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ANTENATAL MANAGEMENT INFORMATION SYSTEM (CASE STUDY: CHINA-UGANDA FRIENDSHIP HOSPITAL, NAGURU)

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ABSTRACT: *To eradicate fetal deaths and stillbirths, the World Health Organization (WHO) set up antenatal care guidelines to help expectant mothers through this period. In Uganda today, it is estimated that at least 90% of the expectant mothers receive antenatal care, and with such a large number of people receiving this service, data is collected manually with pen, which makes it a long process and cumbersome to search specific records during emergencies and analysis of data for proper decision making. Therefore, there is a need for an antenatal management information system. The software is sectioned into registration, triage and consultation. The records officer handles registration of patients, patient visits, viewing and printing patient statistics. The senior clinical officer handles triaging the patient and capturing their vitals, viewing and printing patient statistics. The head midwife handles the monthly progress examination, and views and prints patient statistics. All these processes happen in real time. This system is designed to overcome the problems identified in the current antenatal management information system. The interfaces for the new system were implemented using JSP, Bootstrap and Javascript. PostgreSQL was also used for implementing the system database while Spring was used to create interactivity with the database. After the implementation, the new system was then tested and validated. When developing the system, the focus was on making the whole process of information management in the antenatal department faster, more convenient and efficient.*

KEYWORDS: Antenatal Care, Antenatal Management, Information System, Uganda

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INTRODUCTION

To eradicate preventable maternal deaths and to reduce the Maternal Mortality Rate (MMR), world leaders agreed at the Millennium Summit in September 2000 to improve the lives of the world's poor people through the acceptance of the World Health Organization's (WHO) Fifth Millennium Development Goal (Alkema, 2016). By 2000, WHO estimated lifetime risk of maternal deaths of 1 in 16 in Sub-Saharan Africa while it was 1 in 2800 in developed countries. This huge deviation in the rate of maternal deaths is due to the differences in access and use of maternal health care services (Mpembeni, 2007).

WHO defines antenatal care (ANC) as the care provided by skilled health care professionals to pregnant women and adolescent girls to ensure the best health conditions for both mother and baby during pregnancy (Organization, 2016). ANC as the essential entry point to maternal health care services is equipped to impart preventive service, diagnose and treat complications during pregnancy, and provide proper information to promote the use of skilled attendance at birth (Conrad, 2012). Research has shown that the coverage of ANC services in Uganda is generally high, with more than 90% of all women making at least one visit (UNICEF & United Nations Children's Fund, 2008; Conrad, 2012). With all these high coverage rates, ANC ought to be of undoubtedly high quality to serve as an effective entry point to all other maternal care services (Conrad, 2012).

In Uganda today, ANC is provided and records taken by hand pen, archived in books, and antenatal cards as suited to the particular facility providing the service. With numbers skyrocketing as high as 90% of the women making at least one visit (UNICEF & United Nations Children's Fund, 2008; Conrad, 2012), this method of capturing and storing data becomes very cumbersome given the difficulties the country faces such as shortage of health workers (Ministry of Health, 2015) and concerns around long waiting times, unofficial fees in public facilities, and poor attitude among health workers (Jitta J, 2008; Conrad, 2012) that in turn water down the quality of service provided.

The proposed AMIS seeks to provide better service delivery tailored for the Ugandan Health Sector but also resolve the weaknesses conveyed by the reviewed systems by auto-generating client reports through integrated information processing and storage, increased data security using role-based and rule-based access rights. The system being web-based solves the problem of compatibility there for AMIS; this would be the ideal solution to information management in the antenatal department and also key in informative decision making by the respective bodies in charge.

METHODOLOGY

The study employed a qualitative methodology of research in which the opinions of senior nursing officers, midwives, interns, and records officers were sought and then contextualized according to their understanding. The case study was China-Uganda Friendship Hospital, Naguru. The information which was conformed to other public hospitals countrywide and gave the basis for the design of the system.

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System Study Tools and Techniques

Under the system study, more data on the Antenatal Management Information System was collected, and interviews were carried out using questionnaires, and observations to understand the existing system.

Interviews

Structured and unstructured interviews were used as techniques to acquire information on the current system. Unstructured interviews were used to establish rapport and comfort with the participant in several rounds, and it was used when interviewing random people. Structured interviews were used when interviewing specific individuals in offices since the technique adheres to the use of a guiding protocol to target a specific phenomenon or experience.

For the structured interviews, we prepared a form that served as a questionnaire made of both close-ended and open-ended questions to acquire needed information from the different staff that include records officer, interns, senior clinical officer and head midwife who actively participate in the system flow.

Observation

As part of the study, observation was employed to engage the research team in the workflow to understand the client-flow from the time of arrival until the discharge.

System Analysis

After a successful data collection, it is important to carefully analyze the data to accurately extract the desired information. The desired information includes functional requirements, non-functional requirements, and feasibility analysis. Several tools can be applied to analyze the data acquired; however, SPSS was chosen as a tool to be used for the data analysis of the quantitative data gathered. SPSS is a software package used for interactive or batched statistical analysis.

The fact-finding methods used in this research comprises both quantitative methods and qualitative methods. A questionnaire survey is a quantitative method of data collection whereas an interview is a qualitative data collection method. Observation can be carried out in both quantitative and qualitative context but in this research, the quantitative context was used. Statistical analysis was applied to the quantitative data collected. Qualitative data can be analyzed in five ways: content analysis, narrative analysis, discourse analysis, framework analysis, and grounded theory. However, discourse analysis was used because the data was collected from an interview and discourse analysis is used for analyzing data from natural talking and written text.

System Design

The system was designed following Object-Oriented Analysis and Design (OOAD) which employed tools such as Data Flow Diagrams (DFD), Entity Relation Diagrams (ERD), and Activity Diagrams, etc.

Data Flow Diagrams exhibit the graphical representation of point-to-point flow of data through the proposed system. On the other hand, Entity Relation Diagrams exhibit the role-

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based functionalities of the system, who and how the different actors interact with the system at an encapsulated level.

System Implementation

The system was developed using spring—a Java framework—to handle the backend; the programming language of choice is Java because of its sophisticated security, Java-Script/jQuery, HTML, Bootstrap for the frontend because of their wide base of support features for web development. The IDE is NetBeans. The DBMS is PostgreSQL running over Apache Tomcat Server. The system is based on the MVC architecture.

a. Spring

Spring is a framework designed to simplify Java development. It is a lightweight container which promotes Plain Old Java Object based development, loose coupling through dependency injection and coding to interfaces. It uses Java for the backend and Java Servlet Pages (JSP) to develop dynamic web interfaces.

b. PostgreSQL

PostgreSQL is an open source Relational Database Management System (RDBMS) that uses Structured Query Language (SQL) for adding, retrieving, updating and deleting information stored in a database. It is used for accessing and processing data in a database. PostgreSQL was used because it is designed as a multitasking/multi-user database, which is one of the main requirements for a database to be used for implementing the proposed system.

c. HTML.

HTML simply refers to as Hypertext Markup Language. It was used for describing web pages.

d. Bootstrap.

Bootstrap is a technique of loading into a computer a few initial instructions that enable the introduction by the rest of the program from an input device. Bootstrap is the most popular HTML, CSS and JS framework for developing responsive, mobile fast projects on the web.

System Testing and Validation

At the end of the implementation phase, the system was tested to ensure it attains the stated objectives. We focused on the systematic discovery and debugging of defects. The following procedures were used to test the system:

i. Unit testing where each component of the system was independently tested.

ii. Integration testing where all system components were tested as a whole.

iii. And finally, user acceptance testing for the system to be tested by a small number of end-users of the system.

iv. Once these phases were completed, the system was ready for installation, migration, support and maintenance.

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Unit testing is a type of testing to check if the small piece of code is doing what it is supposed to do. For every component or module developed, we shall do unit testing to test for its functionality. The code must pass the test to be validated.

Integration testing is a type of testing to check if different pieces of the modules are working together.

System Study, Analysis and Design

This chapter defined the revisions carried out on the existing system at China-Uganda Friendship Hospital, Naguru, and requirements evaluated for the new system using procedure and data representation designs.

System Study

In order for the project team to understand and gain requirements of the new system, the current Antenatal Management Information system was studied. The system was studied by interaction with some of the personnel working in the hospital by asking them a series of informal questions to obtain knowledge and understanding of the entire records kept at the hospital facility and the activities carried out in general. The interview data was recorded and then transcribed to produce text that was analyzed using quantitative and qualitative methods of data analysis. Using the observation technique, we learnt about the sensitive issues that the participants in the existing system were unwilling to talk about. Furthermore, we acquired contextual information needed to frame the evaluation and make sense of the data collected using other techniques.

The data collected was analyzed using both structured and non-structured analysis approaches. Using the above techniques, we were able to understand the existing system and to gain the users opinions about the existing and the new system.

