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A clinical expert system for Noma disease diagnosis

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Abstract

Noma disease, a devastating necrotizing infection primarily affecting children in the poor regions of Africa, poses significant challenges for early diagnosis and intervention. An estimated recurrence rate per 100,000 people in these nations is 20 occurrences per year. Noma disease swiftly spreads to other parts of the mouth, including the lips, tongue, cheek, nose, and teeth. This eventually results in the bones and soft tissues being totally damaged and necrosed over. Children in sub-Saharan Africa, particularly in Burkina Faso, Ethiopia, Mali, Niger, Nigeria, and Senegal, are the most susceptible. This paper, presents an Expert system for diagnosing Noma disease. The expert system analyzes patient symptoms and reliably identifies Noma disease using a rule-based inference engine. Expert knowledge acquired from medical specialists with a focus on Noma disease forms the foundation of the Expert system's knowledge base. Through the user interface implemented as a web application, the Expert system asks users to enter their symptoms. In order to assess the possibility of Noma disease and produce precise diagnoses, it applies the established guidelines and information. The system presented in this work, has various benefits; large volumes of patient data, speed, complexity, and successful analysis of intricate symptom correlations are all capabilities of the proposed system. In addition, it provides recommendations and feedbacks in real-time, assisting medical practitioners in making clinical decisions process.

Keywords: Expert systems; Noma disease; Medical informatics system; Decision Support Systems; Health Informatics

1. Introduction

Noma disease is a severe and violent gangrenous process (a condition where body tissues die due to infection or lack of blood flow) that affects the lips, nose, and mouth. The disease was added to the World Health Organization's 2023 classification of neglected tropical diseases (Johnson, 2023). In multiple acute episodes of the disease, which gets worse with time, 90% of individuals afflicted who do not receive treatment pass away (WHO, 2019). Typically beginning as a gum ulcer, noma disease develops rapidly to the soft connective tissue in the cheek and jawbone. The next stage is the degradation of the face tissues and serious infections. In addition to serious facial defects, those who survive have trouble breathing, speaking, swallowing, and seeing. According to WHO classification, these initial phases are known as simple gingivitis (Stage 0), acute necrotising periodontitis (Stage 1), oedema (Stage 2), gangrene (Stage 3), and scarring (Stage 4). According to Ashok et al. (2016), intervention in these earliest acute stages with antimicrobial agents, wound debridement, and nutritional assistance significantly lowers mortality and morbidity. After that, the bacteria can become dormant with or without treatment, progressing to Stage 5 Noma disease: sequelae, when patients often have incapacitating side effects, such as trouble breathing, eating, or seeing (WHO, 2017). Extensive reconstructive surgery can be used to enhance function and appearance after Noma illness becomes dormant. (Shaye & Associates 2019). Children in underdeveloped nations like Niger, Nigeria, Ethiopia, Mali, Senegal, and Burkina Faso are especially prone to Noma illness, a fatal virus that is life threatening and severely disabling. In these countries, there are an anticipated 20 cases annually per 100,000 persons (Datelinehealth Africa Inc., 2023).

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Rapid tissue disintegration, severe facial abnormalities, and often fatal outcomes if treatment is not received are the characteristics of this Noma illness (WHO, 2017). The illness is also linked to malnourishment and inadequate cleanliness. On the other hand, good nutrition and dental cleanliness are workable preventative strategies. In contrast, there is still a need for increased public education and understanding of the illness. Additionally, the likelihood of diagnosing and treating the Noma disease may be hampered by a shortage of medical professionals in rural areas. Thus, the development of an Expert system is required for the accurate detection of Noma disease.

The purpose of the proposed system is the early diagnosis of Noma syndrome promptly and accurately, enabling early intervention and suitable medical attention. The system seeks to increase Noma disease detection precision and effectiveness, which will improve the affected people's standard of life and expectancy. It does this by employing cutting edge artificial intelligence techniques.

In recent times, medical professionals employ experience and intuition to diagnose diseases based on patients' symptoms, which may take longer time, since patients have to wait in the queue to get medical interventions. This work will contribute immensely to speeding up treatment time, if deployed, it will harness the health care delivery system at the hospitals and contribute to knowledge in Medicine and other related areas of endeavors. The system will also contribute to knowledge in the areas of high-performance levels, easy to understand, completely reliable and highly responsive. Furthermore, the system is also capable of a number of actions, including advising, assistance in human decision making, demonstrations and instructions, deriving solutions, diagnosis, interpreting inputs and providing relevant outputs, predicting results, justification of conclusions and suggestions for alternative solutions to a problem.

2. Related Works

The number of Support Systems Clinical Decision have been increasing in recent years, and they have proven to be a valuable help in the diagnosis process. In this section we present a few of this related works.

(Mohammed A. A. et al., 2021) utilized CLIPS and Delphi framework to create a system for diagnosing throat issue. The Expert model performs diagnosis for 10 infections of throat issue. The Expert model will require the patient to choose the right symptoms on each screen. After the dialogue session, the system gives the diagnosis and suggestion of the ailment to the patient. The system was trained in the diagnosis because it were the taking after 10 Symptoms for Throat Issue, COLD or FLU, STOMACH FLU, STREP THROAT, PNEUMONIA, A DRY BARKING COUGH BRONCHITIS, CANKER SORE, TRENCH MOUTH, ORAL THRUSH, KAWASAKI Disease.

An Expert framework was created for diagnosis of migraine which could be a complex neurological clutter characterized by repetitive direct to extreme cerebral pains, went with by extra side effects such as sickness, affectability to light and sound, and visual unsettling influences (Malak S. H. et al. 2023). The framework was designed utilizing AI and CLIPS (C Language Integrated Production System) system to realize precision and proficiency of headache conclusion and give standardized and reliable analyze. Preparatory evaluation comes about illustrated the system's high exactness, with 90% of cases accurately analyzed as migraines. The framework too offers real-time criticism and suggestions, supporting therapeutic experts in their making decision process.

(Mohammed M. A. et al., 2023) developed an Expert framework for diagnosing Tinnitus illness. The system illustrated a high level of precision in diagnosing tinnitus, with a critical extent of diagnoses coordinating the master analyze from the dataset. The assessment of the expert system yielded promising comes about.

An Expert system was designed for the reason of diagnosing and treating Monkey Pox Outbreak with the implementation of SWI Prolog, represented employing a decision tree to diagnose and treat Monkey Pox diseases. Case-based thinking permits the framework to solidify knowledge from past events. Since it is direct, this system is self-sufficient. Ought to shape of the symptomatic system be that is Web-based and available to anyone with a computer and a Web connection, (Obsa A. & Amanuel A. 2022).

Cost Estimation Model was used by (Mpinga EK et al. 2022) to develop a demonstration for assessing the social and financial repercussions of Noma and to provide benchmarks by applying this demonstration to the unique circumstances of two countries in the "Noma belt," namely Burkina Faso and Niger. The idea behind the approach was to establish and implement protocols to prevent and manage this infection, or at least lessen its impact. The model produced a good result in which the level of coordinate costs, particularly those related to healthcare (hospitalization, treatment, lodging, psychotherapy, and physiotherapy), was found to be USD 1829 per case on average in both countries. However, a flaw in the research was that intangible costs were not taken into account.

(Ike M. and Igwe C. N. 2021) developed and actualized a computerized therapeutic diagnosis and medicine system to extend medical services and enhance logistic effectiveness. The system was able to analyze and endorse with high speed processing and flexible storage capacity. The interface of the system is user friendly and the result of the framework is determined by input inserted by the user.

Other recent research works have also reported the predictability and management of diseases for example (Acheme et al, 2021) presented a machine learning model for predicting the survivability of COVID-19 patients, (Nwankwo et al, 2023) presented and health informatics system for management of lassa fever disease, and (Acheme et al 2022) presented a data science model for short-term forecast of covid-19 disease. Most of these previous works are focused on specific areas of diseases in order to improve accuracy. However, our system focuses on Noma diseases so that it could help in Nigeria's various hospitals. Our Expert system's advice could avoid misinterpretation of laboratory test results, which leads to a high waste of resources and longer turnaround times for diagnosis. In addition, our application could become a tool for information sharing between diverse hospital levels, since it allows the storing and recovering of patient data. Our Expert system is not intended to replace medical staff, which too must consider signs and indications to attain a conclusion but can imply a useful tool for the process of diagnosis. Furthermore, our tool is easy to use and the rule set is easy to maintain, without any need of advanced computer skills.

