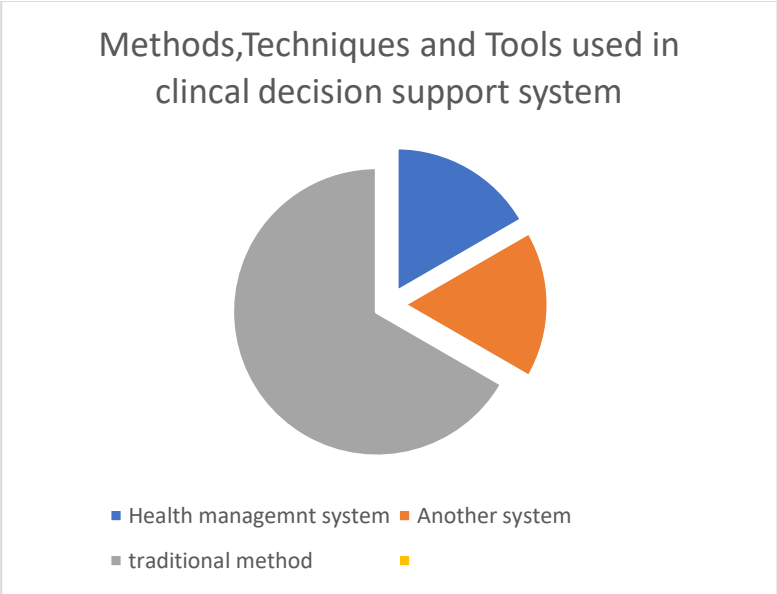
ii. Poor record keeping of patient's data.

iii. Lack of access to medical data for reference during the process.

iv. Lack of equipment to aid in diagnosis such has testing kits.

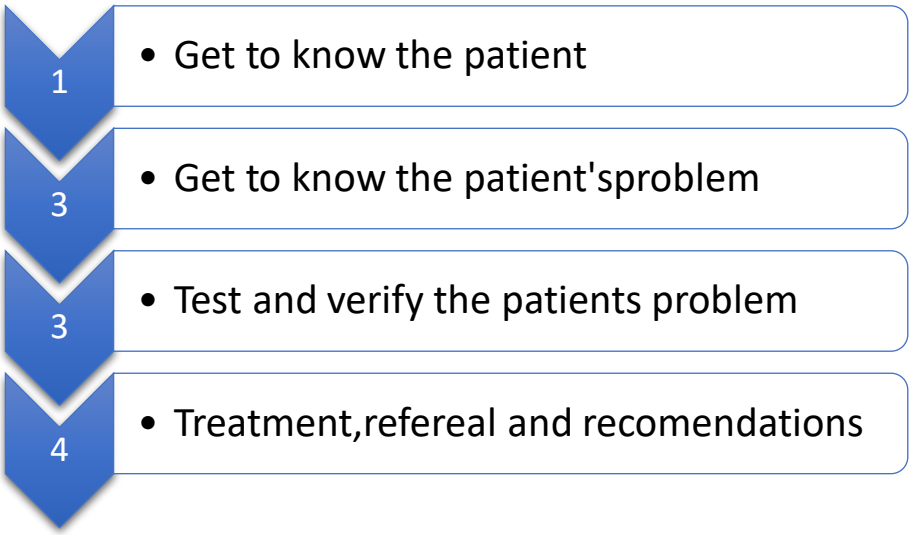
4.2.1.4 Methods, techniques and tools currently used in the decision support process

When respondents asked what the methods or techniques used during clinical decision process were, 20% said they use a health management system which is provided by the government, 60% said they used traditional methods such as books and files for data management and 20% used another electronic system like using spread sheets to handle data and patient's records.



4.2.1.5 The process of clinical decision support

When respondents were asked about the steps taken during the clinical decision process, the responses were analyzed and it was concluded that there are four major steps involved in the process. The steps involved are;



The doctors get to know the patient where they record the patient's bio data and related information. The patient proceeds to step two which is also known as diagnosis then further tests are carried out to make a conclusion. Finally, the treatment is administered or a referral is suggested incase problem is big.

4.2.1.6 Features that would be useful in a CDSS

When respondents were asked what features they would wish to see in a CDSS according to their problems. They suggested a number of features with included;

- Patient data management.
- Diagnosis assistant tool.
- Ability to Share data with other doctors.
- Analysis of data.

After observation of the way doctors work it was concluded that the CDSS should also include a library feature for real time reference during the clinical decision process.

4.3 Design Methods.

This section looks at the modeling process through the use of data modeling techniques and functional modeling mechanisms.

4.3.1 Functional modeling

This refers to the modeling of a system by representing it, functions that include actions, activities process and other operations within the modeled system. In this study, Data Flow diagrams were used to represent the inputs, outputs and processes, data stores of the

system. Data flow diagrams help conceptualize the application development process and think through every important detail.

4.3.2 Data modeling

This study looked at the use of Entity Relationship diagrams to show the existing relationships between entities and attributes and their information requirements. They help in the modelling of data stored in the database. Additionally, a conceptual model was designed independent of the database physical features.

4.3.3 Rapid Application Development (RAD) Model

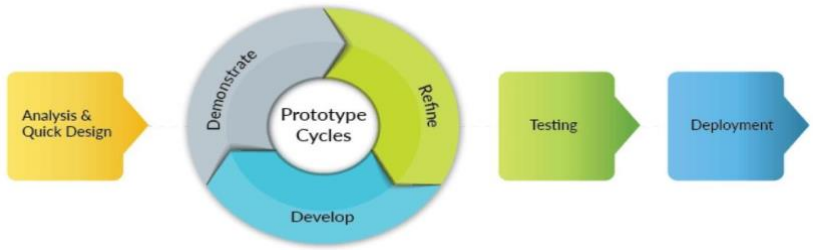


Figure 1 image showing RAD process

In regards to the system development methodology, the research team opted for the Rapid Application Development (RAD) model since it allows fast delivery and development of a highquality system and therefore making it the most perfect methodology for our application.

RAD model is a software development process model that is based on prototyping without paying a lot of attention to the planning but instead pay more attention to the development tasks.

The research team contacted some of the medical workers throughout the different stages of the software process to give feedback about what needed to be changed or improved. This interaction saved the research team quite a lot of time as the feedback was instant. Therefore, the users of this application were involved in the design.

The main strengths of the RAD model include:

- The operational version of the application is made available much earlier than with the waterfall or spiral frameworks.
- Since RAD produces systems more quickly following a business focus, this approach tends to produce systems at a lower cost.

- It concentrates on essential system elements from the user viewpoint.

4.4 Findings

Based on the information that was presented and analyzed in the above section, several findings were determined which include the following;

- The majority of medical centers do not have a clinical decision support system nor an organized way of carrying out the clinical decision process. This clearly shows the need for clinical decision support system to be developed.
- Most respondents to the questionnaires prefer to use a clinical decision support system to aid them during their work.
- The majority still use traditional methods like using files for book keeping, this is very slow and risky as it is easy to lose data of all patients. It is also hard to share this data stored in physical files.
- The major challenges medical workers face during clinical decision process are; Lack of skilled doctors or personnel to carry out the diagnosis, poor record keeping of patient's data, lack of access to medical data for reference during the process and lack of equipment to aid in diagnosis such has testing kits.
- There are four major steps involved in the clinical decision process that is; getting patient data, diagnosis of the problem, testing and verification of the problem and treatment. These are the steps to be automated in the clinical decision support system.

4.5 System requirements

System requirements are the required design specifications that a target system should have in order to use a certain software or hardware.

4.5.1 Functional requirements

Functional requirements are a description of the activities that the system must perform. The functional requirements section are mainly about the clinical decision support system application. The following therefore are the services that the application performs.

Login:

The application has a login feature with fields for username and password. The user will be able to login if they have provided the right credentials. On successful login, the user will be able to proceed to the system dashboard.