Existing System

China-Uganda Friendship Hospital, Naguru, at the moment uses a paper-based information management system to manage their records, create records, backup and generate reports. On arrival, each antenatal client is required to possess a 32-page exercise book in which their vitals are recorded, their biodata is captured and entered into the HMIS registry and then sent for triage. At triage, the client's vitals are captured and recorded in their exercise book. If it is their first visit, they are given an examination progress card and their obstetrics history is captured and filled in the card. After this, they are sent for examination by specialized personnel where their monthly visit progress is captured and recorded on the examination progress card. At the end of the month, the doctor in charge files a report on the number of clients that have been serviced all month long.

DATA ANALYSIS RESULTS

The techniques used for data collection were observation and interviews where we acquired meaningful insights from the dataset. After data collection, we analyzed the data, structuring the findings from the survey research in order to obtain accurate information about the existing and the new system.

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Interview

Interview technique was used to gain more information about the existing system being used for Antenatal Information Management at China-Uganda Friendship Hospital, Naguru, to achieve requirements for the new system. Major stakeholders were interviewed face to face from the records officer to senior clinical officer and to the head midwife. An interview guide was planned and used which involved a set of questions to which respondents gave answers based on their experience and personal understanding of the existing system. All the answers from the respondents were recorded and analyzed for further understanding of the existing system.

Below are the findings of the interview:

Table 1: Analysis of interviews

Question	Answer (1) Records Officer	Answer (2) Head Midwife	Conclusion
Is it easy to keep track of records using the existing system?	It requires more time to go through files of previously recorded client visits.	It is not easy, since not all recorded information is found at the time of review since clients leave with their exercise books containing records.	The existing system is not capable of tracking records because all records are kept in a file system format, which is tedious to those in charge of maintaining the record consistency.
Is the process of recording and keeping antenatal records reliable? Give reason for your answer.	No, because clients take the exercise books containing their records with them and may lose them before they come for the next visit.	No, because clients come in large numbers compared to the official stationery supplied by the Ministry of Health. So, some clients data are not entered into the official documentation, making it hard to file reports.	The existing system is tiresome because all client records are recorded manually on paper which is also not adequate, making it hard to generate reports for the department.
Does it have an impact on your work? How does it have an impact?	Yes, it impacts on the daily activities especially on generation of reports concerning department progress.	Yes, because there are delays with the process of ordering for supplies since the entire management system is manual and all records are on paper; so, it delays in	The system requires a faster report generation process and real time communication in order to satisfy all units in the department.

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		helping to know which unit in the department requires what supplies.	
What solution do can you recommend?	Need of a system that auto generates official forms, to boost the process of recording client data and has real-time communication and ensures security.	Need of a faster report generating system to enhance and automate report generation, and easy monitoring on the records and the department requirements.	There is need for an Antenatal Information Management System for China-Uganda Friendship Hospital, Naguru.

Strengths and Weaknesses of the Existing System

The existing system, currently being the most used and dependable method across the country by most health facilities even though slightly computerized, has its strengths and weaknesses.

a) Strength

The strength of the existing system is as follows:

i. The existing system doesn't need computer knowledge or specialized professional personnel to maintain and work with the system.

ii. The current system doesn't need internet connection, daily fee of internet subscriptions with the internet service provider (ISP) or an area supporting internet service in order to manage antenatal records.

iii. The current system doesn't require purchase of hardware or subscriptions to software for system update or upgrades of the operating system in order to manage records.

b) Weaknesses

The weaknesses of the existing system are as follows:

i. Records kept in paper increase the chance of data loss due to bulk files requiring extra time to recover the records or to go through all the files and papers to find the needed information, hence slowing down decision making by the management.

ii. Less security of client records since they are kept using the file system which does not require authentication of user password to gain access to the client records which are confidential data, that is, only restricted to staff at the facility.

iii. Inconsistency in data entry, proneness to errors, and mistaking of information due to less certainty of the records gathered during daily activities.

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iv. Time consuming and costly to produce monthly reports since all records are kept in paper form stored in files, hence requiring one to type the record reports in the computer in order to print out reports which require extra money for the service.

v. Difficulty in making backups of records since all records are on paper and kept in files which would require extra space and effort to go through all paper records and rewrite them on other paper; this is costly and tiresome.

System Analysis

Based on the outcomes from the system study the users, functional and non-functional requirements of the Antenatal Information Management System were evaluated as follows:

User Requirements

From the system study, four users of the system were recognized. These are system administrator, records officer, senior clinical officer and head midwife. Their requirements in the system include the following:

a) System Administrator: The administrator is the person that manages the computer systems in the organization. His requirements in the system include

i. User registration (setup and maintain account)

ii. Maintain system

iii. Verify that peripherals are working properly

iv. Monitor system performance

v. Install software

vi. Create a backup and recovery policy

vii. Password and identity management.

b) Records Officer: The records officer is the person that is responsible for registration and queuing clients for service. His requirements in the system are as follows:

i. Able to account for daily clients count

ii. Able to register clients

iii. Able to queue clients for service

iv. Able to view serviced clients' statistics.

c) Senior Clinical Officer: The senior clinical officer is a person that is responsible for the triaging of the clients and capturing their vitals. His requirements are as follows:

i. Able to capture client vitals

ii. Able to triage clients

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iii. Able to refer patients for consultation and examination

iv. Able to view serviced clients' statistics.

d) Head Midwife: The head midwife is a person that is responsible for carrying out antenatal progress examination and prescription of the needed drugs as per trimester. The head midwife's requirements include

i. Able to do antenatal progress examination

ii. Able to prescribe drugs

iii. Able to view serviced clients' statistics.

Functional Requirements

The functional requirements are activities that the system must be able to perform. The system provides the following functionalities:

a. It should be able to store user details

b. It should be able to provide views for all stored details

c. It should be able to register clients' details

d. It should have a simple user interface

e. It should be able to generate and print reports.

Nonfunctional Requirements

Nonfunctional requirements are the constraints that should be enforced on the services provided by the existing system. The system was designed to meet the following non-functional requirements:

a. The system should verify or validate all user inputs and update accordingly

b. The system should be robust and able to run on most platforms with no errors

c. The system should be user friendly

d. The system should be complete, consistent and reliable to the user

e. The system must not allow unauthorized users to access stored data

f. The system should be able to produce expected results when supplied with right inputs.

System Design

The system was designed using process and data models. The design used to describe the system includes system architecture, level One DFD and database design.

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Architectural Designs of the System

The architectural design gives a high-level view of the new system with the main components of the system and services they provide, as well as how they communicate. The system is implemented using a three-tier architecture that encompasses user interface, process management and DBMS as illustrated below. This structure ensures that users' interaction with the system is independent of storage consideration.

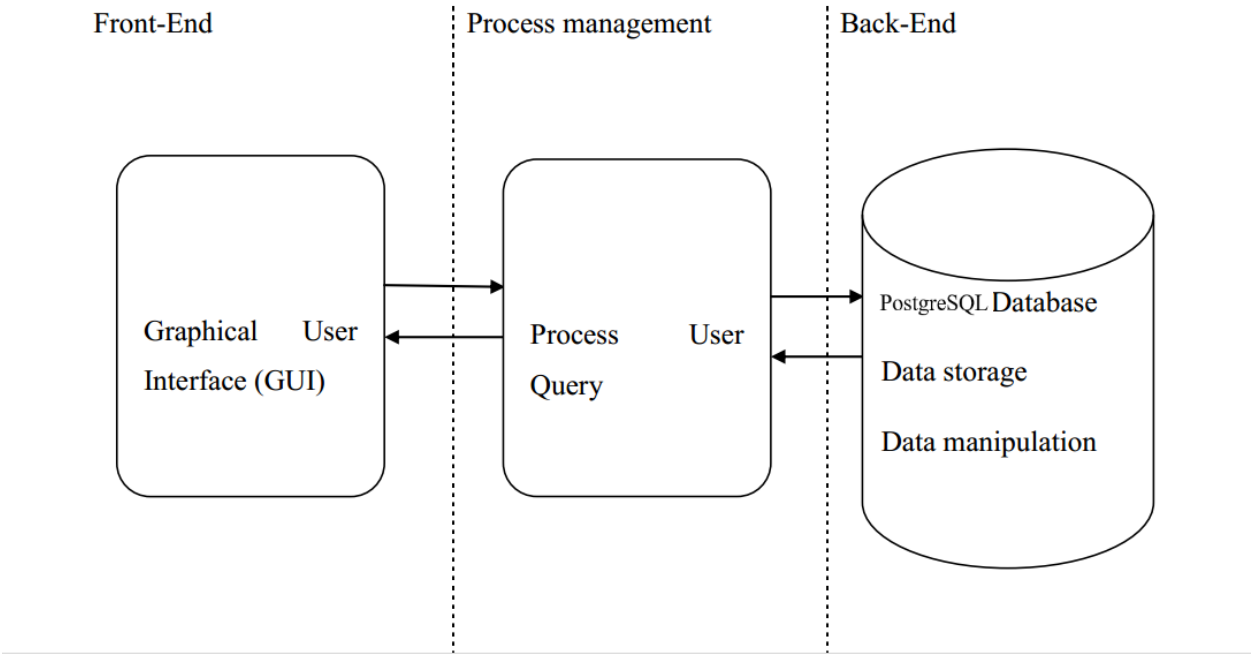

Figure 1: System architecture

Process Modeling

In process modeling, the sequence diagram was used to model the flow of logic within the proposed system in a visual manner. It shows the major sub-processes identified in the Antenatal Management Information System. Data obtained from the Data Flow Diagram (DFD) was collectively used to produce the Data Dictionary (DD) of the system.