3. Methodology

This section gives a description of the research methodology to be applied during the intended study of Noma disease diagnosis. It discusses the Research design, Choice of programming Language, Data Collection, Primary Data, Secondary Data, Analysis, Data Model, Research Instruments, System Model, System Flowchart and Architecture of the Proposed System and Database design.

3.1. Choice of Programming Language

Python is a programming language that was designed with high level programming multiple paradigms such as object oriented, procedural and functional programming, it has code reuseability and readability. Python is a powerful high-level interpreter programming worldview that is uncomplicated to learn and understand. Guido van Rossum was the maker, and it was initially distributed in 1991. Some imperative qualities and of Python incorporate

- It is an easy-to-understand fashion that is simple to perused and get a handle on, which makes it a superb choice for beginners. Its semantics are evident and simple to comprehend, bearing part of similarities to pseudo-code.
- Interactive and interpretable, which empowers less demanding testing as well as debugging since the code is run line by line. Also, it features a mode for interaction that lets you test brief bits of code and get instant feedback. Multipurpose implies that is a flexible language utilized for different purposes such as web advancement, data science, artificial intelligence, machine learning, robotization, and more. It includes a tremendous standard library and a large ecosystem of third-party packages.
- Dynamic typing is powerfully written, which suggests you do not have to expressly declare the data type of variables. The type of a variable is decided at runtime based on the value assigned to it.
- Indentation it is uses indentation to characterize code blocks, such as loops and functions. This implements a clean and reliable coding style, but it also implies that inaccurate indentation can lead to errors.
- Object-Oriented it supports object-oriented programming (OOP) standards such as classes, objects, inheritance, and polymorphism. Be that as it may, it moreover permits for procedural and functional programming styles.

3.2. Population of Study

Kombo & Tromp M. (2020) define population as a group of individuals, objects or items from which samples are taken for measurement. Orodho P. (2021), says that it is the set of elements that the researcher focuses upon and to which the results obtained by testing the sample will be generalized. The researcher employed a population size of 120 which were randomly selected from different Hospitals and Health Care Centers for this population sample.

3.3. Sample Size and Sampling Technique

The sampling technique is a method of determining the representative population for a study. A random sampling technique was used to select the respondents. As being researched, Noma disease is an orofacial gangrene affecting malnourished children and is mainly observed in tropical countries, particularly sub-Saharan Africa. Epidemiological data on Noma disease are scarce, but a current estimate of the global incidence is 30,000–40,000 cases per year, with a mortality rate of approximately 85% and a burden of disease calculated to be a loss of 1–10 million disability-adjusted

life years. The etiology of Noma disease is multifactorial with malnutrition as an ever present factor, often in combination with concomitant diseases, such as measles, malaria, and human immunodeficiency virus (HIV), and poor oral hygiene. The pathogenesis is a fast-spreading, noncontagious gangrenous infection occurring in the face, often preceded by acute necrotizing gingivitis and stomatitis. Rare microbiological studies suggest an opportunistic infection caused by an imbalance in normal intraoral microorganisms. Prevention lies in food security, measles vaccination, prevention of malaria and HIV, including the early detection and treatment of necrotizing gingivitis and stomatitis. Early treatment with antibiotics may prevent gangrene or reduce its extent. Late treatment consists of surgical rehabilitation, which is often complex. However, access to medical care is very limited for Noma patients due to the extremely poor conditions in which they live which are frequently located in remote rural areas. We decided to use a Random Sampling technique for this research.

3.4. Method of Data Collection

The secondary data collection technique was used to gather significant information for this study. This technique was through existing records via internet from the various healthcare facilities and published papers.

3.5. Analysis of Existing System

The diagnosis of Noma disease is a difficult task, which requires the clinician to relate high dimensionality of data. The Expert system of medical decision-making may be the solution to deal optimally with the flood of data and the explosion of knowledge occurring in the medical area. In addition, expertise in laboratory test results interpretation emerges from years of experience. In this way, an Expert system, which has the ability to compute a high amount of data and contains knowledge from expert results, is a useful tool for improving interpretation of laboratory tests outcomes. Insufficient communication and missing information are among the major factors contributing to unintended errors in medicine. Providing accurate and timely information at the point of care has the potential to make a significant reduction of these adverse events. Furthermore, Graber, Franklin and Gordon analyzed 100 cases of diagnostic errors, 33 of which led to the death of the patient. These errors relate to different sources and problems of communication, especially with test results.

3.6. Analysis of The Proposed Expert System Structure

The system to be designed is called an Expert system for diagnosing of Noma disease, which can tend to solve the issue of Noma infection diagnosis. This will be made conceivable, as the Expert system is an intelligent system; subsequently, it could be a human–patient–computer interactive system rather than the human-patient-doctor interaction. When the Expert system is consulted, the patient is anticipated to interact with the system through the user interface, the patient will be asked to supply the fundamental data for enrollment and the login with the user name and password. The system will present the list of signs and symptoms of all of Noma illnesses from which the client is expected to choose the correct signs and symptoms. It carries out a diagnosis by checking through its information base where the signs and symptoms related with Noma infections of all stages are stored, at that point the system gives exact results of the diagnosis based on the signs and symptoms inputed by the user.

3.7. The Architecture of the Proposed Expert System

An expert system is termed as a system, not a program because the building of an expert system is a mixture of many elements that drive into the decision making viz. goals, facts, rules, inference engine, etc (Dennis, 2021). The proposed Expert system architecture is shown in the Figure. 3.1. The main architecture components of the Expert system are user, user interface, knowledge base, inference engine, knowledge engineer and human expert.

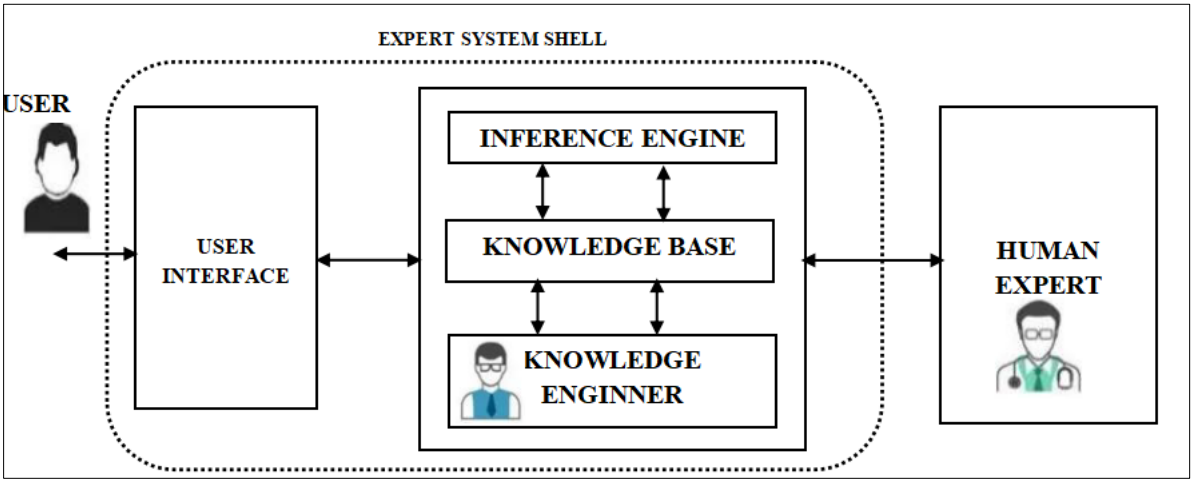

Figure 1 The Architecture of the Proposed Expert System

3.7.1. User

The users are the patients who are seeking to be diagnosed by the expert system through the user interface.