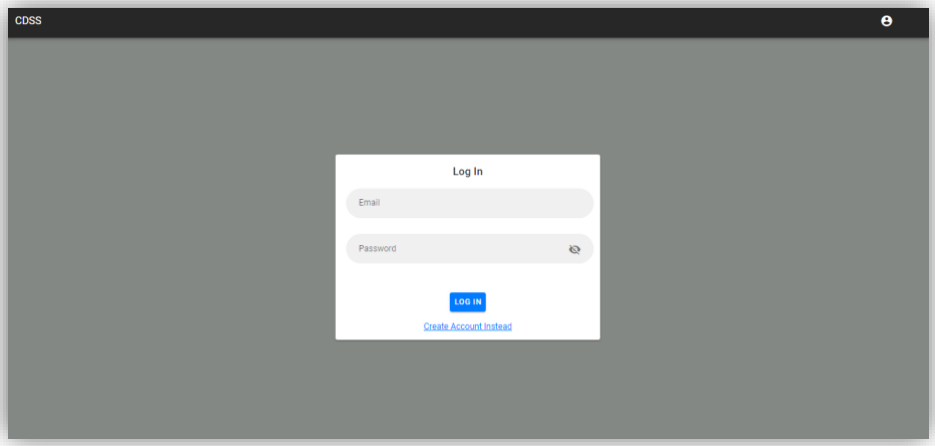


Figure 2 Login page of system

Dashboard

The mobile application has a dashboard that is visible to all users of the application and contains the patient's tab and diagnosis tab. When one is clicked the app routes you to the respective page.

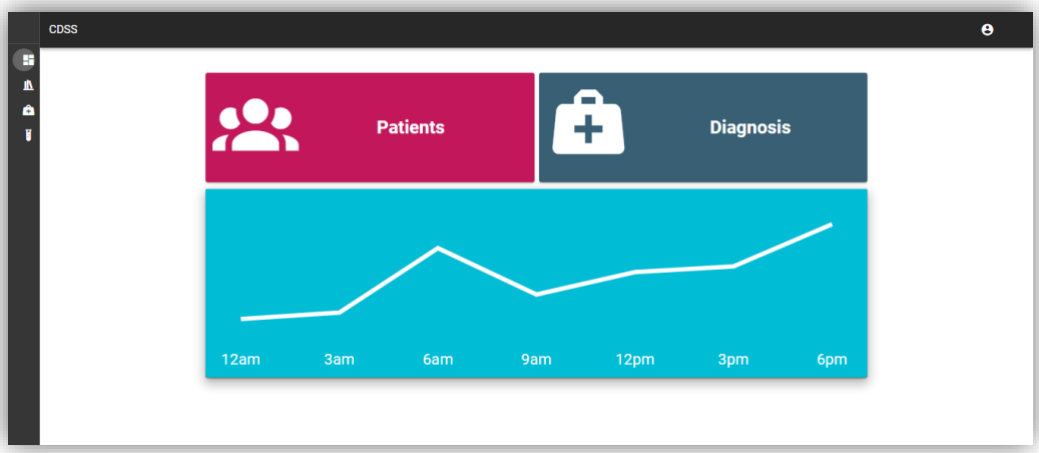


Figure 3 App Dashboard

Patient's page

This page shows a list of all patients and their records, one can add, modify and delete a patient's record. One can also search through the patient's data easily. This helps in management of the patient's data in the app.