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a) Key symbols in process modeling

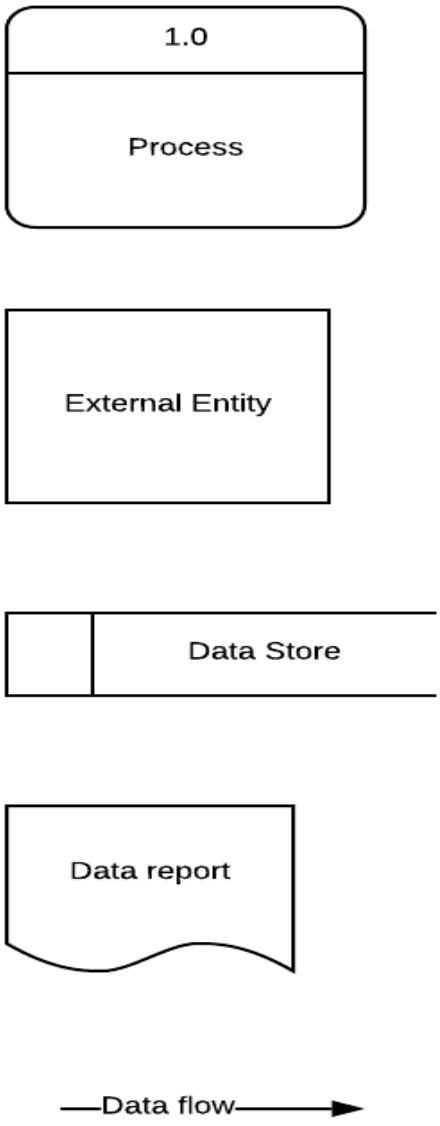

Figure 2: Symbols used in process modeling

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b) Context diagram

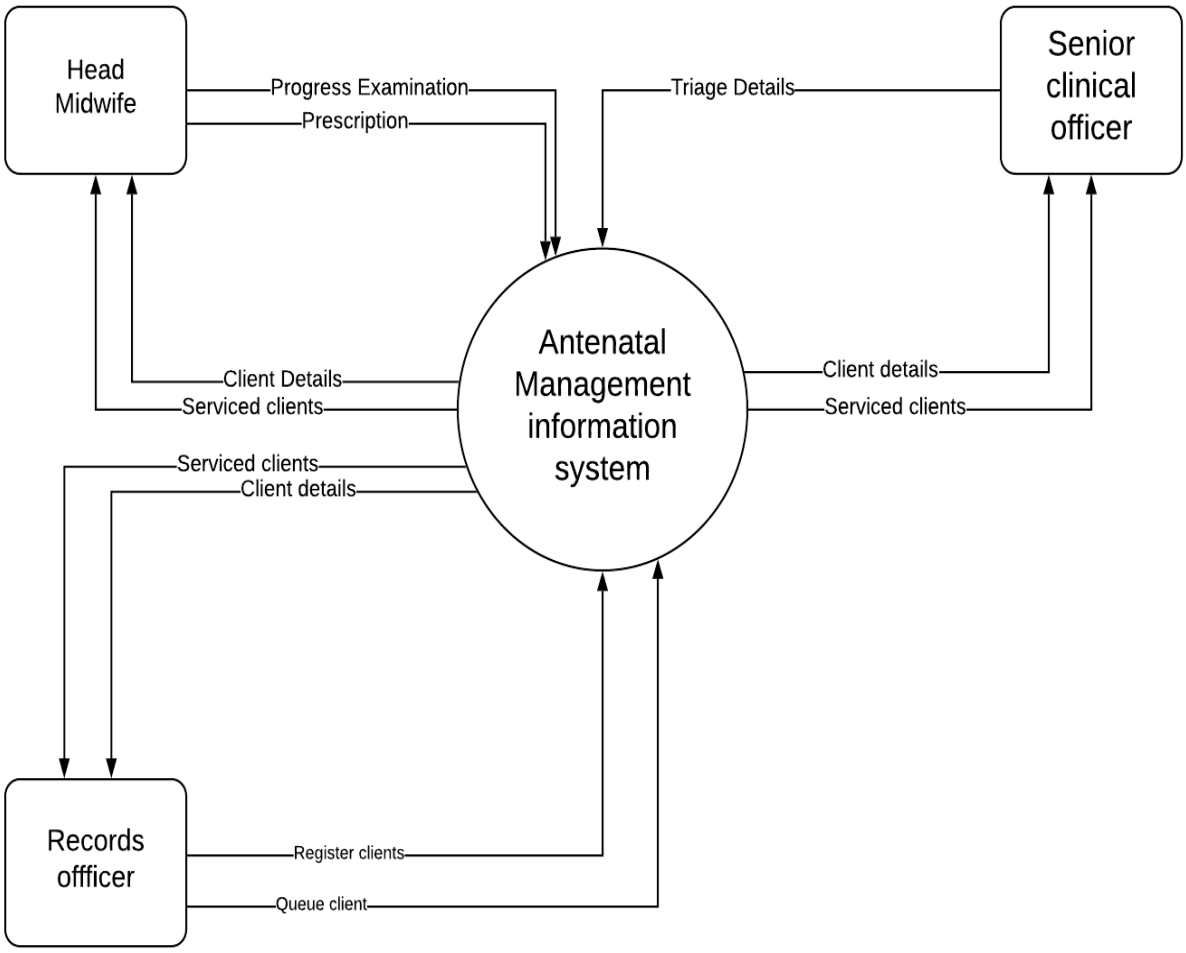

Figure 3: Context diagram for antenatal management information system

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c) Level 1 data flow diagram

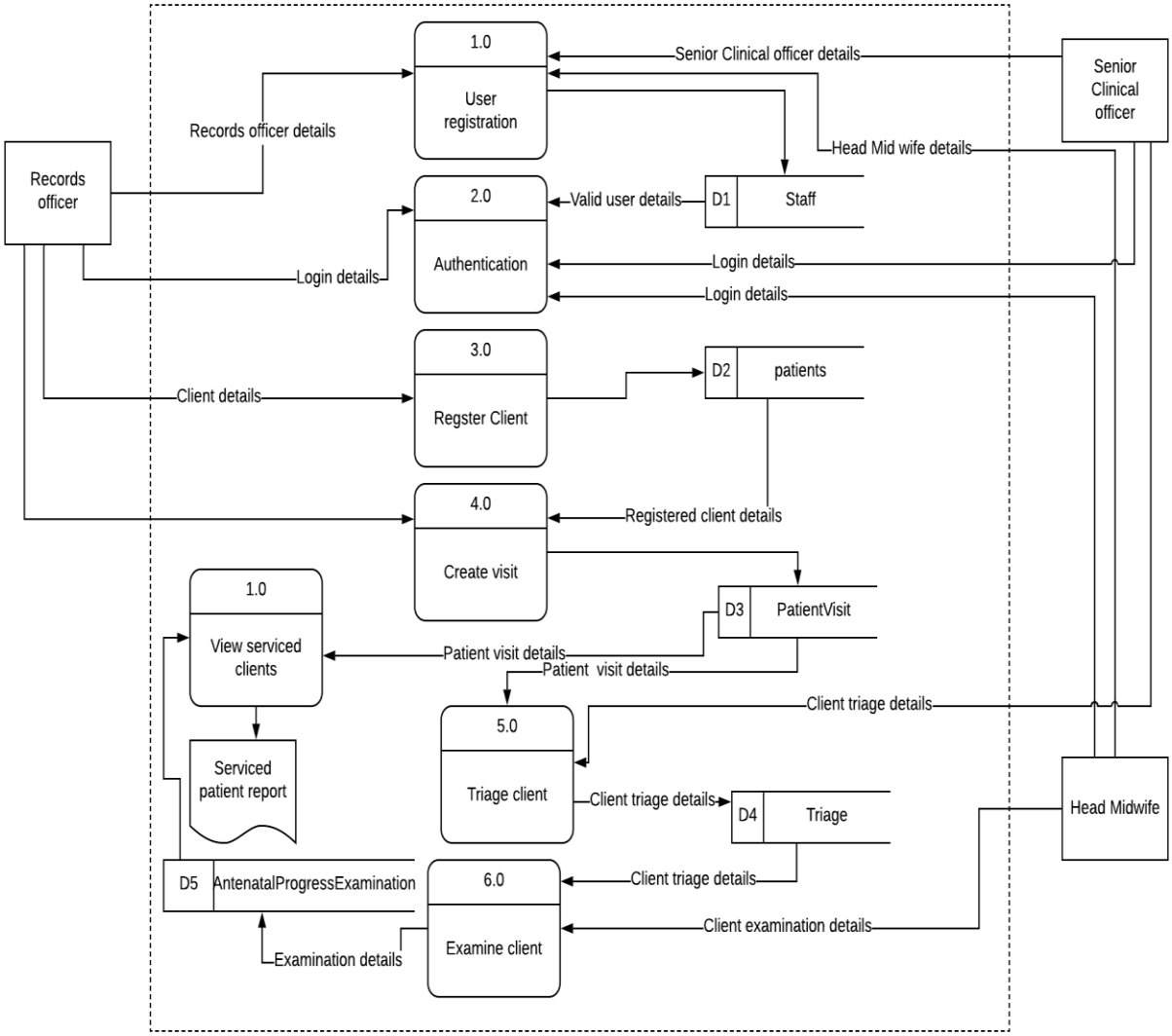

Figure 4: Level 1 data flow diagram for the antenatal management information system

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d) Data dictionary of level 1 DFD of the antenatal management information system

Below are the descriptions of all the design objects used in the system development of an Antenatal Management Information System. These objects include processes, data stores, and the external entities involved in the system.