3.7.2. User interface

The user interface is the method by which the expert system interacts with a user through input and select method, The Success of any expert system depends on the quality and the easiest to implement the user interface.

3.7.3. Knowledge Base

The knowledge base is a unit where the knowledge of an expert system is accumulated. The knowledge base is one of the most important components of an expert system because the quality of this unit determines how the user will deal with the expert or the system.

The knowledge base encloses information with reference to symptoms that are characterized as a set of if-then production rules. The knowledge base is analogue to the long-standing human memory. The heart of the expert system is the knowledge base. Engineering problem solving uses heuristic knowledge as well as recognized scientific ideologies and computational algorithms. A heuristic knowledge is a "rule-of-thumb" that aids one to limit how to proceed. The domain knowledge of an expert system is organized in the knowledge base and this module is so critical that the successful practice of the system relies on the excellence and dependability of the knowledge confined in it (Durgaprasad J. et al 2021).

A knowledge base comprises both stationary and declarative knowledge (facts about objects, events and situations) and dynamic or procedural knowledge that deals with the info about the sequence of action. The whole sorting of production rules is prepared in the knowledge base and this can be understood with the help of examples. For example:

- IF Red or purplish red gum, Swelling and ulceration of the gums, and Foul breath or halitosis
- THEN You are diagnosed with (Acute Necrotizing Ulcerative Gingivitis (ANUG) stage 1 of Noma disease).

3.8. Inference Engine

It functions like an engine; it directs the search in different directions in the knowledge base up to the answer to the question. An inference engine can be either simple or complicated, depending on the structure of the knowledge base. In the proposed system, the inference engine selects a rule for testing and examines whether the condition(s) of this rule are valid or not. These conditions are examined through signs and symptoms selected by the users. When the conditions of a rule are valid, then the result of that rule will be correct and valid. Therefore, this rule is activated and its result is added to the knowledge base. In addition, this result is displayed on the user's home page and equally sent to the provided phone number and email.

3.8.1. Knowledge Engineer

Knowledge engineers acquire and gather information from domain experts. Document review technique is also undertaken to support knowledge acquisition. Collected information is then transformed into knowledge representation such as inference diagram, and rule base specification. Knowledge representation findings are useful before the programming tasks started. The knowledge acquisition can be classified into three categories: manual, semi-automatic and automatic. In this write-up, the manual method is adopted. In Manual methods the knowledge engineer extracts expert knowledge and then codes it in a suitable format.

3.8.2. Human Experts

Human experts provide facts about the expert system's particular domain or subject area are provided that are organized in the knowledge base. The knowledge base often contains a knowledge acquisition module that enables the system to gather knowledge from external sources and store it in the knowledge base.

3.8.3. Forward chaining

In an Expert system, someone may start with a preliminary state and tries to reach the goal state for the specific problem. The method of shifting over different solutions to proceed from the preliminary state to the goal state is termed search and the realm of all probable paths of search is the search space. There are 2 search methods broadly used in rule-based systems are “forward chaining and backward chaining”. In “forward chaining” the search proceeds in the forward direction. The forward chaining is a data driven search. Forward chaining is advantageous when goal conditions are minor in number when related to the initial state. The antecedent part is checked first and then goes to the consequent part.

3.8.4. Backward chaining

A system is supposed to perform backward chaining if it attempts to back a goal state or suggestion by examining known information in the framework. It searches in the state space working from the goal state to the preliminary state by the application of inverse operators. When there are rare goal states and many preliminary states, it may be better to start with the goal to work back toward the controller state. Backward chaining is a goal driven or ambitious search.

3.8.5. Hybrid chaining

Hybrid chaining always starts with forwarding chaining and anywhere a fact is required from the operator, go into contrary to the leaf node of the knowledge and have it to proceed with forwarding chaining mechanism.

3.8.6. Working memory

The working memory aims at the gathering of symbols or reliable information that mirrors the present condition of the problem, which comprises of the data gathered during problem implementation.

3.9. Hierarchical Structure of the Proposed Expert System

The hierarchical structure of this expert system reflects the layered organization of its components, This structure allows for the efficient management of knowledge and the effective implementation of reasoning mechanisms to provide expert-level decision-making capabilities. The diagram of the hierarchical structure of the proposed Expert system is shown in Figure 3.2. This expert system's hierarchical structure will aid increase diagnosis speed and accuracy, which will benefit patients' results. The expert system breaks down the complex diagnosis process into manageable modules that focus on the diagnosis process using a hierarchical framework (Smith, J., & Jones, A. 2023).

3.9.1. Hierarchical Structure

The expert system is structured hierarchically, consisting of the following levels: User/patient, patient registration, patient login (username and password), information storage, patient signs and symptoms, diagnosis and result. The proposed expert system's hierarchical structure provides a methodological approach to medical diagnosis, enabling precise disease stages and effective patient data processing.

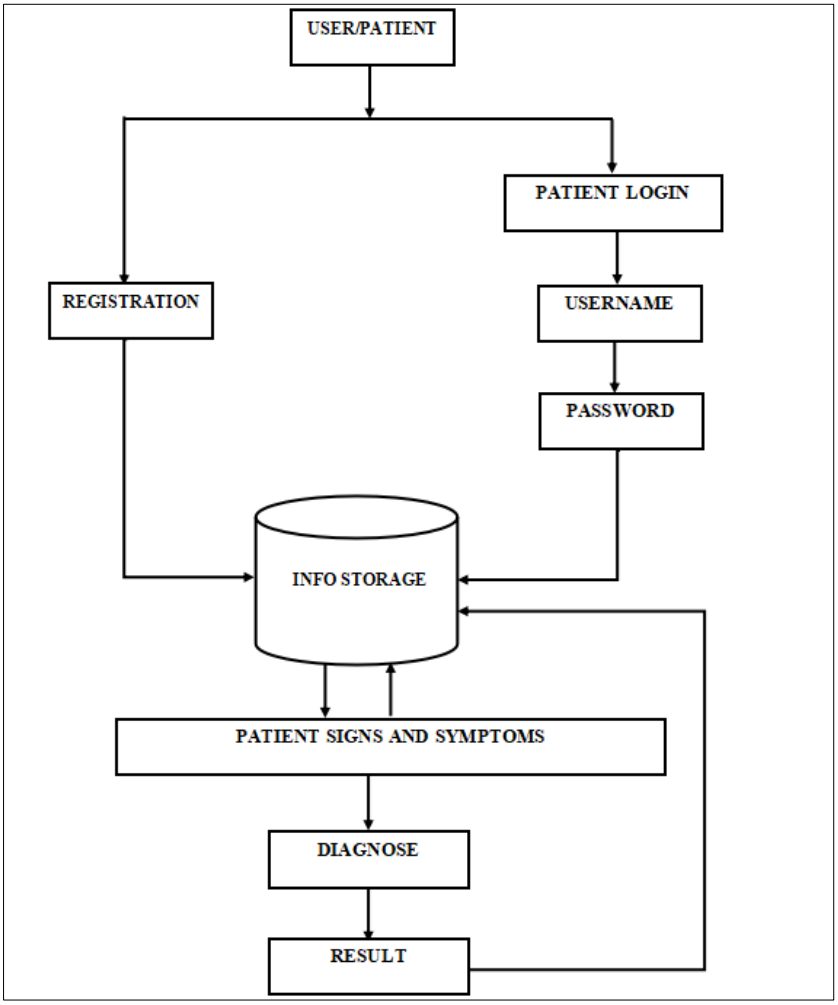

Figure 2 Hierarchical Structure of the Proposed Expert System

3.10. System Design

System design is the art of designing how the program works which is the process of defining the architecture, modules, interfaces and data for the system to satisfy specific requirements. The design phases consist of the input interface design, output design and storage. The hierarchical structure of the proposed Expert system is in figure 3.2 is adopted in this research.

3.10.1. Input Interface Design

Input interface design is the environment where raw data are fed or input into the system in order to perform an operation. What goes into the system is specified by the input specification design. These specifications include patient names, sex, date of birth, state of origin, l.g.a, town/city, parent occupation, parent monthly income, phone number, email address, user account, password, signs and symptoms. The input devices for this Expert system are the electronic keyboard and the mouse.