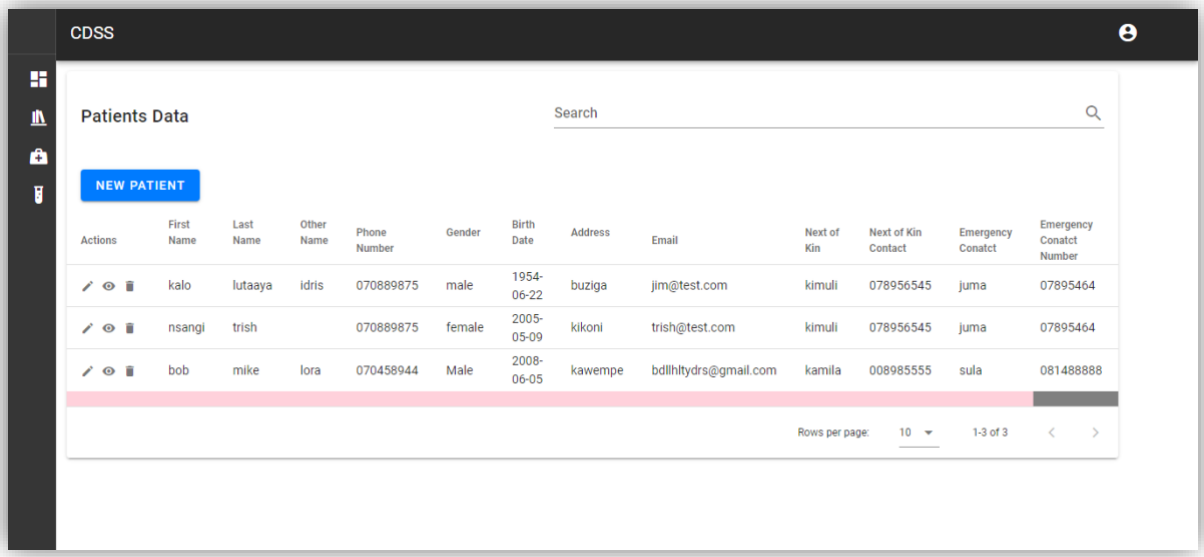


Figure 4 Patient management page

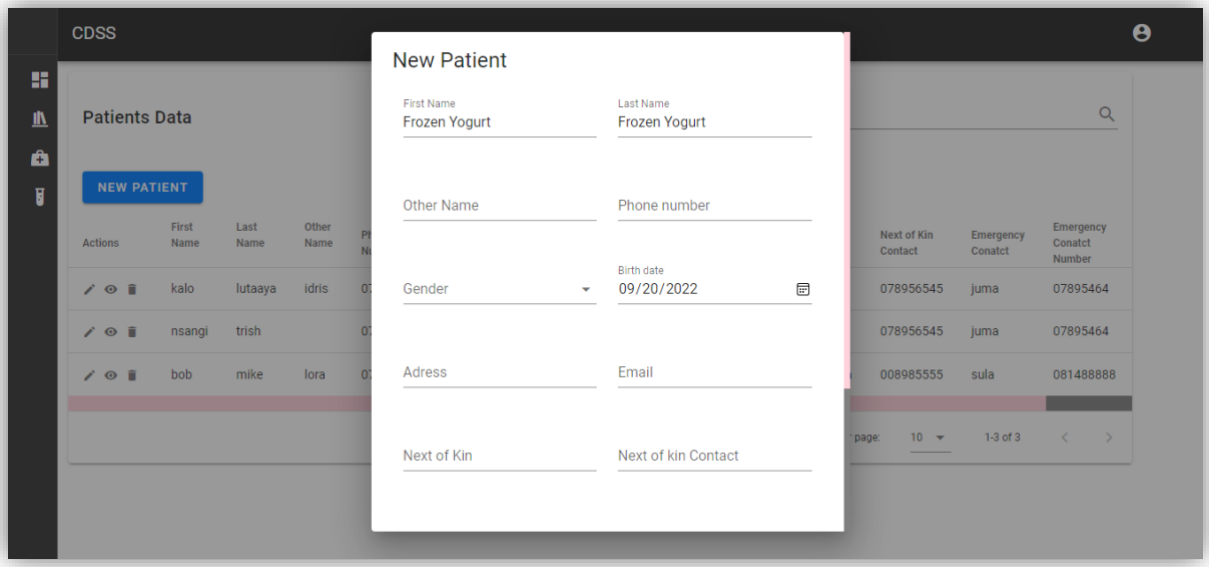


Figure 5 Adding new patient to system

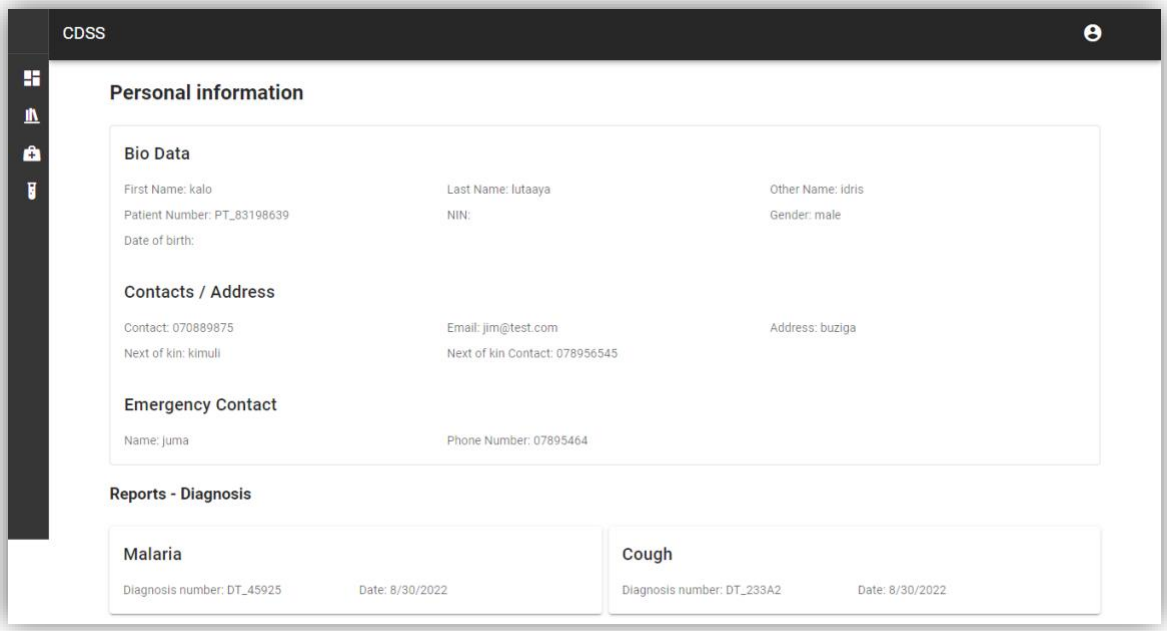


Figure 6 Patient information page

Diagnosis

The app has a diagnosis feature where the user can use the built in AI assistant to reach a final conclusion. The user is required to first fill in the patient number to proceed with the process. The user is required to insert the symptoms and the systems recommends possible diseases to which the doctor can make a conclusion.

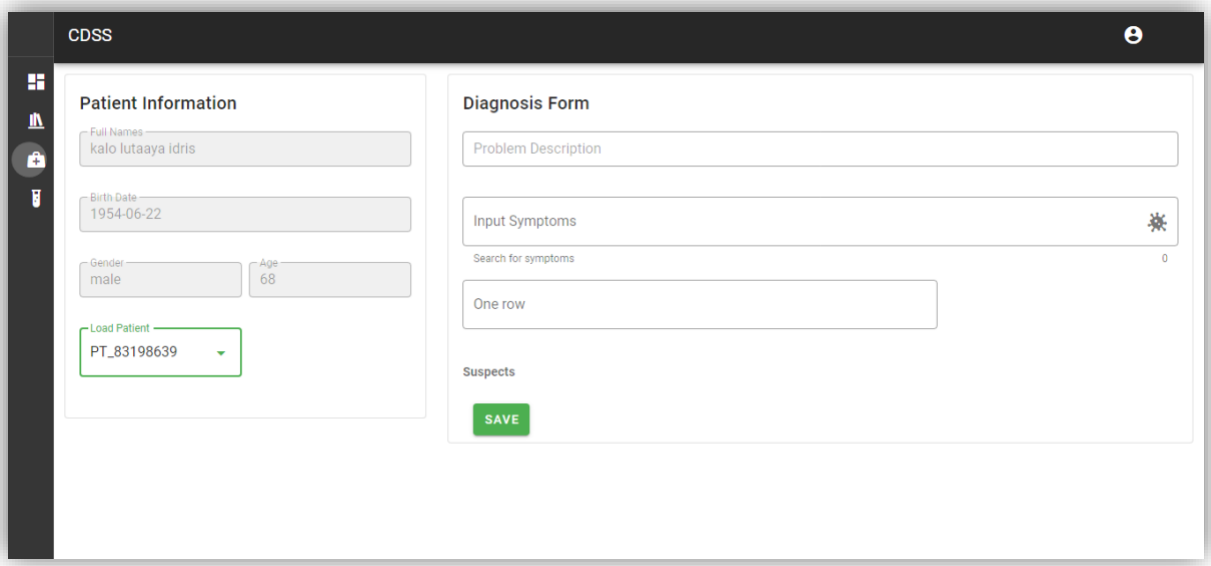


Figure 7 Diagnosis page

Testing

The app can also be used to record results from the tests to further improve the diagnosis of the doctor. This helps the doctor make informed decisions.

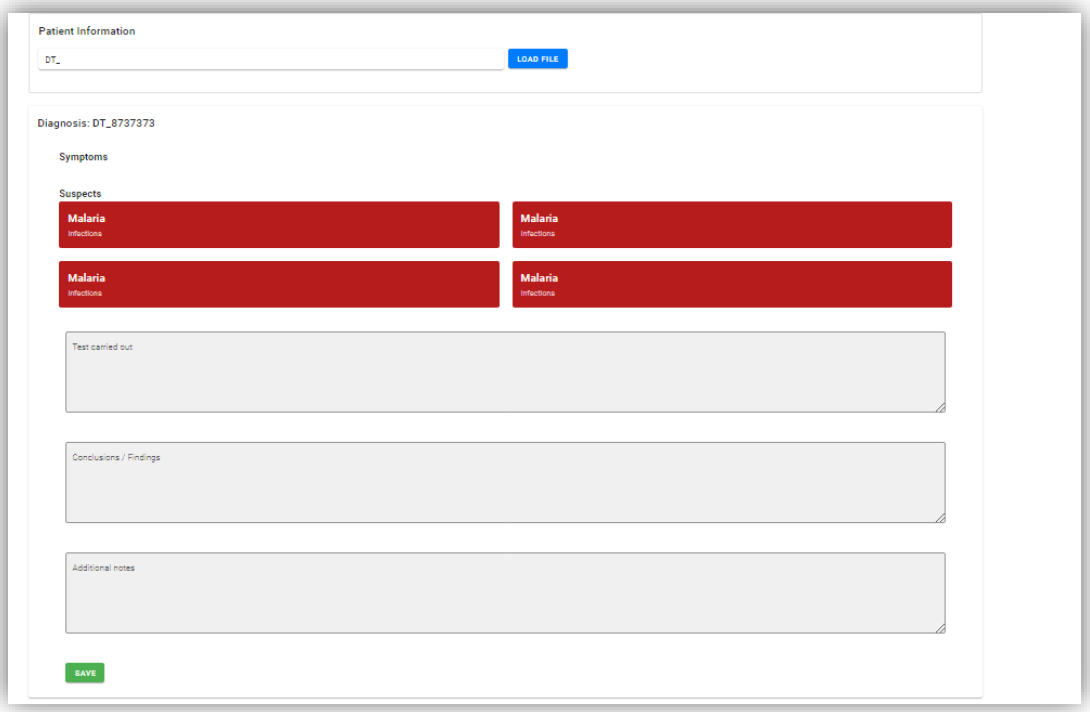


Figure 8 A lab test form from the app

Medical Library

This feature provides doctor with real time medical reference to help them during work. It groups problems, issues and diseases into categories in which doctor can choose from.