Table 2: Description of process

Process	Description
User registration	Allows the head midwife, records officer and the Senior clinical officer to insert their details into the system.
Authentication	Allows the system to authenticate registered users and provide authentication responses.
Register client	Allows the records officer to register new antenatal clients and view those already existing respectively.
Create visit	Allows the records officer to create/instantiate a unique visit for the client so as to service them.
Triage client	Allows the clinical officer to capture patient vitals and refer them for examination respectively.
Examine client	Allows the head midwife to perform the antenatal progress examination on the client and prescribe drugs respectively.
View serviced clients	Generates serviced clients report.

Table 3: Description of data stores

Data Stores	Description
System user	Stores details of registered users in the system
Patients	Stores client details
Patient Visit	Stores client visit details
Triage	Stores triage details
Antenatal Progress Examination	Stores progress examination details

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Table 4: Description of external entities

External entity	Description
Records officer	Responsible for registering clients and creating new client visits; views serviced clients reports.
Senior clinical officer	Responsible for capturing client vitals and referring them for examination; views serviced clients report.
Head midwife	Responsible for performing the progress examination, prescribing drugs; views serviced clients report.

Data Modeling

The data modeling of the system was done by ascertaining the data requirements, entities and their related attributes that make up the system. Modeling of the relationships between the entities were designed with an enriched entity relationship diagram for the system.

a) Data requirements

i. **Patient**: This stores information about clients registered. The information stored includes the patient ID, first name, last name, middle name, current address, next of kin name, next of kin relationship, spoken languages, phone number, NIN, gender, and date of birth.

ii. **Patient visit**: This stores information about the client's specific visit. The information stored includes patient visit ID, patient ID, facility unit ID, unit service ID, and staff ID.

iii. **Staff**: This stores information about staff. The information stored includes first name, last name, middle name, role, address, email, username, password, and staff ID.

iv. **Triage**: This stores information about client vitals. The information stored includes patient visit ID, triage ID, temperature, height, muac, bp, para, abortions, gravida, weight, LNMP, edd, BMI, and staff ID.

v. **Antenatal examination progress**: This stores information about the client's progress. The information stored includes fundal height, week of_ammenorrhea, presentation, relation_to_brim, position, 1ie, return date, date, staff ID, and fetal heart.

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b) Identification of entities and associated attributes

Table 5: Entities and the associated attributes

Entities	Attributes
Patient	Patient ID
	First name
	Last name
	Middle name
	Current address
	Next of kin name
	Next of kin relationship
	Spoken languages
	Phone number
	NIN
	Gender
	D.O.B.
Patient visit	Patient visit ID
	Patient ID
	Facility unit ID
	Unit service ID
	Staff ID
Staff	Staff ID
	First name
	Last name
	Username
	Password
	Role
	Email
Triage	Triage ID
	Patient visit ID
	Staff ID
	LMP
	BP
	BMI
	MUAC
	Para
	Abortions
	Temperature
	Height
	Weight
	Gravida
	Edd

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Antenatal Examination	Antenatal Examination ID
	Patient visit ID
	Fundal height
	Weeks of amenorrhea
	Presentation
	Lie
	Position
	Date
	Return date
	Staff ID
	Fetal heart
	Relation to brim

c) Modeling relationships between entities

The relationships modeled depicted some possible associations between the entities identified. It also gives the corresponding multiplicities (participation and cardinality) among the entities of the system.

Figure 5: Relationship between staff and patient

The staff registers one or more patients and each patient is registered by a particular staff. Hence, the cardinality is 1:M.

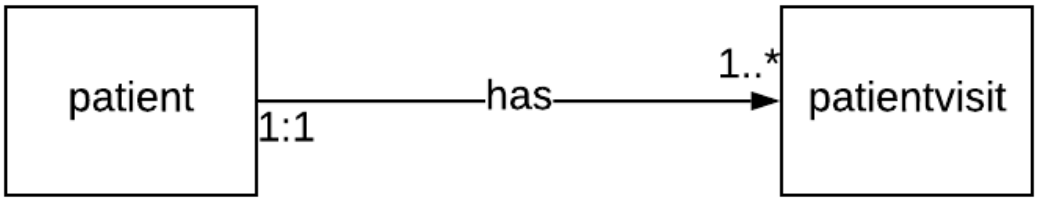

Figure 6: Relationship between patient and patient visit

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A patient has one or more patient visits and each patient visit belongs to a particular patient. Hence, the cardinality is 1:M.

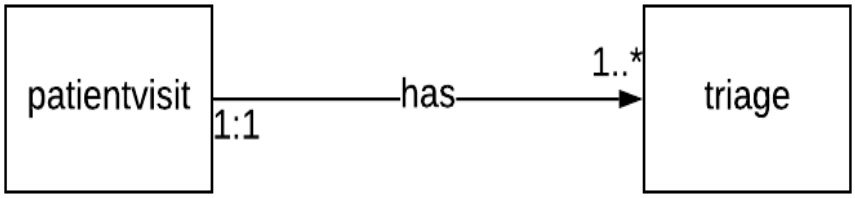

Figure 7: Relationship between the patient visit and triage

A patient visit has one or more triage records and each triage record belongs to a particular patient visit. Hence, the cardinality is 1:M.

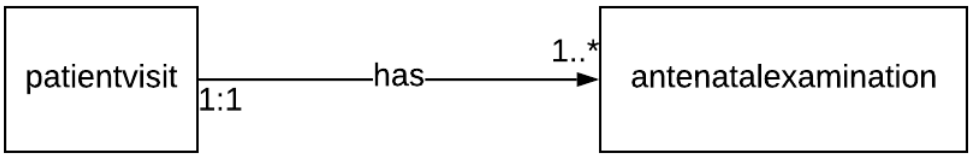

Figure 8: Relationship between a patient visit and antenatal examination

A patient visit has one or more antenatal examination records and each triage record belongs to a particular patient visit. Hence, the cardinality is 1:M.

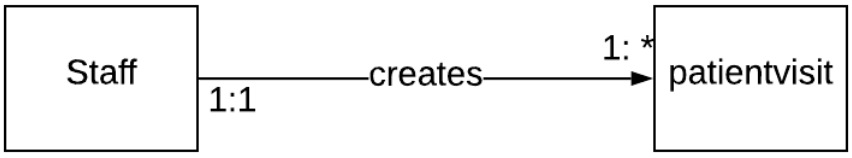

Figure 9: Relationship between staff and patient visit

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A patient visit has one or more antenatal examination records and each antenatal examination record belongs to a particular patient visit. Hence, the cardinality is 1: M.

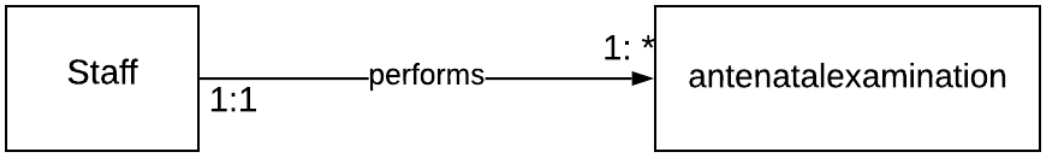

Figure 10: Relationship between staff and antenatal examination

A staff performs one or more antenatal examinations and each antenatal examination record belongs to a particular staff member. Hence, the cardinality is 1:M.

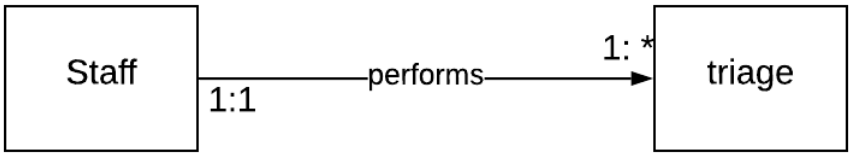

Figure 11: Relationship between staff and triage

A staff member performs one or more triage records and each triage record belongs to a particular patient visit. Hence, the cardinality is 1:M.

d) The Entity Relationship Diagram (ERD)

The ERD presented below depicted the entities, some of their attributes and the relationships between them as it was presented individually above. The diagram further indicates the multiplicities between these entities. Therefore, we decided to include the attributes in the ERD in order to avoid presenting an outrageous diagram.