3.10.2. Output Design

Output design refers to the information produced after processing the data that is signs and symptoms that is input by the user into the system through the input devices. The output device is the computer monitor screen, output through SMS or e-mail and paper through the printer.

The outputs expected from the system are:

- Patient diagnosed result
- Recommendation and medical advice.

3.10.3. Storage

Storage is the database where patient information is stored and retrievable when necessary. The system expects users to enter accurate data into the designated data field because these data are defined based on the sort of data they are.

3.11. System flowchart

The system flowchart for the design is shown in Figure 3.3. The system requires a new user to register and an existing user to login into their home page. The existing user selects to seek for checkup after treatment and is discharged from the hospital, the system requires the existing user if there is further complaints or not, while the new user asks to register and login for diagnosis by supplying different signs and symptoms for proper diagnosing of Noma disease and its stage.

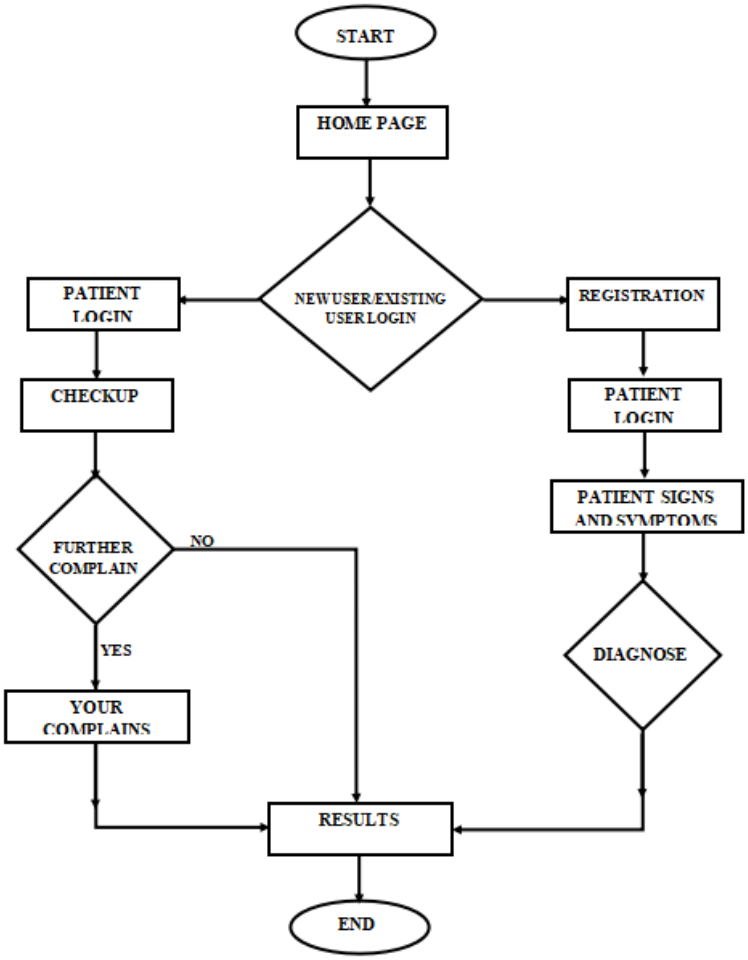

Figure 3 System Flowchart

3.11.1. Database Design

MySQL Oracle Corporation (2020) is an open-source relational database management system (RDBMS). Its name is a combination of "My", the name of co-founder Michael Widenius's daughter My, and "SQL", the acronym for Structured Query Language. The official way to pronounce "MySQL" is "My Ess Que Ell". A relational database organizes data into one or more data tables in which data may be related to each other; these relations help structure the data. SQL is a language that programmers use to create, modify and extract data from the relational database, as well as control user access to the database. In addition to relational databases and SQL, an RDBMS like MySQL works with an operating system to implement a relational database in a computer's storage system, manages users, allows for network access and facilitates testing database integrity and creation of backups.

The database engine that will be employed for this task is MySQL server. MySQL officially, but also called "My Sequel" is the world's second most widely used open-source relational database management system (RDBMS). Tables 1- 4 are the proposed tables for the Expert system.

Table 1 User registration

Column	Data Type	Length	Description
ID (Primary)	INT	11	The Primary Key
Surname	Varchar	50	Patient Surname
Last Name	Varchar	50	Patient Last Name
Date Of Birth	Varchar	50	Day, Month, Year
Gender	Varchar	50	Patient Gender
State of Origin	Varchar	50	Patient State of Origin
L.G.A	Varchar	50	Patient L.G.A
Resident State	Varchar	50	Patient Resident State
Resident L.G.A	Varchar	50	Patient Resident L.G.A
Parent Occupation	Varchar	50	Patient Parent Occupation
Parent Monthly Income	Varchar	50	Patient Parent Monthly Income (#)
Username	Varchar	50	Patient Username
Password	Varchar	50	Created Password
Confirm Password	Varchar	50	Confirming created password
Email	Varchar	50	Email Address
Phone	Varchar	11	Members Phone number
Address	Varchar	50	Patient Address

Table 2 User login

Column	Data Type	Length	Description
Username	Varchar	12	Valid Username
Password	Varchar	8	Valid Password

Table 3 Patient diagnose result

Column	Data Type	Length	Description
Patient Surname	Varchar	50	Patient Surname
Patient Last name	Varchar	50	Patient Lasrtname
Date Diagnosed	Varchar	50	Day, Month, Year
Result	Varchar	50	Result of the Patent.

3.12. Diagnosis signs and symptoms to select by the user

The diagnosis signs and symptoms to be selected by the user in the user home page are listed in table 3.4.

Table 4 The table contains the diagnosis of signs and symptoms and disease stages to be selected by the user

S/n	Diagnosis signs and symptoms	Stages
1.	Red or purplish red gum.	Acute Necrotizing Ulcerative Gingivitis (ANUG) stage 0
	Swelling and ulceration of the gums	
	Foul breath or halitosis.	
2.	Swelling or oedema inside (intra-oral) and around (perioral) the mouth areas.	Oedematous stage 1
	Painful cheek.	
	High fever.	
	Excessive salivation.	
	Mouth soreness.	
	Difficulty during eating.	
	Anorexia, and	
	Pain and swelling of lymph nodes (Lymphadenopathy).	
3.	Rapid perforation of the cheek.	Gangrenous stage 2
	Presence of necrotic area with slough formation.	
	Exposition of the teeth and denuded bones.	
	Progressive drying of the facial gangrene	
	Anorexia.	
	Apathy.	
4.	Trismus (Lockjaw).	Scarring (Disfigurement) stage 3
	Sequestration or loosening of teeth from the gums and exposure of bones and beginning of scarring tissue	
5.	Difficulty eating.	Sequelae (Terminal) stage 4
	Speech problems	
	Salivary leakage.	
	Teeth displacement	
	Dental anarchy (disfigurement).	
	Fusion of the bones of the face (maxilla and mandible) and	
	Nasal regurgitation (Food and saliva coming out of the nose).	

3.13. The Diagnosis Test Questions

The diagnosis test questions are listed below:

- Do you have red or purplish red gum?
- Do you have swelling and ulceration of the gums?
- Do you have foul breath or halitosis?
- Do you have swelling or oedema inside (intra oral) and around (perioral) the mouth areas.
- Do you have painful cheek?
- Do you have high fever?
- Do you have excessive salivation?
- Do you have mouth soreness?

- Do you have difficulty during eating?
- Do you have anorexia?
- Do you have pain and swelling of lymph nodes (Lymphadenopathy)?
- Do you have rapid perforation of the cheek?
- Do you have presence of necrotic area with slough formation?
- Do you have exposition of the teeth and denuded bones?
- Do you have progressive drying of the facial gangrene?
- Do you have apathy?
- Do you have trismus (Lockjaw).
- Do you have sequestration or loosening of teeth from the gums and exposure of bones and beginning of scarring tissue?
- Do you have speech problems?
- Do you have salivary leakage?
- Do you have teeth displacement?
- Do you have dental anarchy (disfigurement)?
- Do you have fusion of the bones of the face (maxilla and mandible)?
- Do you have nasal regurgitation (Food and saliva coming out of the nose)?