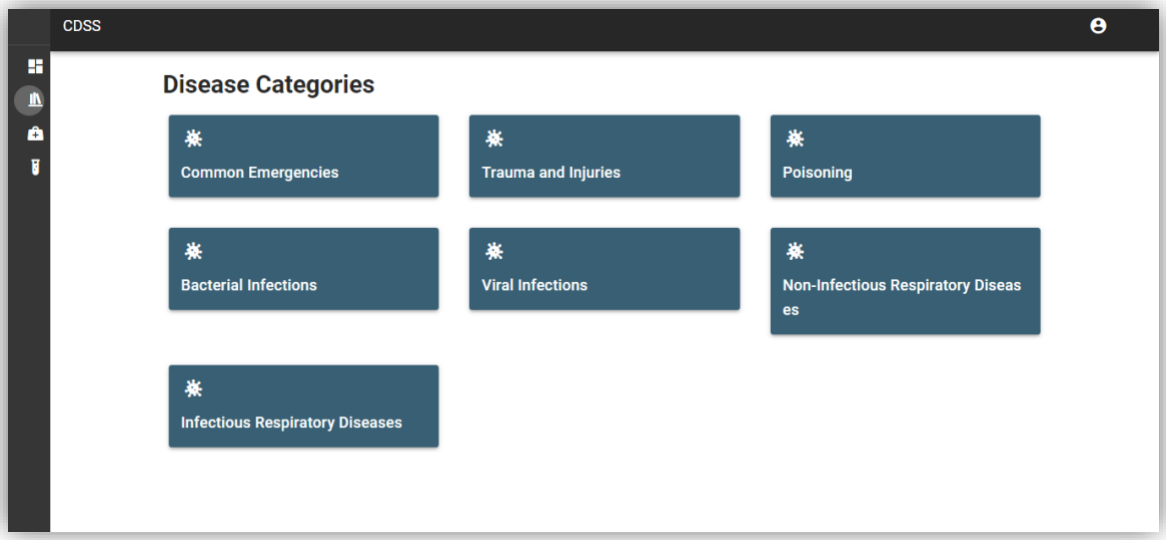


Figure 9 Library home page

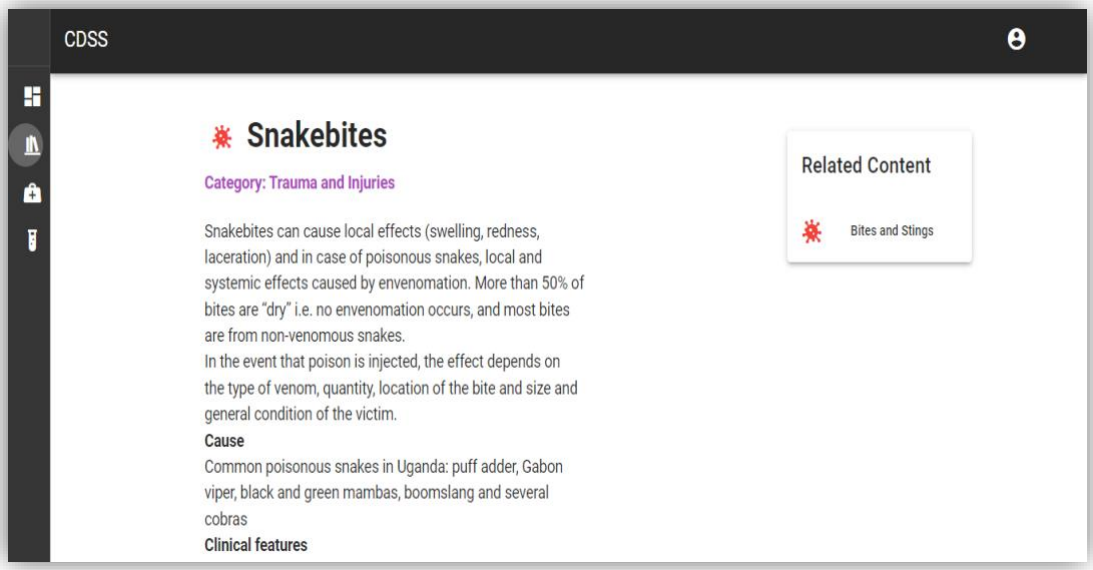


Figure 10 information page about a disease

4.5.2 Nonfunctional requirements

Nonfunctional requirements are specifications that describe the system's capabilities in terms of operation and constraints. These are discussed below;

4.5.2.1 Usability requirements:

- the application is in English so as to enable all of the users to use it.
- The app should be able to provide accurate diagnosis to the doctors.
- The app should only be used after logging in.
- The app should be able to handle patient data management and make data accessible through out all the modules.
- The app should allow patient to share the data online.

4.5.2.2 Performance requirements:

The application shall be able to support simultaneous user access. This will be accessed via web making and it able to run on all machines irrespective of computer type.

4.5.2.3 Security requirements:

The application must be extremely secure since it deals with a lot of private information of the users. This should be performed using the authentication and encryption. The application should be in position to follow these main security rules;

− Confidentiality: only the verified doctors with accounts have access to user personal information and orders.

− Integrity: only verified doctors with accounts can modify their personal information. Therefore, the system shall provide password protected access to the application's features and interfaces.

4.5.2.4 Supportability requirements:

The application should be able to be accessed regardless of the operating system a user may be using. One only requires a browser to access it.

4.6 System design

System design is the process of designing the architecture, components and interfaces for a system such that it meets the end user requirements.

4.6.1 Architectural design

The application was broken down into two major components which are the client-side and the server side. The client side was further broken down into the functional component and the graphical component. The functional component forms the core system which receives user input, makes calculations required whereas the graphical component is the graphical user interface which provides the text boxes, buttons, and other elements that allow the user to navigate and access the different features of the application. The server component on the other hand comprises of an interface that manages database input, structuring and acts as a central storage for synchronized data. The data is then stored in the database. The client side also communicates with a third-party cloud service called Infermedica which provides the system with real time diagnosis functionalities via a secure Application Programming Interface (API) connection.

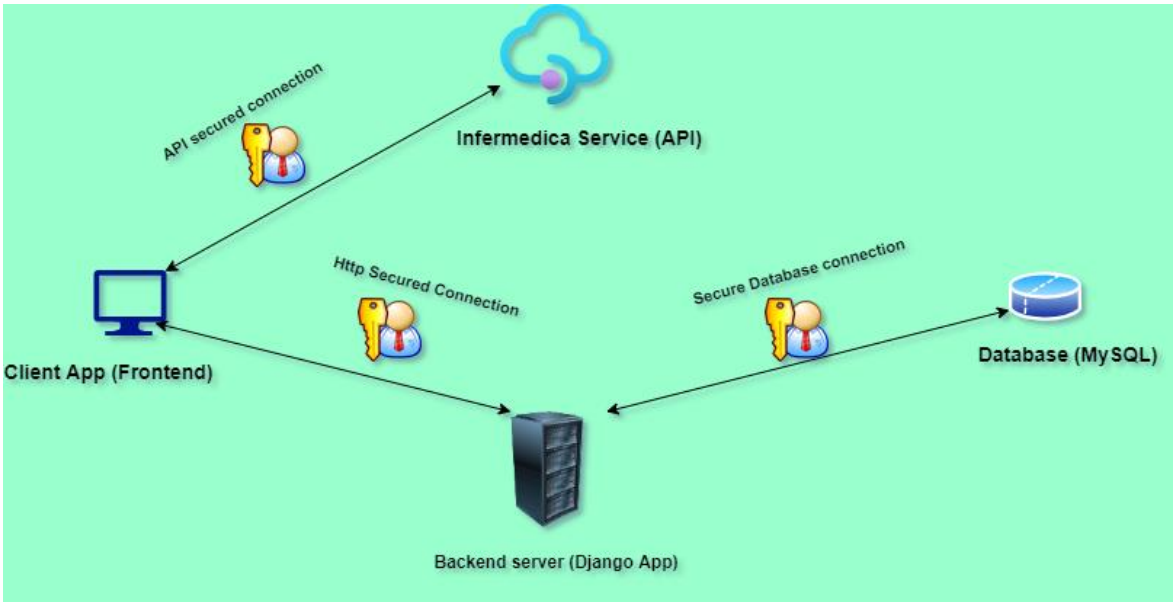


Figure 11 System architecture

ENTITY	DESCRIPTION
Client	This is the app on user computer browser. It is the front end of the system. It is implemented with HTML, CSS, VueJS, and JavaScript. It communicates with the backend through HTTP requests and gets data as response to display to user.
Backend Server	This is the app running the business logic of the app for example database insertions, deletions and modifications. It is written in Django Python.it communicates with the client using HTTP requests
Database	This holds the data of the application. MySQL was used as the data store of the app
Infermedica	Infermedica is an artificial intelligence (AI) powered platform which collects, analyzes and employs medical knowledge and provides advanced reasoning technology to identify patients' conditions.it is an AI-powered health care platform that helps doctors deliver efficient, safe, and reliable care to their patients. The client communicates using API endpoints provided by Infermedica to get real-time diagnosis

Table 2 System Architecture

4.6.2 Design rationale

The Application uses a 3-tier application architecture due to its benefits such as:

- **Maintainability**. Since each tier is independent of the other tiers, updates or changes can be carried out without affecting the application as a whole.
- **Scalability**. Since the tiers are based on the development layers, scaling the application is a straightforward action.
- **Flexibility**. Since each tier can be managed or scaled independently, flexibility is thus increased.
- **Reliability**: the architecture, if deployed on multiple devices, makes it easier to increase reliability of the system by implementing several levels of redundancy.
- **Reusability**: separation of the system into multiple layers makes it easier to implement reusable components, for example in the business layer, a single

component may be accessed by multiple components in the presentation layer at the same time.

Therefore, the system architecture used server client architecture where the client connects to the application backend in to make data requests and processing.

4.6.3 Process Modelling

In process modeling, we focused on the visual presentation and documentation of information flow within the Application. It involved describing how the information enters and leaves the application, how the information changes, and how and where it was stored, together with the scope and boundaries of the system.