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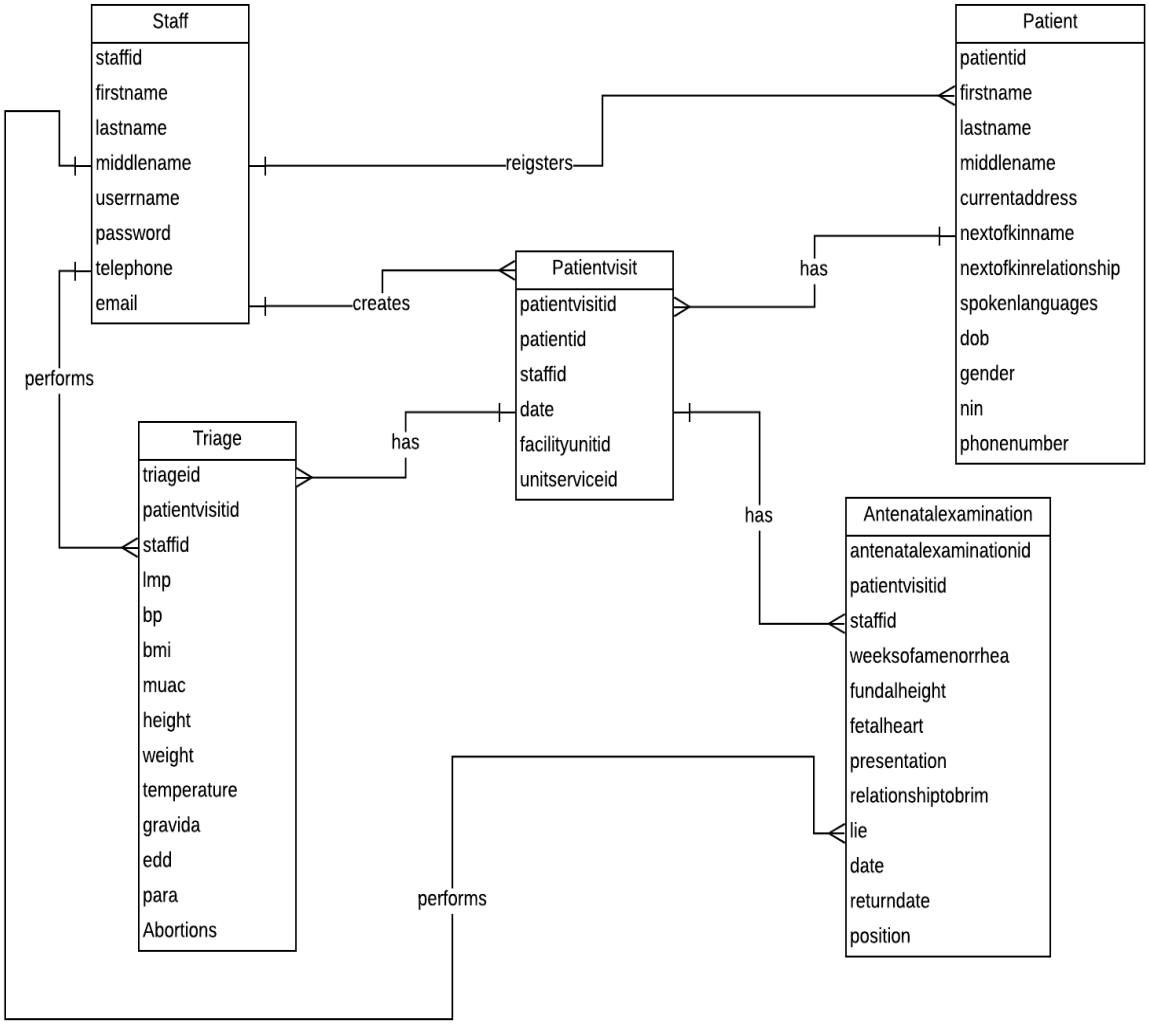

Figure 12: Entity relationship diagram of antenatal management information system

e) Structure of relationship of database

Table 6: Staff table structure

Field name	Data type	Constraint
Staff ID	Big Integer	Primary key, auto increment, not null
First name	Text	Not null
Last name	Text	Not null
Other name	Text	
Username	Varchar	Not null
Password	Varchar	Not null
Telephone	Varchar	Not null
Email	Varchar	Not null

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Table 7: Patient table structure

Field name	Data type	Constraint
Patient ID	Big Integer	Primary key, auto increment, not null
First name	Text	Not null
Last name	Text	Not null
Middle name	Text	
Current address	Varchar	Not null
Next of kin name	Text	Not null
Spoken languages	Text	
D.O.B.	Date	Not null
Staff id	Big integer	Not null, foreign key REFERENCES Staff (staff ID)
Phone number	Varchar	Not null
Gender	Text	Not null
Nin	Varchar	

Table 8: Patient visit table structure

Field name	Data type	Constraint
Patient visit ID	Big integer	Primary key, not null, auto increment
Patient ID	Big integer	Not null, Foreign key REFERENCES Patient (patient ID)
Staff ID	Big integer	Not null, Foreign key REFERENCES Staff (staff ID)
Date	Date	Not null
Facility unit ID	Big integer	Not null
Unit service ID	Big integer	Not null

Table 9: Triage table structure

Fields	Data type	Constraint
Triage ID	Big Integer	Primary key, not null, auto increment
Patient visit ID	Big Integer	Not null, Foreign key REFERENCES Patient visit (patient visit ID)
Staff ID	Big Integer	Not null, Foreign key REFERENCES Staff (staff ID)

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Lmp	Date	Not null
Bp	Varchar	Not null
Bmi	Integer	Not null
Muac	Integer	Not null
Height	Integer	Not null
Weight	Integer	Not null
Temperature	Varchar	Not null
Gravida	Integer	Not null
Edd	Date	Not null
Para	Integer	Not null
Abortions	Integer	Not null

Table 10: Antenatal examination table structure

Fields	**Data type**	**Constraint**
Antenatal examination ID	Big integer	Primary key, not null, auto increment
Patient visit ID	Big integer	Not null, Foreign key REFERENCES Patient visit (patient visit ID)
Staff ID	Big integer	Not null, Foreign key REFERENCES Staff (staff ID)
Weeks of amenorrhea	Integer	Not null
Fundal height	Integer	Not null
Fetal heart	Integer	Not null
Presentation	Text	Not null
Relation to brim	Text	Not null
Lie	Text	Not null
Position	Text	Not null
Date	Date	Not null
Return date	Date	Not null

System implementations, Testing and Validation

Functions Provided by the System

The Antenatal Management Information System provides different functions to its users depending on their roles and access rights. The system prompts the users for their usernames and passwords—the users provide them then the system verifies the user. The user is then able to use the system for various tasks depending on his or her roles.

Function Provided to Records Officer

The system enables the records officer to register new patients and create new visits for them. He also views patient statistics and prints reports.

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Functions Provided to Senior Clinical Officer

The system allows the senior clinical officer to enter triage details of a patient and thereafter refer them for examination. He also views patient statistics and prints reports.

Functions Provided to the Head Midwife.

The system allows the head midwife to examine a patient and prescribe drugs. She can also view patient statistics and print reports.

Sample Screen Shots Capture

System Login Page

This shows the first page of the system. All the users have access to the system through this page. The users of the system have to be authenticated first by entering their required usernames and passwords before they can be able to access the system.

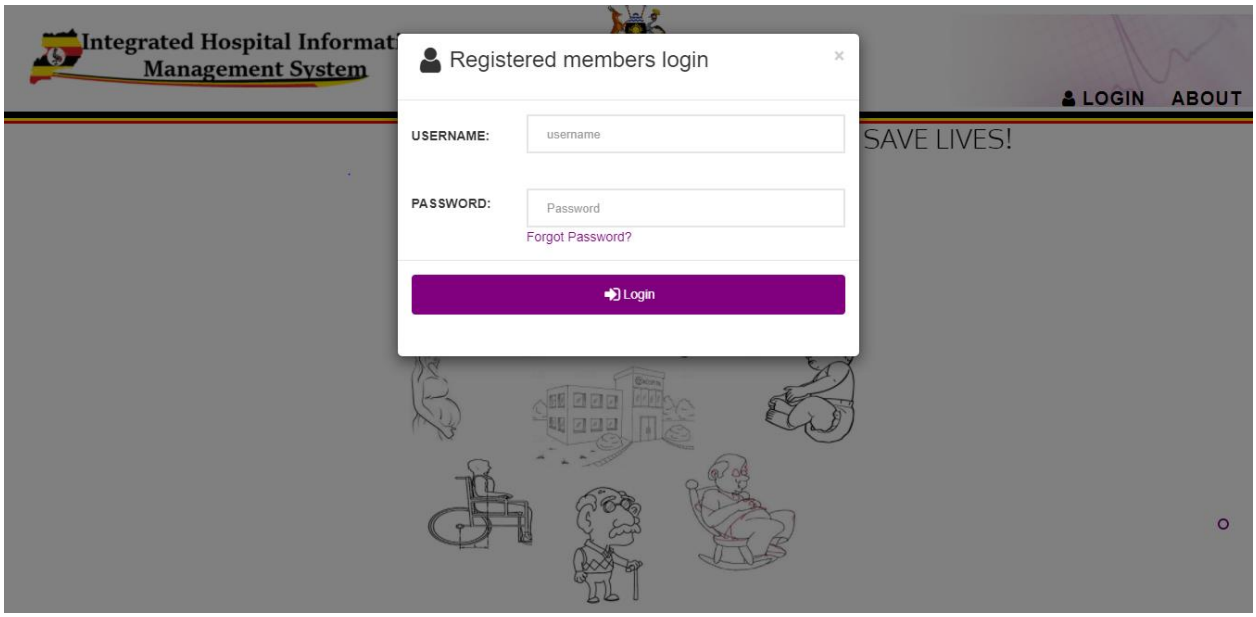

Figure 13: System login

Authentication

Authentication allows the system to authenticate registered users and provide authentication responses when wrong login details are used to have access to the system.