4. Implementation and Results

In this study, five design tasks were identified. They were:

- The web application design;
- The database implementation;
- Module testing.
- Module and sub-system integration.
- The system testing.

4.1. Implemented Modules

The web application as implemented with several modules, here we present more details about these modules as shown in figure 4.2

Figure 4 Home page

The home page of the application serves as the landing page of the application. This is the first page the user interacts with the web system. The page presents the following main modules; these are:

- Home
- About Us
- Services
- Our team
- Contact us
- Register here

Register Here Module

This module allows the first-timer to create a user account and submit the necessary information, the clink next. Figures 4.3a and 4.3b show the patient registration form. The user must ensure he/she enters the correct data in figure 4.3a, and an easy username, and password in figure 4.3b, then clink on register patient.

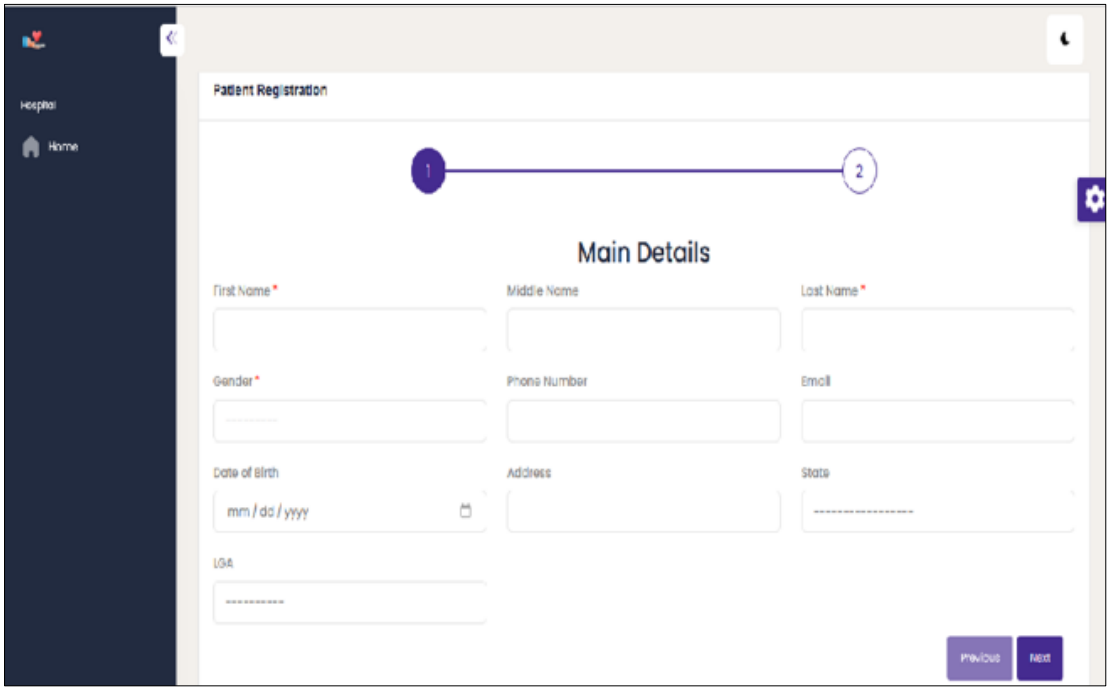

Figure 5a Patient Registration Form

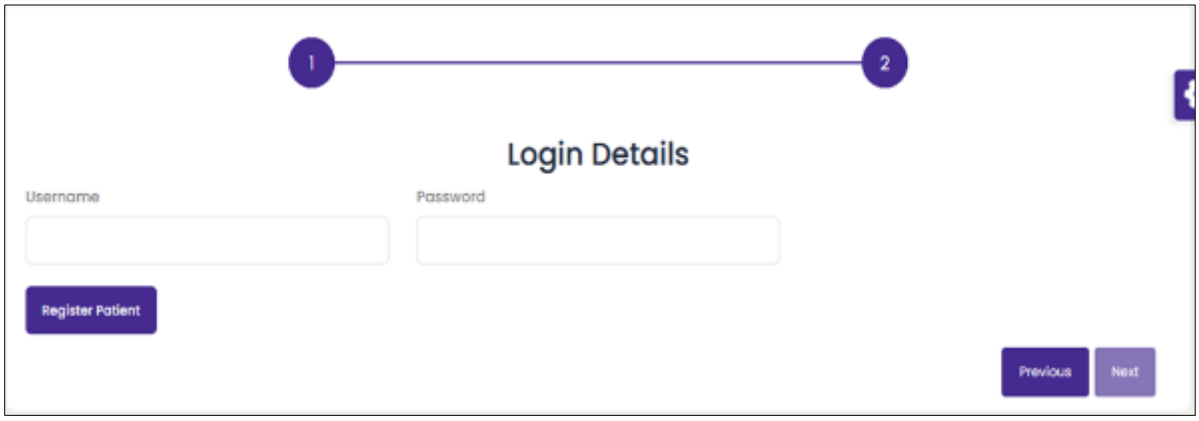

Figure 5b Patient Registration Form

4.1.1. Login Module

This login module is an interface that enables a patient to supply a username and password to access the user page. The interface is in the figure 4.4. After the username and password is inserted into the provided field, then click on Sign Me In

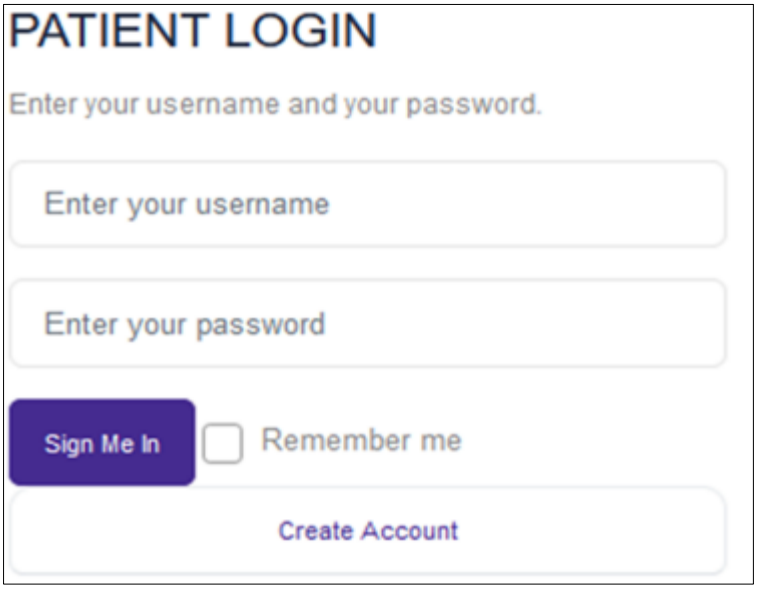

Figure 6 Login Interface

4.1.2. Consultation Page

The consultation page consists of the following

- Dashboard
- New case
- Previous case
- Logout

4.1.3. New Case

It is a sub-module for consultation where the user can select signs and symptoms for diagnosing Noma disease shown in figures 4.5a to 4.5h. This can be done multiple times. Consultation ranges from stage 0 to 6