These are the different symbols used with their meanings:

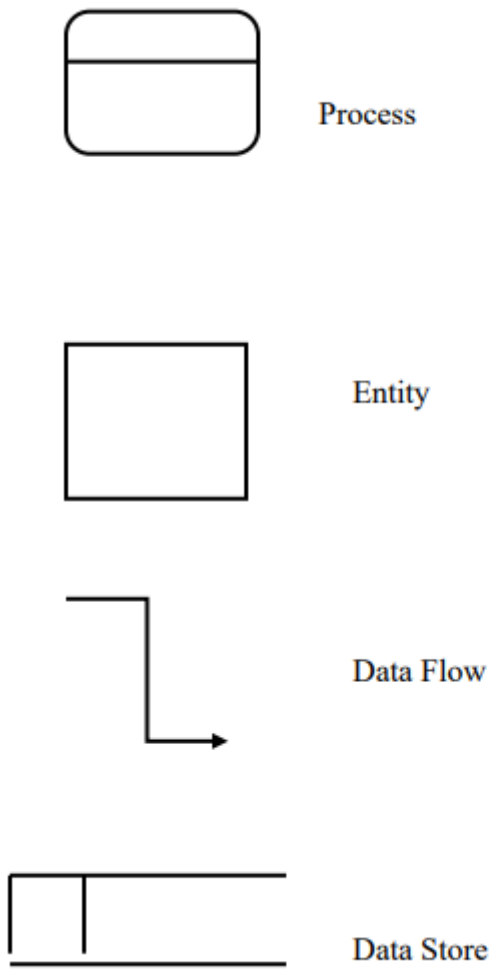


Figure 11: Diagrams showing symbols used in Process Modeling and their meaning

4.6.4 Context diagram for Clinical Decision Support System

The context diagram defines the boundary between the system and its environment. It shows how the entities interact with the Application.