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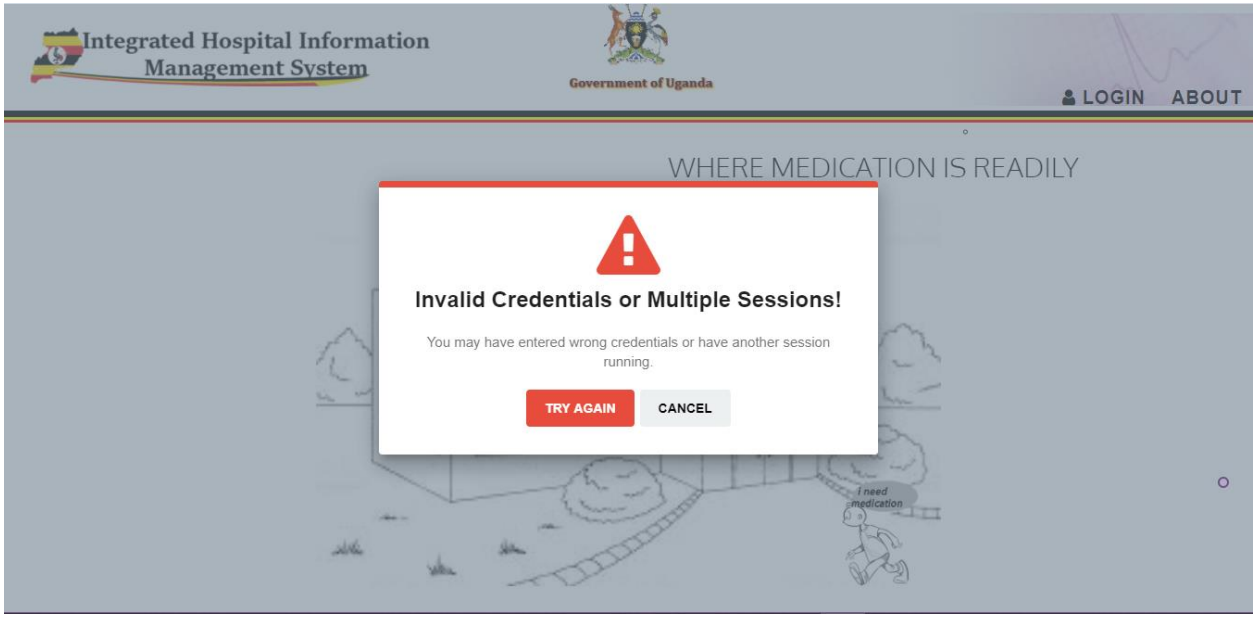

Figure 14: System authentication response

Search Patient

Search patient allows users to search for a patient and if they do not exist, prompts the user to register them as a new patient in the system.

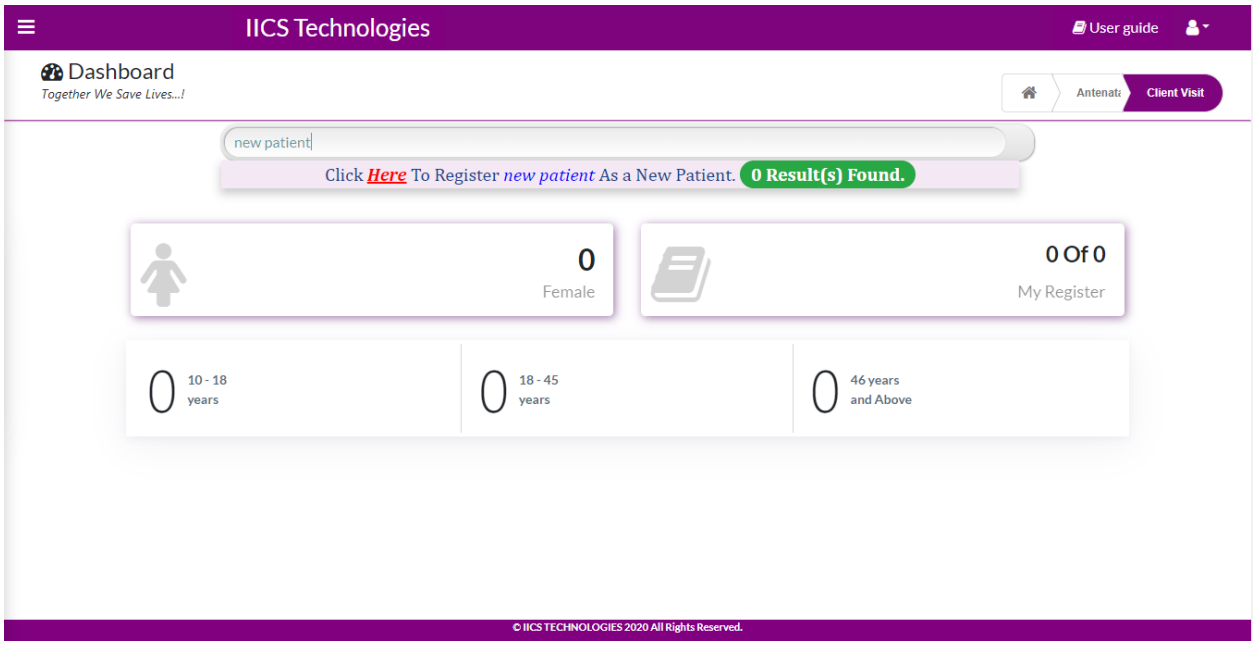

Figure 15: Search patient

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Register Patient Form

The registration form allows the user to register a new patient into the system.

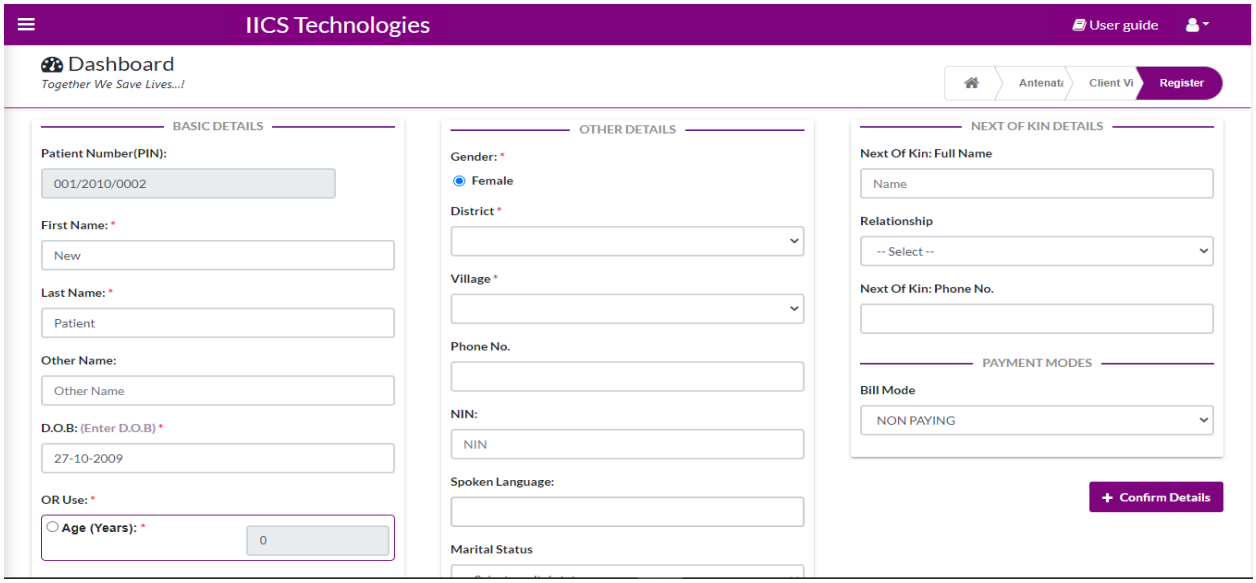

Figure 16: Patient registration form

Patient Visit Form

Patient visit form allows the user to create a new patient visit and queue the patient for the desired service.