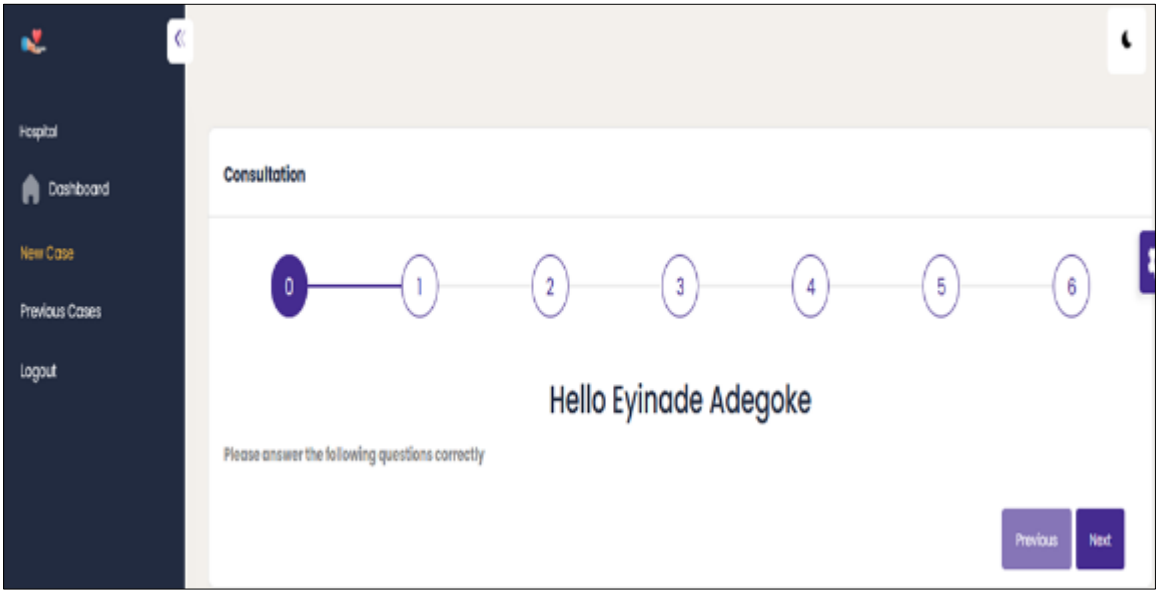

Figure 6a Consultation Page

- Stage 0: Please answer the following questions correctly.
- Stage 1: Do You Have Swelling Or Oedema Inside (Intra Oral And Around (Perioral) The Mouth Areas Painful Cheek High Fever Mouth Soreness Difficulty During Eating Anorexia And Pain And Swelling Of Lymph Nodes Lymphadenophathy?

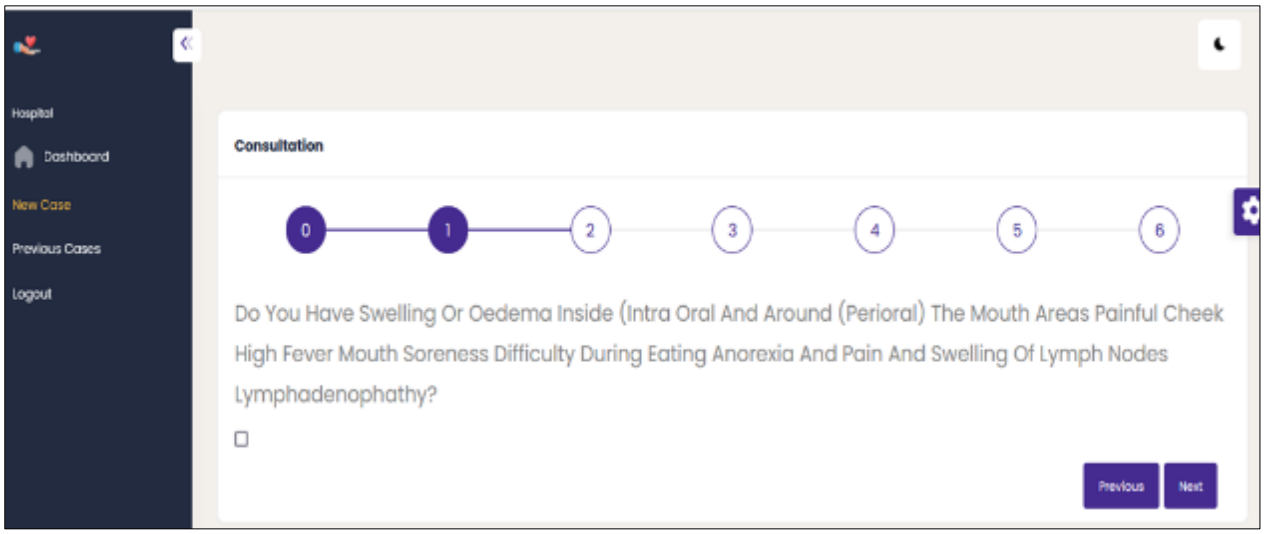

Figure 6b Consultation Page

- Stage 2: Do You Have Red Or Purplish Red Gum Swelling And Ulceration Of The Gums Foul Breath Or Halitosis?

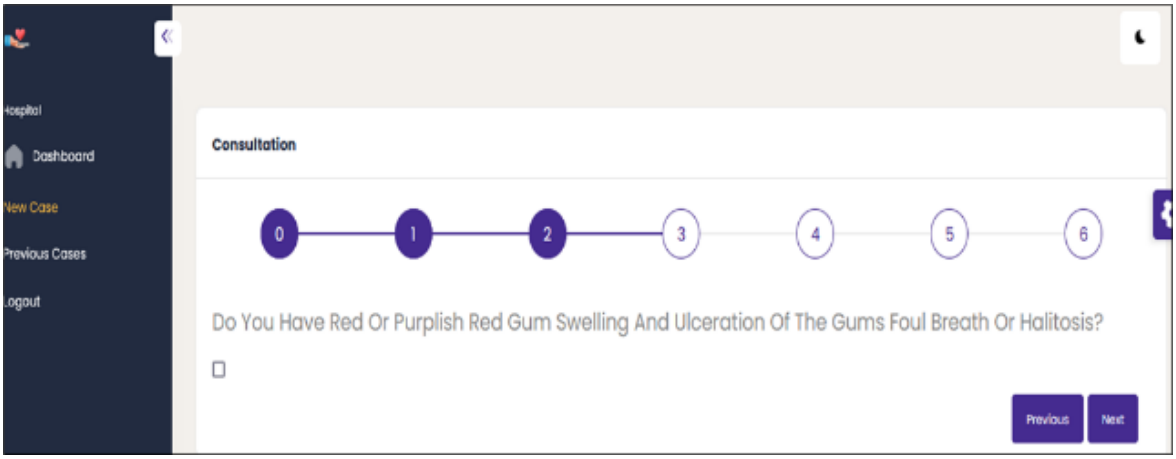

Figure 6c Consultation Page

- Stage 3: Do You Have Rapid Perforation Of The Cheek. Presence Of Necrotic Area With Slough Formation. Exposition Of The Teeth And Denuded Bones. Progressing Drying Of The Facial Gangrene Anorexia Apathy?

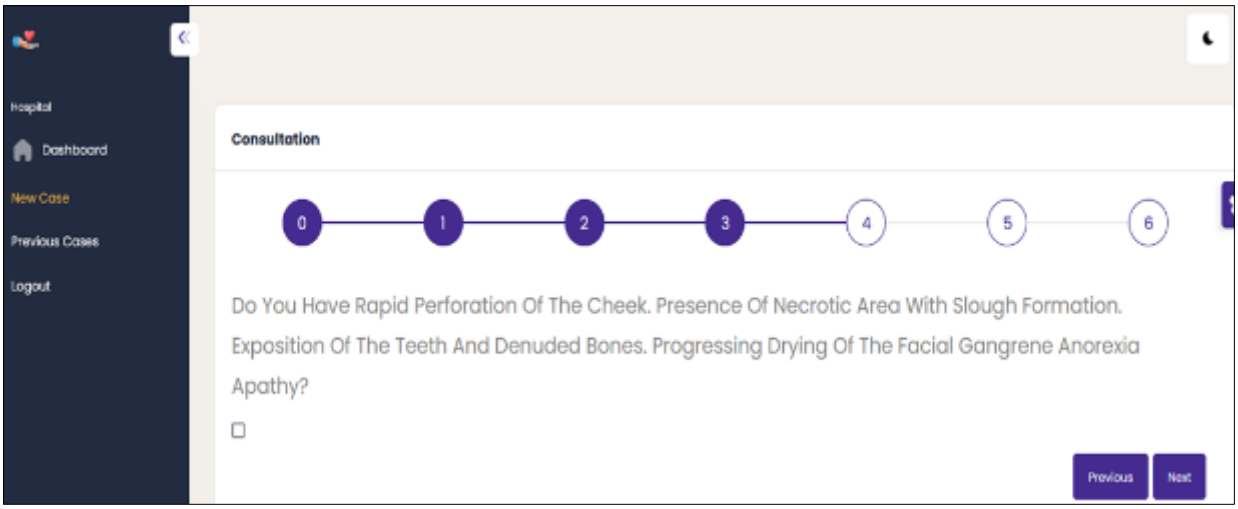

Figure 6d Consultation Page

- Stage 4: Do You Have Trismus(Lockjaw) Sequestration Or Loosening Of Teeth From The Gums And Exposure Of Bones And Beginning Of Scarring Tissues Be?