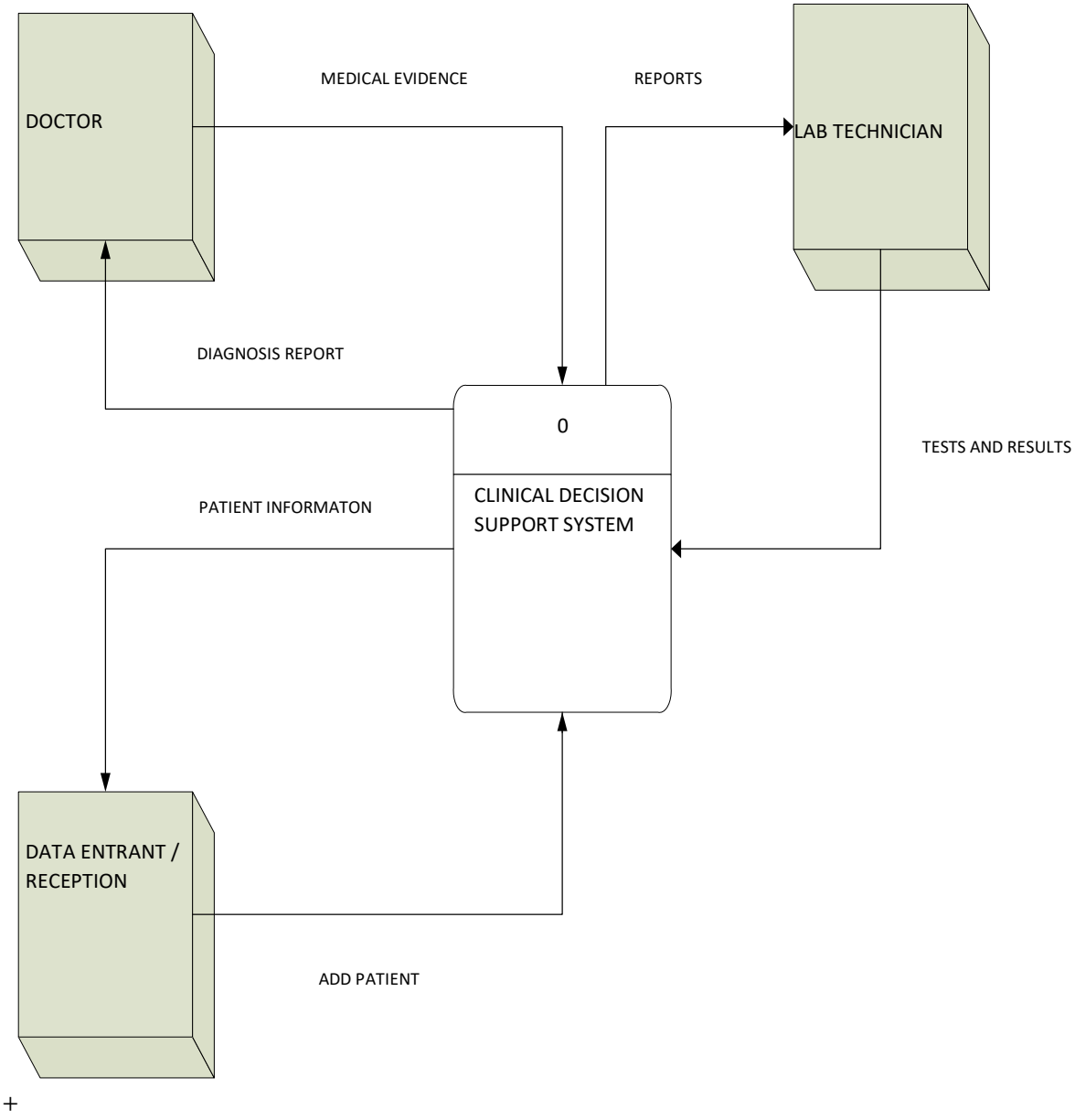


Figure 12 Context Diagram

4.7 Sequence Diagram

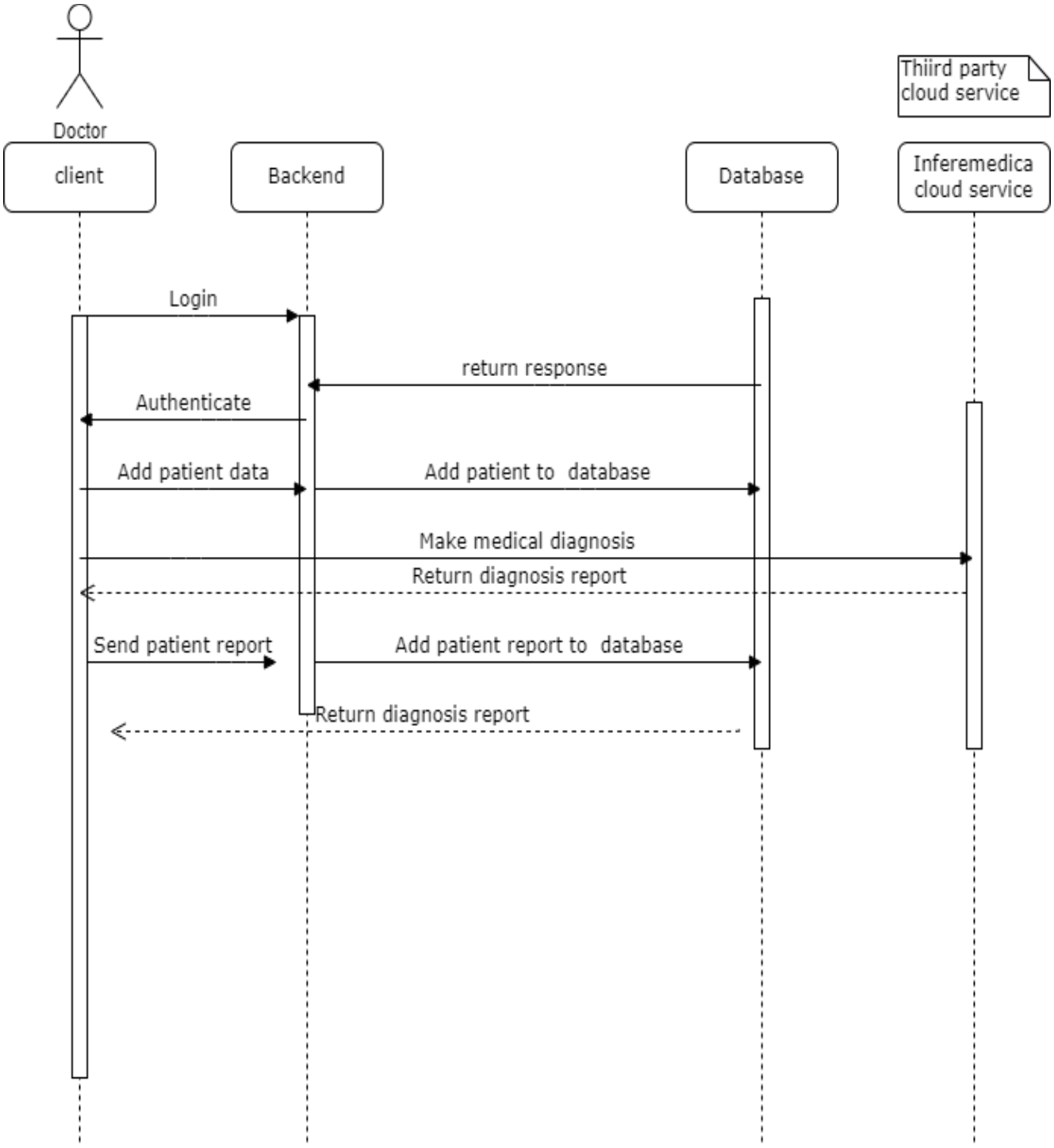


Figure 13 Application sequence diagram

ENTITY	DESCRIPTION
Doctor	The main actor in the system. He is the one who uses the system
Client	This is the app on user computer browser. It is the front end of the system. It is implemented with HTML, CSS, VueJS, and JavaScript. It communicates with the backend through HTTP requests and gets data as response to display to user.
Backend Server	This is the app running the business logic of the app for example database insertions, deletions and modifications. It is written in Django Python.it communicates with the client using HTTP requests
Database	This holds the data of the application. MySQL was used as the data store of the app
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Table 3 Sequence Diagram

4.8 Database design

The section presents the conceptual, logical and physical design of the database.

4.8.1 Logical Database design

This was formed by identifying the entities in the system and their associated attributes as shown in the table below

Entity name	Description	Attributes
Diagnosis	This entity contains all diagnosis details	- diagnosis_number {PK} - Problem_Description - Symptoms - Conclusion - Date_taken - Patient_number {FK}
Patient	This entity contains all details about patient	- Patient_number {PK} - names - gender - birth_Date - address - email - nin - next_of_kin - emergency_contact
MedicalLibary	This entity contains all details about medical library	- id {PK} - name - category - body
DiseaseCategory	This entity contains all details Disease category	- id {PK} - name

Table 4 Logical Database Design

4.8.2 Conceptual Database design

This study used the Entity Relationship diagrams to show the existing relationships between entities and attributes and their information requirements. The diagram helped in the modeling of data stored in the database.

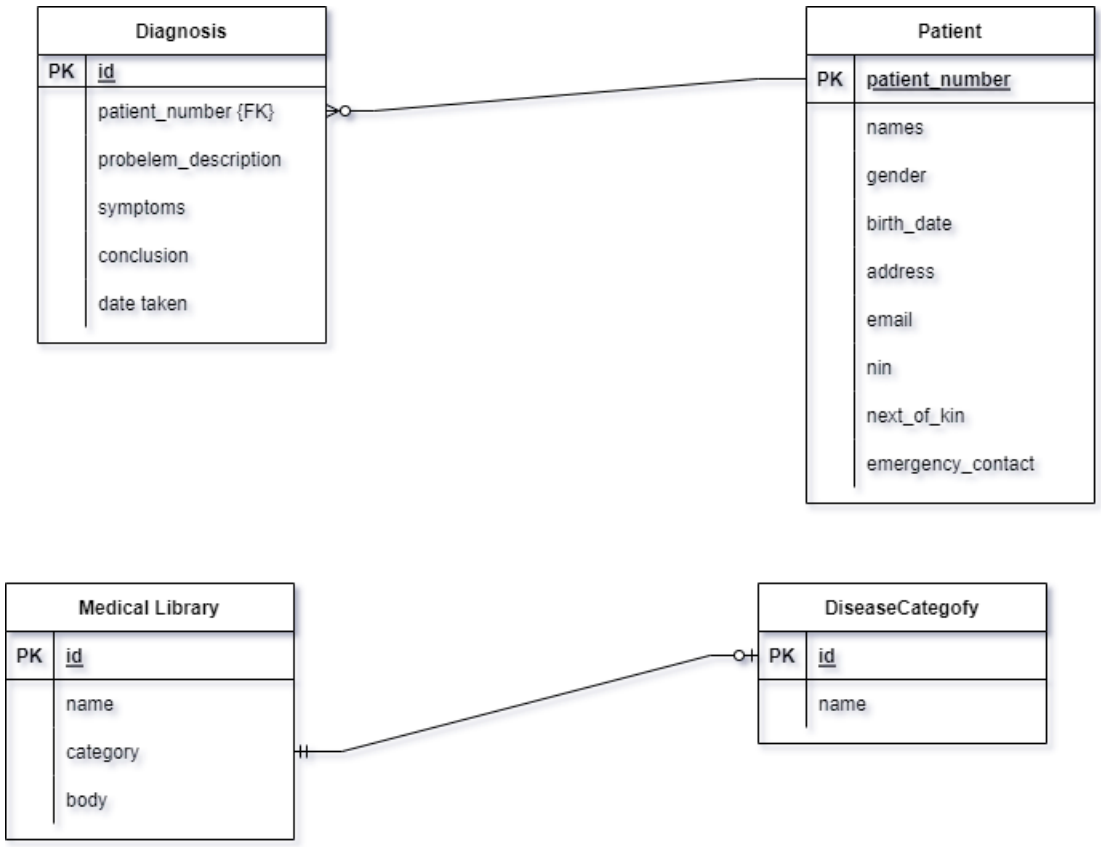


Figure 14: ERD Diagram of application

4.9 Conclusion

The data collected from the research study was cleaned and analyzed to get a deeper understanding of the requirements necessary for the system. The requirements helped in designing the system architecture and database which would later be used in the implementation phase.

CHAPTER FIVE: SYSTEM IMPLEMENTATION, TESTING AND VALIDATION

5.1 Implementation

This section describes the programming languages used and the development tools applied in the development of the application.

5.1.1 Modeling language

Unified Modeling Language was used to aid in the creation of class diagrams, sequence diagrams to communicate aspects of the system and therefore worked as a blue print in coming up with a complete design to be implemented.

5.1.2 Programming languages

The research team used:

- Python for implementing the system functionality.
- Html and CSS to create and model the user interface.
- MySQL as database.
- JavaScript to add interactivity.
- Infermedica to add diagnosis functionality

Other tools used;

- Visual studio code as our main editor for building the system.
- Django models for creating and managing the application's database.
- Vuetify and Material design to style the app interface.

5.2 Users:

The beneficiaries of the new system and those affected by the system include the following;

Doctors:

Doctors can use the diagnosis feature to aid them in carrying out medical diagnosis.

Nurses:

The system provides features like data management, and well detailed information which the nurses can use during their work.

5.2.1 Location.

The application is available to any potential customer using the internet. The users may also use the application from any location.

5.2.2 Responsibilities.

The primary responsibilities of the application are as follows;

- Provide doctors with detailed information on how to handle different medical situations.
- Assist doctors in carrying out diagnosis by providing recommendations and solutions.
- Patient data management. The application will enable users to delate, modify and add new patient data with ease.
- The application will provide detailed reports and easy sharing of medical data between departments.

5.3 User interface

The users are prompted with the login screen by the application. Once the user logs into the application successfully, they are availed a dashboard with several selection features and the menu on the sidebar with a catalogue of features. The user can select any of the available features and perform the desired actions.

A user can perform data management, diagnosis, print diagnosis reports, carry out tests and also read from the digital library provided by the system.

5.4 Testing

This section gives information on the Application's testing activities. The methods of testing used include:

5.4.1 Unit testing

Under this section, the individual units and modules of the application were tested to evaluate whether the features operate as expected. Each unit of the application was examined to ensure that it performs the tasks it is meant to and discover any errors in the code to verify that certain application parts are working well. These tasks included capturing and analyzing user information, validating the information and retrieving data.

The success of each individual unit gave a go ahead to carry out integration testing. All the identified errors were dealt with accordingly.

5.4.2 Integration and system testing

This was done after the different modules of the application were placed together to come up with a complete application. This type of testing was majorly aimed at the different modules that are compatible and that they can be integrated to develop the complete working application. Testing was done throughout the development of the application.. Whenever a feature or a functionality was added, we tested it by restarting the server. This helped us to find errors right away and had every functionality of the application tested.

5.5 Validation

This was done by comparing the functionalities of the application to the expectations of the application that were described in the planning phase.

Users aided this process by giving feedback about the usage of the application and this was done to verify whether the application met the intended user requirements.

5.6 Requirements' acceptance

This describes the application requirements and guides throughout the process of development and validation.