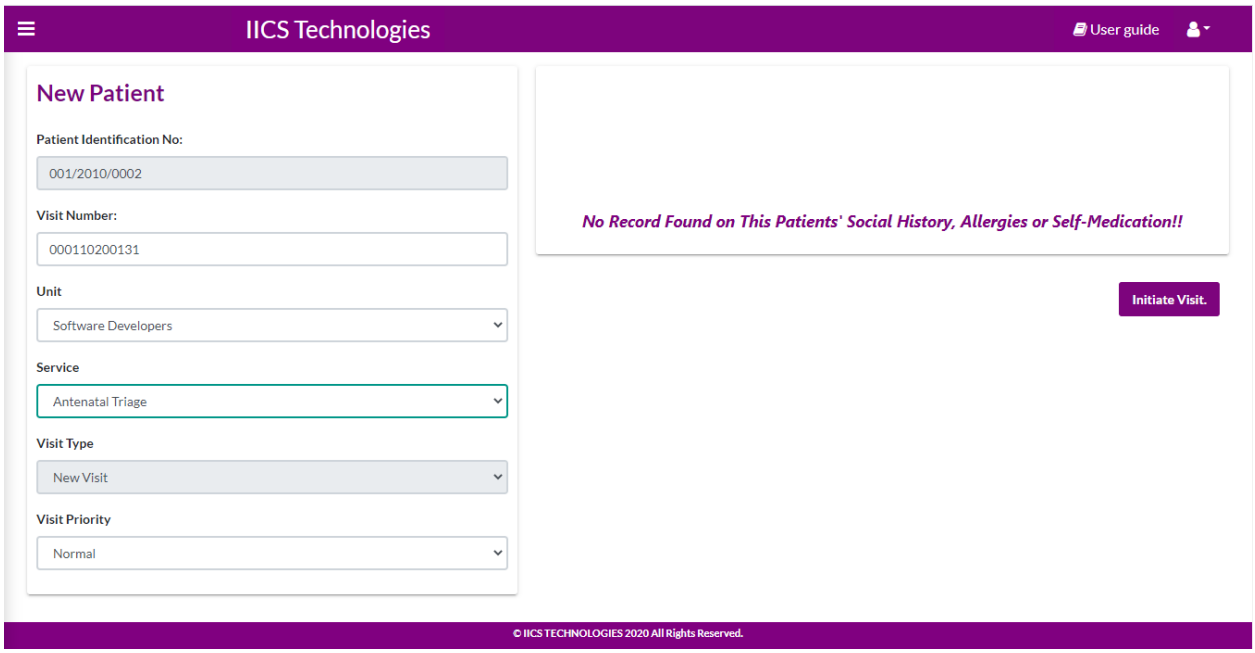

Figure 17: Patient visit form

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Triage Home

The triage home page allows users to view how many patients are queued up for service and also allows them to pop the first patient in the queue.

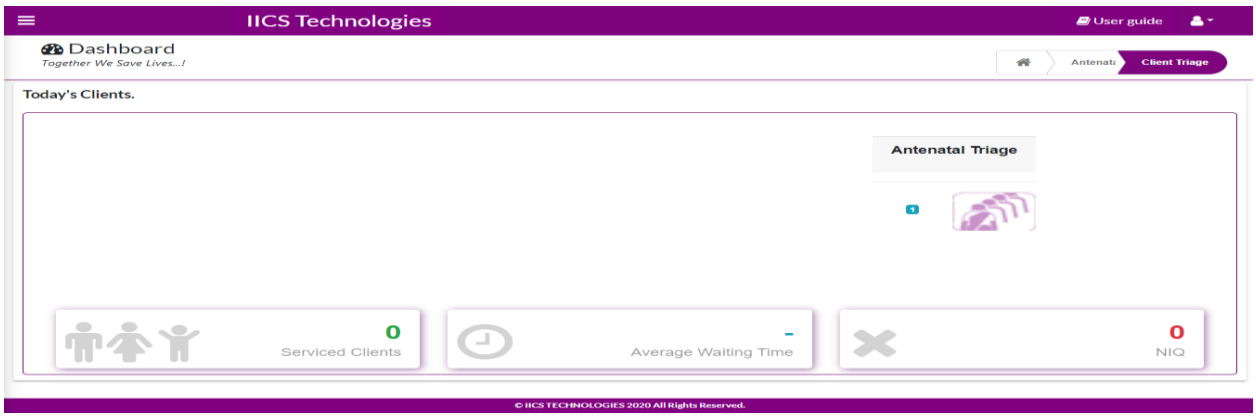

Figure 18: Triage home page

Triage Form

The triage form allows the user to capture patient vitals of the popped patient and thereafter forward them for clinical consultation.

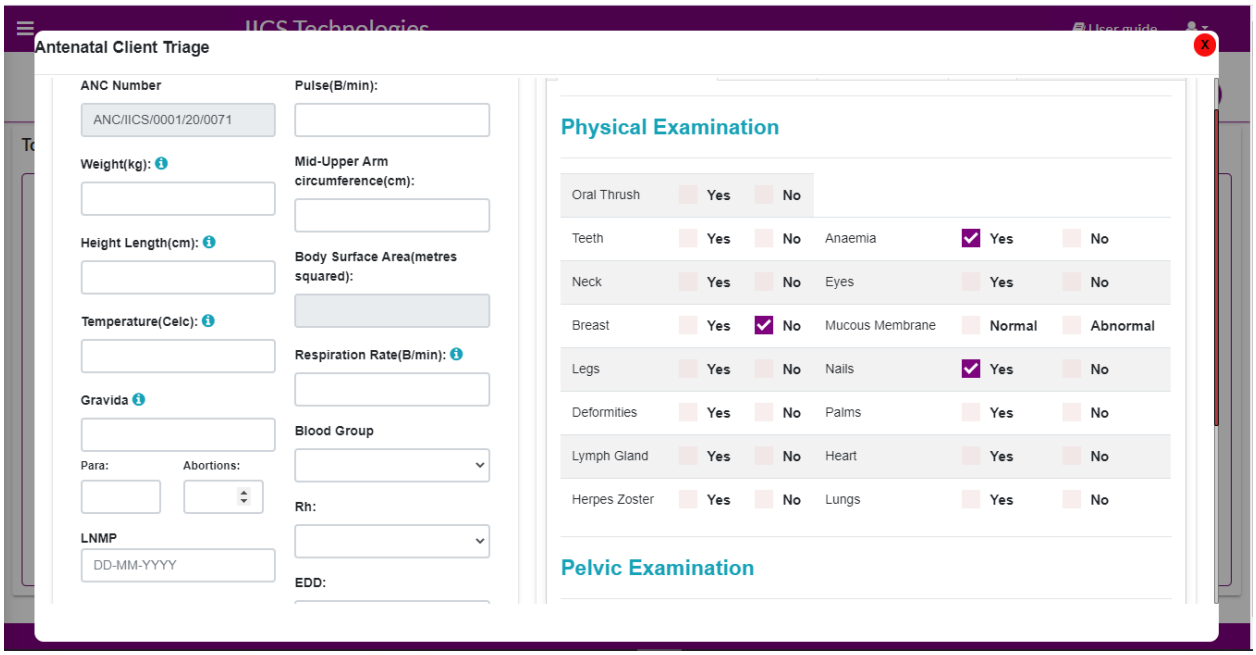

Figure 19: Triage form

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Clinical Consultation Home

The Clinical consultation home page allows users to view how many patients are queued up for service and also allows them to pop the first patient in the queue.

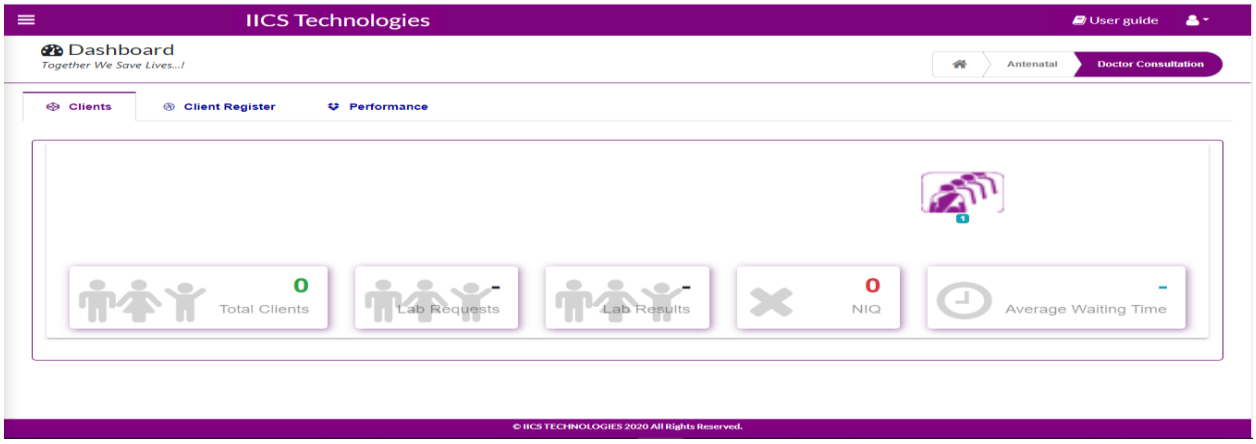

Figure 20: Clinical consultation home

Antenatal Progress Examination Form

The Antenatal Progress Examination form allows the system user to perform progress examinations and also view the patient's previous progress details.