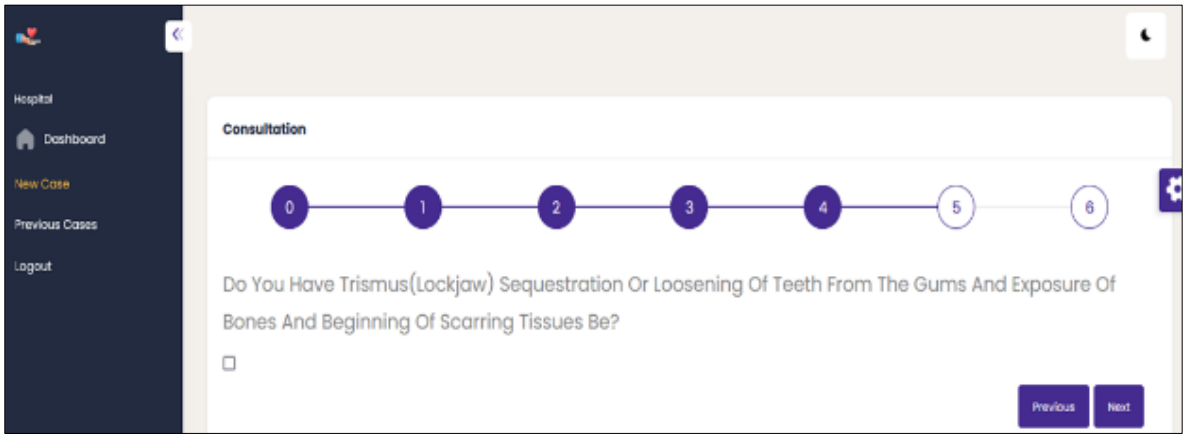

Figure 6e Consultation Page

- Stage 5: Do You Have Difficulty Eating Speech Problems Salivary Leakage Teeth Displacement Dental Anarchy (Disfigurement) Fusion Of The Bones Of The Face (Maxilla And Mandible) And Nasal Regurgitation (Food Saliva Coming Out Of The Nose)?

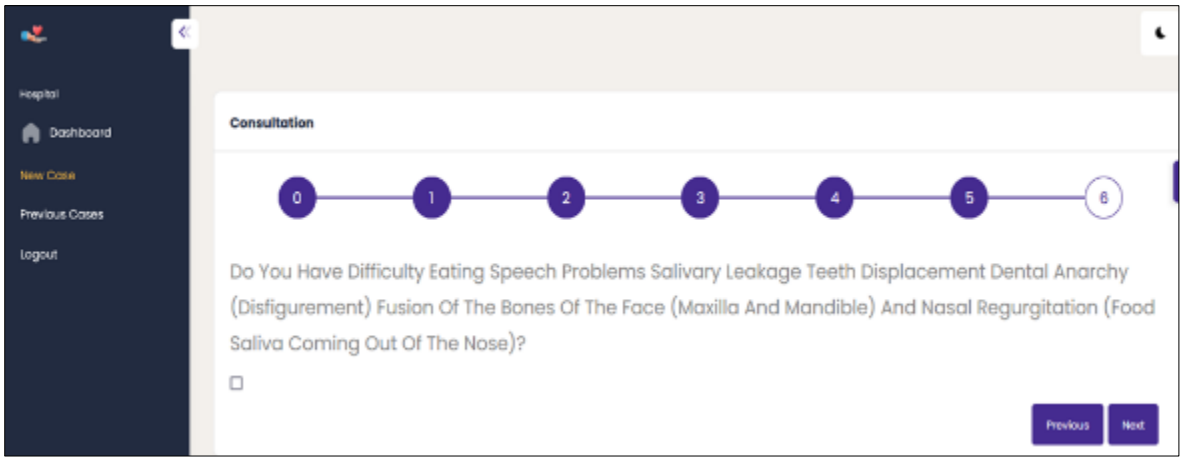

Figure 6f Consultation Page

- Stage 6: Thank You for your response, Proceed to view your result

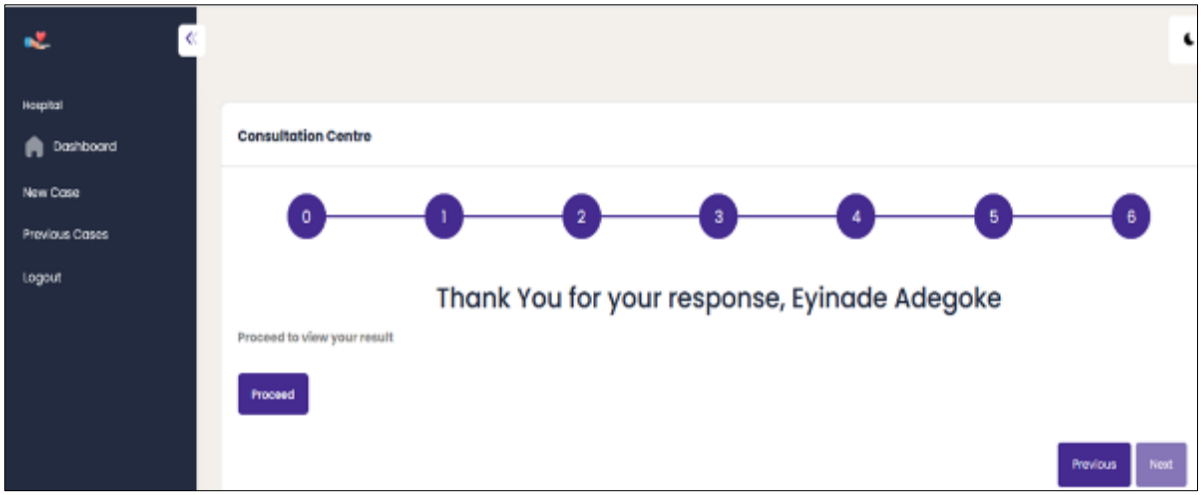

Figure 6g Consultation Page

Result: After careful study, this is the result of your diagnosis of GANGRENOUS STAGE 2

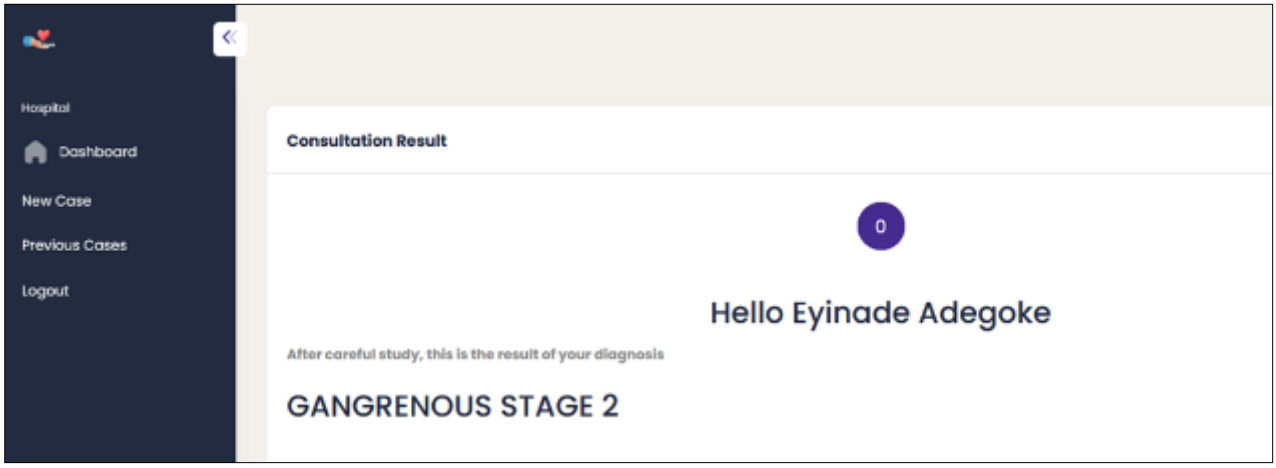

Figure 6h Consultation Page

4.1.4. Patient Dashboard

The dashboard consists four boxes of patient name and current disease stage in the yellow box, while the date and no of cases in the deep pink box shown in the figure 4.6.