5.6.1 The system inputs

- Inputs to the application include the username if a given user, their password that is associated to them and their personal information that is submitted at the time of registration to the application in order to gain access to the application. This information is stored in the database from which the application can retrieve this data to grant them access to the application.
- Patient details that are submitted by the user which include information about the patient names, address, contacts, date of birth and any another data associated with the patient.

5.6.2 System Outputs

Patient diagnosis reports can be printed and shared by the doctor upon request.

5.6.3 System limitations

The application is web based thus it requires internet connectivity to access.

5.6.4 System platform support

The application is web based thus can run on all systems which have a browser that is Linux, windows, mac OS, iOS devices and androids.

5.6.5 System service and maintenance

The contact page enables users to send requests and feedback or support in case they are to encounter any problems.

5.6.6 Problem solutions

In case of a problem, the user shall send the application error reports to the developers of the application such that they can be looked into for purposes of debugging.

5.6.7 Errors

The research team does not expect the Application to contain any errors but in an event that they arise, the users have the option of sending a message to the developers.

5.7 Conclusion

We managed to come up with a Clinical Decision Support System using prototype method which runs on the web online. Validation and verification were carried out to ensure that the system requirements are all met.
The system can help medical practitioners to make informed decisions during clinical decision process.

CHAPTER SIX: DISCUSSION, RECOMMENDATIONS AND CONCLUSION

6.1 Discussion

The objective of this project was to design and develop a Clinical Decision Support System (CDSS) application which enhances and automates the clinical decision process.

To do this, we clearly stated the problem the Clinical Decision support System was solving. We then clearly outlined the objectives of the projects. These were to help us in data collection.

We carried out data collection using both qualitative and quantitative methods. We used tools such as questionnaires, carried out interviews, and observations in different medical centers to get the data.

The data was later cleaned and analyzed to get better understanding of it. The data clearly showed there was need for a Clinical Decision Support System. The data also revealed the system requirements needed foe the system.

With the system requirements in place, we managed to design the system by modeling the processes of the system the database using Context diagrams and Entity Relationship Diagrams.

The system was developed using a client server architecture, with technologies such as JavaScript, HTML and CSS for the frontend and Python used to develop the backend server.

We carried out tests to ensure that the system meets the system requirements and its it deployable state.

After the entire research process, we came up with a fully functioning Clinical Decision Support System.

6.2 Achievements and Lessons learned

This project has been one of the most rewarding experiences for the research team. The research team learned how to undertake certain tasks under pressure. Having gone through the entire software development life cycle made us learn how to get organized in all aspects

of life. Additionally, the sets of documents that we have produced have given us an insight into the importance of documentation.

It was amazing how we were able to learn web application development using Python and JavaScript throughout the process while developing the application. We made use of YouTube tutorials, git hub repositories and stack overflow‘s solutions to each and every problem we faced while developing the application.

Additionally, working on this application was a great opportunity for the research team to put the knowledge acquired during these 3 years into practice and also it was a checking point to our weaknesses and helped us transform them into strong points.

Therefore, we have learned a lot, skill wise, for example, how to gather requirements, design, implement and test a software. In addition, we were able to learn how to implement the server side, client side and data side each one separately from one another.

We were also able to learn how to analyze the social, technological, economical, ecological, political and ethical aspects of a project and get the best out of it.

6.3 Challenges faced

Inadequate funds to fully facilitate the project was a great challenge since it involved making trips to meet with people and collect data. Also, some web hosting services with better solutions required money.

Identifying what technology to use for the development of the project was quite a challenge since several tools, languages, and frameworks had their disadvantages and disadvantages. We chose the applied frameworks because of their ease of use and fewer configurations to perform.

6.3.1 Future Work and Enhancements

Partnering with the ministry of health to be able to connect the system to the national digital health network or infrastructure. This can greatly improve the use and encourage adoption among different hospitals

The system still has room for improvement. There are more features which can be added, for example, integrating it with other tools like Magnetic Resonance Imaging (MRI) scanners to directly capture results from the tests.

6.3.2 Recommendations

Doctors and hospitals are encouraged to use the CDSS application discussed above so as to easily carry out data management and improve the whole processes of clinical decision so as to make informed decisions.

6.3.3 Conclusion

Lack of a Clinical Decision Support Information System in the country has created inefficiency in most hospital operations. However, with the Clinical Decision Support System, medical practitioners can be able to make informed decisions and also get up to date medical information to support them in Clinical Decision Support System. This will help in improving the efficiency in hospital medical operations.

References

1. Ahmadian, L., Engen-Verheul, v., M., B.-R. F., Peek, N., Cornet, R., Keizer, d., & N.F. (2011). The role of standardized data and terminological systems in computerized clinical decision support systems: literature review. . *International journal of medical informatics*, 80-93.

2. Aranda-Jan, C., Mohutsiwa-Dibe, N., & Loukanova, S. (2014). *Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa.* BMC Public Health.

3. Barnett, G., Hoffer, E., Hoffer, E., Feldman, M., Kim, R., & KT, F. (2008). *Senior Member Presentation Proposal. DXplain-20 years later--what have we learned?* AMIA Annu Symp Proc. .

4. Berner, E. (2009). *Clinical decision support systems: state of the art. Rockville, Maryland.* Agency for Healthcare Research and Quality.

5. Chen, W., & Skjelvik, D. (2009). A mobile clinical decision support system for clubfoot treatment. *Artif Intell Med.*, 181-185.

6. De Dombal, F. (1992). Computers, diagnoses and patients with acute abdominal pain. . *Arch. Emerg. Med.* , 267-270.

7. Dimitrios, Z., & Nailya, D. (2018). *CDSS-RM: a clinical decision support system.* National Library of Medicine. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6240189/

8. Garcia, E., & Klein, J. (2014). Clinical decision support systems in myocardial perfusion imaging. J Nucl Cardiol. . *J Nucl Cardiol*.

9. Gasthony, A., Emmanuel, O., Pontius, B., Alex, M., Violah, N., & Josaphat, B. (2021). *Why women die after reaching the hospital: a qualitative critical incident analysis of the 'third delay' in postconflict northern Uganda.* National Library of Medicine. Retrieved from https://pubmed.ncbi.nlm.nih.gov/33753439/

10. Jesse, I., & Jerry, H. (2008). The effect of computerized physician order entry with clinical decision support on the rates of adverse drug events: a systematic review. *Journal of general internal medicine*, 451–458. Retrieved from https://doi.org/10.1007/s11606-008-0504-5

11. Joseph, R., & Stella,Neema. (2013). Pregnant women's experiences of routine counselling and testing for HIV in Eastern Uganda: a qualitative study. *National Library of Medicine*.

12. Joseph, R., Cissy, L. ,.-M., & Grace, N. (2010). Challenges faced by health workers in providing counselling services to HIV-positive children in Uganda: a descriptive study. *Journal of the International AIDS society*.

13. MA, S., A, B., & AR., N. (2014). An adaptive expert system for automated advices generation-based semi-continuous m-health monitoring. . *In: International Conference on Brain Informatics and Health.*, 388-399.

14. Ministry of Health, U. (2016). *Uganda Clinical Guidelines 2016.* Ministry of Health, Uganda.

15. Mohammad, h., zadeh, H., Woensel, W., Abidi, S., & Abidi, S. (2017). Semantics-based plausible reasoning to extend the knowledge coverage of medical knowledge bases for improved clinical decision support. . *BioData mining*.

16. National Health Service, U. (2012). Retrieved from effectivepractitioner: https://www.effectivepractitioner.nes.scot.nhs.uk/media/254840/clinical%20decision%20making.pdf

17. Peiffer-Smadja, N., Rawson, T., Ahmad, R., Buchard, A., Georgiou, P., Lescure, F.-X., . . . Holmes. (2020). A. Machine learning for clinical decision support in infectious diseases: a narrative review of current applications. *Clin Microbiol Infect*, 584-595. Retrieved from https://doi.org/10.1016/j.cmi.2019.09.009.

18. Ree, T. S., & Pincock, D. (2020). An overview of clinical decision support systems: benefits, risks, and strategies for success. *National Library of Medicine*. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7005290/

19. Roman, L. (2009). Combined EMR, EHR and PHR manage data for better health. *Drug StoreNews,*, 40-78.

20. Shaker, H. E.-S., & Samir, E.-M. (2014). A distributed clinical decision support system architecture. *Journal of King Saud University - Computer and Information Sciences, 26*, 69-78. Retrieved from https://reader.elsevier.com/reader/sd/pii/S1319157813000116?token=5782E2C686002D36F3967B238BED2A0B13401FCC0CED92D60D0766B0F9F47D21AB175833867EF182650912BD48285DDF&originRegion=eu-west-1&originCreation=20220823135317

21. Strategic Information, (. (2018). *Health Management Information System (HMIS) in Uganda.* M & E Technical Support Program.