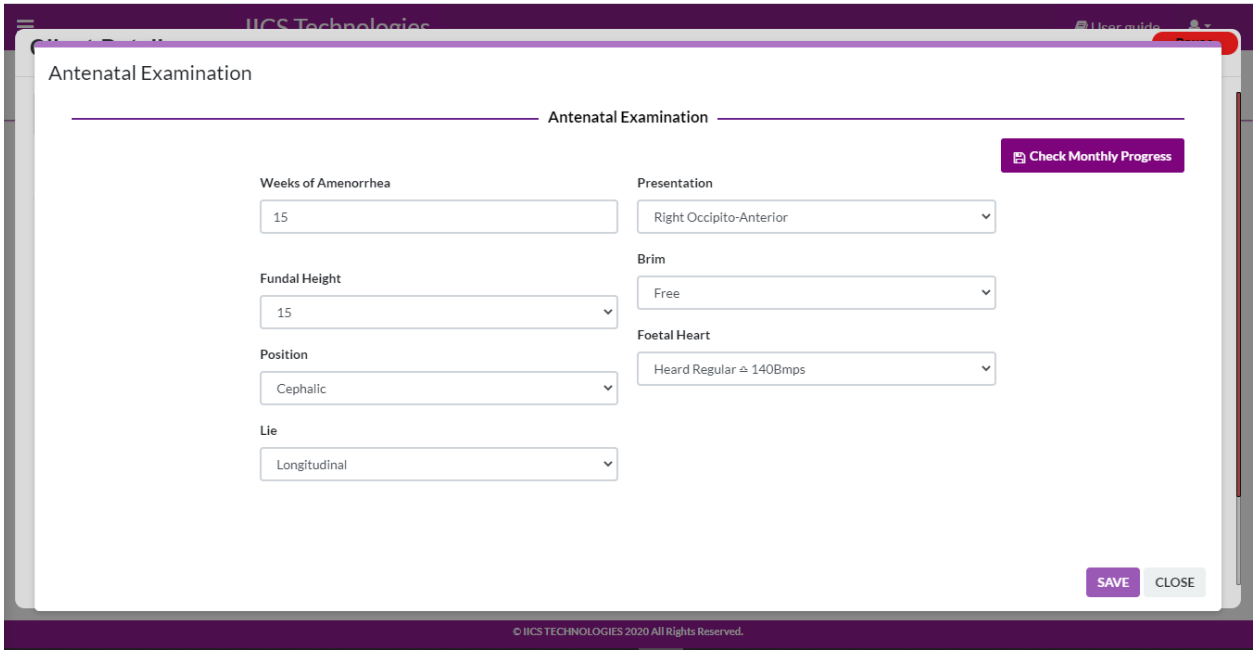

Figure 21: Antenatal progress examination

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Patient Statistics

The patient statistics view allows users to view patient statistics and also print out the required reports.

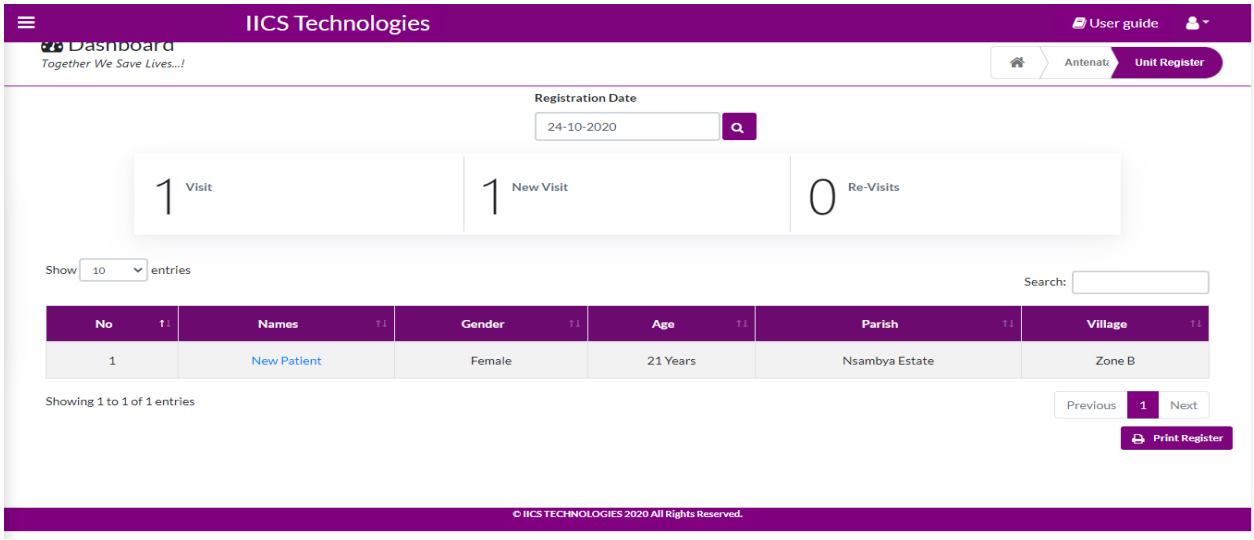

Figure 22: Patient statistics

System Testing and Validation Results

The Antenatal Management Information System was tested using unit, integration and system testing techniques. After every part of the system was implemented, it was tested using input to guarantee that each unit responded as expected. After individual units were tested as they were being developed, those whose functionality was associated with others were integrated and also tested using integrated testing. With this, interaction between these units was verified and defects also corrected. System testing was performed on the complete integrated system to check whether all the specified requirements were met. These three types of testing were done by the project team developers. User acceptance system was done by the users of the system. A sample of six users of the system each was used to test the system functionality.

In general, the users stated that the system had a clean layout, was simple and easy to learn. In other words, it was user friendly. They also commented that it will ease information management within the antenatal department. Below are some of the tested cases that were used to test the system:

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Table 11: Login test case

Description	User's action	Expected system response	Observed system response
Login with right password	Input right credentials	Redirect user to appropriate page	System responded as expected
Login with wrong password	Input wrong credentials	Prompt user to try again with correct credentials	System responded as expected

Table 12: Patient registration test case

Description	User's action	Expected system response	Observed system response
User registers patient into the system	User enters patient details in correct format	System creates new patient	System responded as expected
User registers patient with wrong format	User enters patient details with wrong format	Prompt user to enter details in correct format	System responded as expected

Table 13: Patient visit test case

Description	User's action	Expected system response	Observed system response
User creates visit for patient	User creates new visit for patient	System queues patient for service	System responded as expected
User creates visit for patient already queued	User creates visit for patient already queued	System responds "Patient already queued"	System responded as expected

Table 14: Triage test case

Description	User's action	Expected system response	Observed system response
User captures patient vitals into the system	User enters patient vitals in correct format	System creates new triage record and queues patient for consultation	System responded as expected
User captures patient vitals with wrong format	User enters patient vitals with wrong format	Prompt user to enter details in correct format	System responded as expected

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Table 15: Examination test case

Description	User's action	Expected system response	Observed system response
User input patient examination details into the system	User enters patient examination details in correct format	System creates new patient examination record	System responded as expected
User inputs patient examination with wrong format	User enters patient examination details with wrong format	Prompt user to enter details in correct format	System responded as expected

Table 16: View patient statistics

Description	User's action	Expected system response	Observed system response
User views serviced patients in the system	User tries to view serviced patients report	System displays report successfully	System responded as expected
No serviced patients in the system	User tries to view services patients report	System to respond "No patients found"	System responded as expected

System Requirements

In order for the system to perform as expected, the following system specification for hardware and software are essential:

i. **Hardware Requirements**

Table 17: Hardware requirements

Hardware	System requirement(Minimum)
Processor	Intel Pentium III
Memory	1024 RAM (2048 MB recommended)
Disk space	20 GB

ii. **Software Requirements**

Table 18: Software requirements

Software	System requirement
Operating system	Microsoft Windows XP or higher, Linux Kali or Higher, Mac OS
Web browser	Google Chrome, Edge, Mozilla, Opera, etc.

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CONCLUSION

The stated objectives of the Antenatal Management Information System were attained. The current system was studied, processed and data modeled for a new system. These were then designed and implemented, tested and validated as discussed in chapter five. In addition, all the requirements specified in the system analysis section were provided by the system. The system enables the records officer to register and view patients. The system enables the senior clinical officer to triage, capture patient vitals view, and print patient reports. The system enables the head midwife to examine the patients' monthly progress, view and print patient reports.

All in all, the Antenatal Management Information System addressed the hard-pressing challenges presented by the current system as it automated the whole patient flow in the hospital.

Future Work

Due to the inadequate time, some functionalities were not included in the system. The following enrichment could be made to the system:

i. Optimization on patient search: Fasten the patient's search based on a new search vector.

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