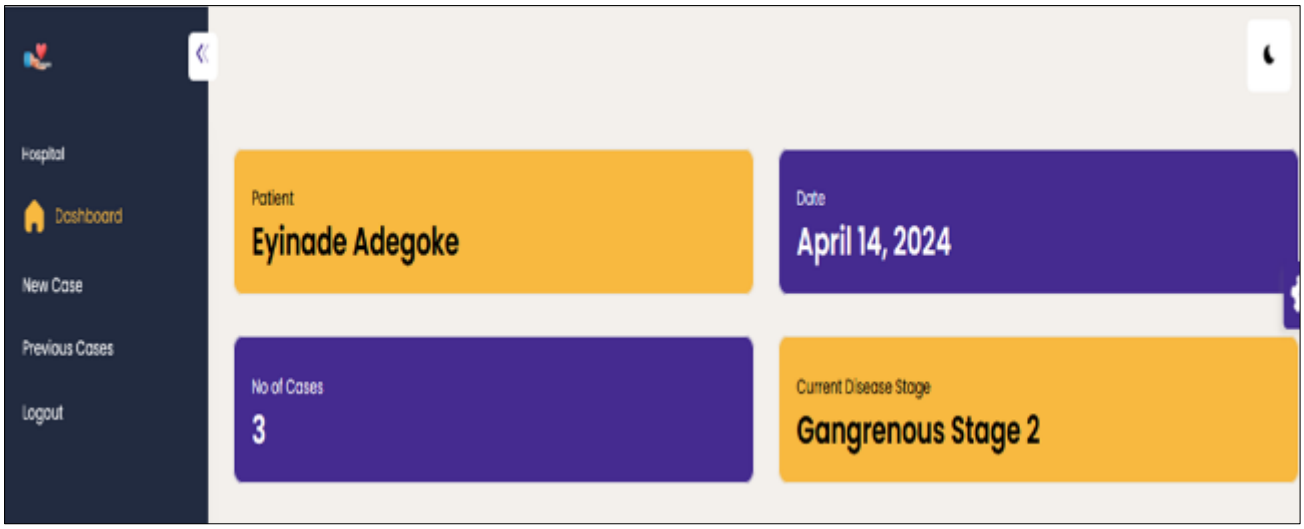

Figure 7 Patient Dashboard

4.1.5. Previous case: It is a module where the diagnosis can be revisited

Logout: This module allows the user to exit from the system

4.2. Database Implementation

The way to implement the database is very basic and clear. It followed the logical physical structure, It was done utilizing the "Code-first approach". With the model classes, all the database tables, keys and referential integrity were implemented. The database was refreshed at whatever point the model classes were executed. The web application had simple access to the database via an applications properties file situated in the project directory which contained all the necessary configurations. Screenshots of code snippets implementing a database table using the code-first approach and the data source configurations. Django helped oversee and manage the database outside the development environment. It was utilized to create and maintain database connections, records, systems, capacities, and other physical qualities of the database.

4.3. Unit Testing

Unit testing is the technique of checking and correcting errors made during the designing and coding of the program inorder to enhance the best performance to system requirements and the specification. The unit testing table is indicated in table 4.1

Table 5 Unit Testing Use Cases

The test modules	Expected tested result	Actual test result
Home Page	Expected to signup and login into the account created.	When the software runs, the home page is displayed with the background of medical scientists' pictures with other modules
Register Here (signup)	The module is expected to receive correct and accurate data input from the user and store it directly in the database.	The data supplied by the user is stored in the database.
Login	The Login Module is expected to allow the user to supply a username and password to take the user to the consultation page	It re-directed the user to the consultation page without error.
New Case	Expected user to select correct symptoms	The user selected the symptoms and the actual result generated.
Previous Cases	Expected to store the numbers of diagnoses the user entered.	It stored the multiple numbers of diagnoses entered by the user.
Logout	Expected to exit user from user profile	It exited the user from the user profile.
Dashboard	Expected to display user name, date of the diagnosis, no of cases and current result.	It displayed the patient's name, and current disease stage in the yellow box, while the date and no of cases in the deep pink

4.4. System TestinG

Testing is a method to check whether the actual system matches the expected output with the requirements. The purpose of software testing is to identify errors, gaps or missing requirements in contrast to actual requirements. Testing demonstrates that the software functions appear to be working according to specification and that behavioral and performance requirements appear to have been met. In addition, data collected as testing is conducted provide a good indication of system reliability and quality as a whole.

Testing should begin in the small and progress toward testing in the large. 80 percent of all errors uncovered during testing will likely be traceable to 20 percent of all program components. The components would be isolated and thoroughly tested. Testing ensures that internal operations are performed according to specifications and all internal components have been adequately exercised. The type of testing carried out was unit testing which involves testing the various modules separately.

4.5. Integration

System integration is the successful putting together of the various components, assemblies and subsystems of a system and having them work together to perform what the system is intended to do. The modules were merged together to make up the complete system. Integration follows the coding phase in the development life cycle, as shown in table 4.2 below and is intertwined with the testing.

4.6. System Principle Operation

The system principle operation is launched through the command prompt by typing python manage.py runserver and press the enter key on the system keyboard, it will generate the IP address of 127.0.0.1:8000. This IP address will be copied to the web browser URL.

4.7. Discussion Of Findings

According to the research findings, it was discovered that the Expert system will do a lot of good than harm on the Nigerian healthcare sector, as it can be used to serve different purposes which include: to evaluate and diagnosing Noma diseases, creating awareness, public education, to make the availability of healthcare services to all irrespective of location. It was also discovered that the Expert system faces some issues in Nigeria which include medical ethics, clinical safety etc.

5. Conclusion

Noma disease has caused a great havoc by disfigured faces of the malnurish children in sub-sahara Africa which Nigeria is one the nation especially norther part of the country. In the developing countries, poverty and lack of good environmental system, quality of water couple with poor hygene which resulted to nutrition deficiency has given birth to this dangerous and deadly disease called Noma. An Expert system as emerged as new artificial intelligence technology as the latest tools for combating the Noma disease through it early diagnosis and identification of the disease stages.

The promise of an Expert system to transform the healthcare industry is profound. The use of this tool for diagnosing and treatment of Noma disease is effective based on the findings of this research work. The discussion above shows that all facets of healthcare will be impacted by the Expert system. Currently, the integration of Expert in certain areas of medicine, such as medical imaging, is quite advanced, benefitting greatly from earlier research in computer vision. In many areas, the Expert system is in the early stages of development and implementation because of the financial cost. The Noma disease diagnosis and treatment is a great thing to happen to the medical world as the disease itself is not what we are familiar with here in Nigeria for instance, but it is present amongst us. However, this is changing quickly as the Expert system landscape is developing at a rapid pace. However, there are some roadblocks as identified above. The most important of them is the need to develop a trusted Expert system. This will take time, as people need to get comfortable with algorithms making decisions for them. But as has been shown in the case of driverless cars, people do develop trust over time and as they become familiar with the processes and outcomes involved. The various risks of the Expert system can be managed as our understanding increases. As the Expert system emerges from research labs and experimentation to implementation and spreads into the mainstream and as humans and machines begin to collaborate more closely, the transformational possibilities of the Expert system for transcending the healthcare industry will become enormous.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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