22. Wright, A., Sittig, D., Ash, & J.S. (2011). Development and evaluation of a comprehensive clinical decision support taxonomy: comparison of front-end tools in commercial and internally developed electronic health record systems. *Journal of the American Medical Informatics Association*.

Appendix

Questionnaire

MAKERERE UNIVERSITY

Greetings, we are students of Makerere University at the college of computing and informatics Sciences (COCIS). We are building a system as final year project called a clinical decision support system (CDSS). This system will assist medical personnel make informed medical decisions with the help of an information system. The data collected will enable us build a reliable and efficient system.
We pledge confidentiality of the data collected.

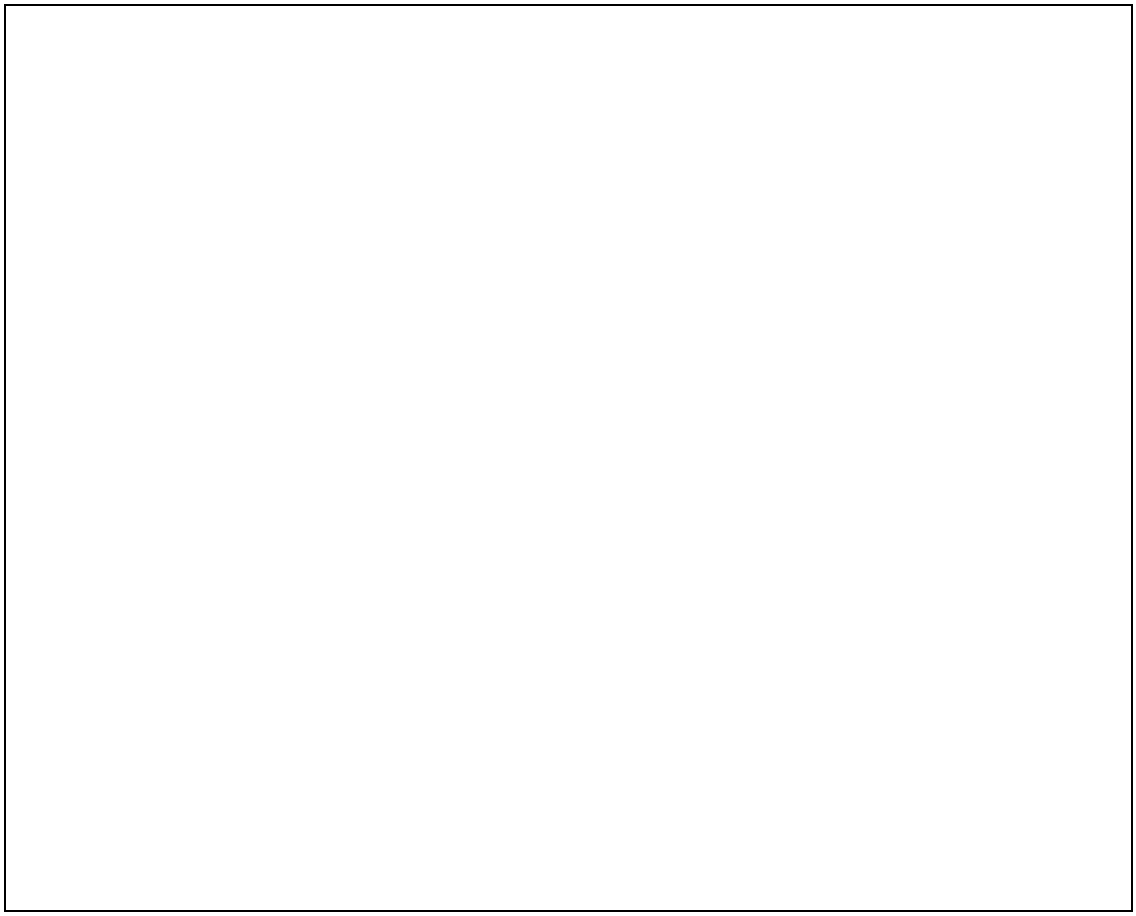
1. Name of hospital: ……

2. What are challenges faced during clinical decision in the hospital?

3. What are proposed solutions to the above problems?

4. What CDSS/methods are currently being used?

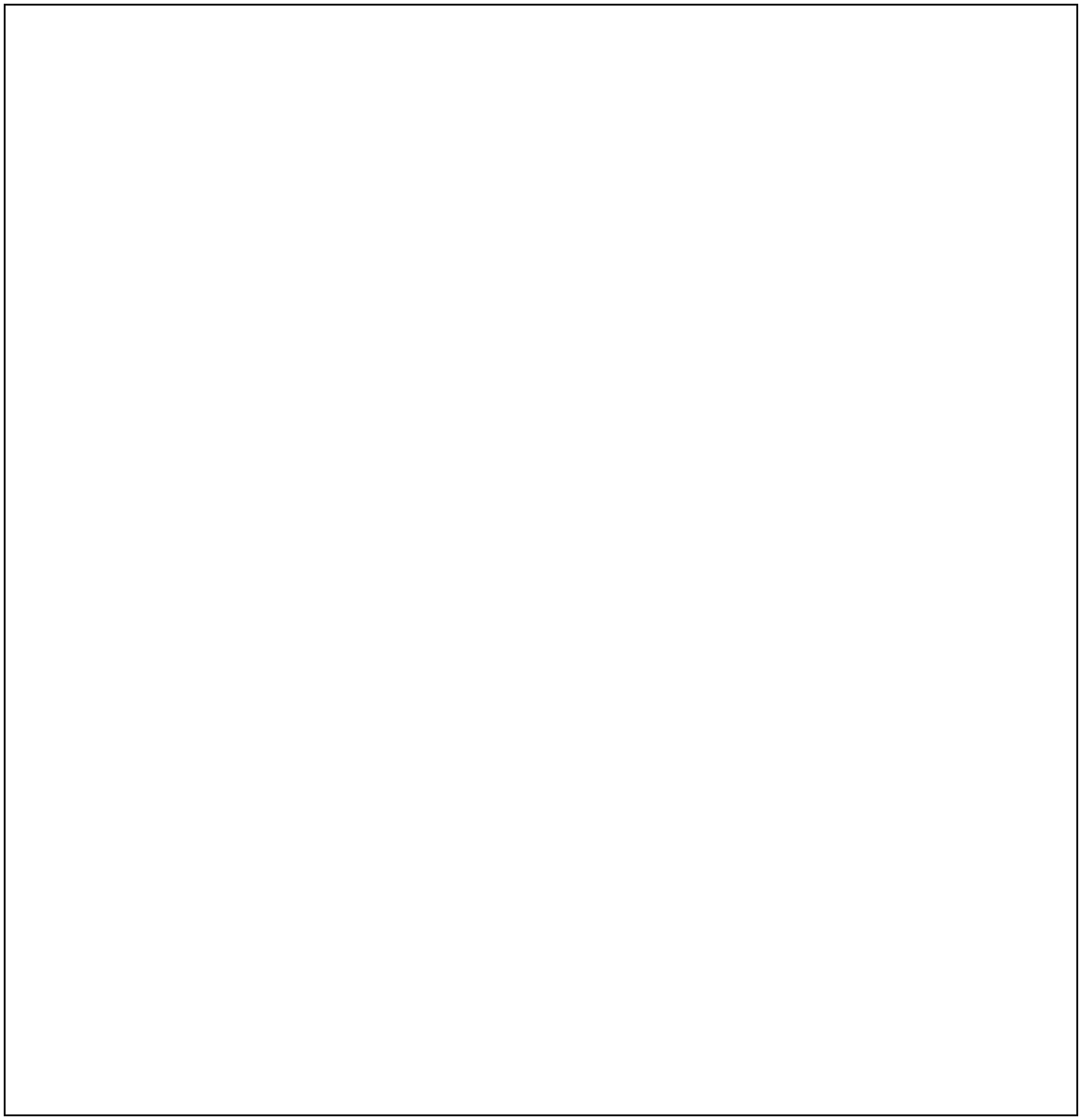
5. Elaborate briefly the process of clinical decision in your hospital?



6. Will the Clinical Decision support system be useful in your clinical decision process?

   YES ( ) NO ( )

7. What features would you want in a CDSS?



Thank you for your time