Medical Expert System for Diagnosis and Remedy for Infectious Diseases

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Abstract Nowadays, medical applications, especially the diagnosis of diseases, are increasing because of their importance and effectiveness to detect diseases and classify and recommend a remedy for patients. Nigeria is facing the challenge of Doctors shortage and with limited or no presence in rural areas. This research presents the design and implementation of a Medical Expert System that aims to provide patients with a background for suitable diagnosis and remedy for the following viral infections (Measles, Chicken Pox, and Mumps); this is because the above listed viral infections exhibit almost the same symptoms with slight variation. The implemented system gives accurate diagnosis and remedy for the viral infections listed above.

Keywords: Expert System, Infectious Diseases, Diagnosis and Remedy

1. Introduction Nigeria is facing the challenge of Doctors' shortage (World Health Organization, 2015). Measles and other contagious cases fatality rates in Africa generally range from 3% to 5% and can be as high as 30% during severe outbreaks. The disease is endemic in Nigeria and it exhibits a seasonal pattern with increasing incidence during the dry season between November and May (Akintola, Ayodeji & Adeniyi, 2014). Mumps is one of the older described infectious diseases before the widespread use of Mumps vaccines, Mumps was a common disease of childhood with nearly everyone having serologic evidence of prior infection by the age of 15. Symptoms include a swollen neck, dry mouth, swollen salivary glands, and difficulty in swallowing (Stephen, 2016). Besides, Chickenpox is a contagious disease caused by the varicella-zoster virus (VZV). It causes a blister-like rash, itching, tiredness, and fever. The best way to prevent chickenpox is to get the Chickenpox vaccine (Southern Cross Library, 2019). This research aims to design and implement a medical expert for Measles, Chickenpox, and Mumps. The user or patient is asked to answer with yes or no if a particular symptom appears or not. Diagnosis of Measles, Chickenpox, and Mumps are primarily based on historical and clinical findings, and as such, there is a need for a system that can assist health experts in the diagnosis process. An effective health sector requires an automated medical diagnosis system that is fast and reliable. Such a system would address the issue of inadequate health workers in Nigeria and developing countries, where few Doctors would have to attend to quite a large number of patients. While saving time, it will also save cost for diagnosis and also save the stress of waiting for an expert. Consequently, this will bring about early detection and remedy for the diseases.

2.0 LITERATURE REVIEW

2.1 Application of ICT in Disease Diagnosis and Remedy

Continuous developments in Information and Communication Technologies (ICT) and the Internet, Ambient Devices, and Intelligent Computer Systems have resulted in increasing use of these technologies in the practice of medicine and the provision of medical care. This has led to new concerns regarding the social impact of technology in medicine. Such concerns range from how information technology has changed the practice of medicine and the resulting social consequences, to how the practice of medicine responds to the increasing pervasiveness of technology in our daily lives. Information systems in healthcare are often used to store, access, and transmit electronic medical data. These activities include implementing computerised databases and facilitating data exchange (Goran, Penny, Carlisle, Karin, Kai & Emilio, 2006).

2.1.1 Technology and the Self-Help Patient

There is an increasing trend towards utilising the latest developments in technology to facilitate patient self-help and health management. The combination of intelligent systems, hand-held devices, and mobile technologies offer a range of applications designed to support patients" independent lifestyles whilst maintaining contact with healthcare professionals. Some current examples are self-monitoring of sugar levels for people with diabetes, together with data link via mobile phone to the medical practitioner (Fleming, 2005); intelligent monitoring devices in the home for people with potential cognitive difficulties (for example, the elderly) that will alert remote caregivers (Pollack, 2005); intelligent materials (used as clothing) that can monitor "vital health data, communicate with remote health centres and present data in a variety of formats for further analysis by doctors and researchers" (Goran, et al, 2006).

2.2 Related Concepts

Sani, Success, and Adamu (2019) implemented an e-Veterinary System for Diagnosis of Viral Diseases in Poultry using JAVA. The implemented system was able to diagnose Influenza, Flu, and Bronchitis in poultry birds based on inputted symptoms to the knowledge base processes the symptoms and displays the diagnosis result. The diagnosis of this system is limited to poultry birds and the result is not promising.

Kasidet and Robert (2017) reviewed Measles control in Kenya, with a focus on recent innovations. In an evaluation of various innovations in communication technologies used in 11 urban districts in Kenya, positive results were shown for all the innovations, suggesting that scaling up some of these innovations will be very beneficial to the campaign. The adaptive planning and management of supplemental Measles immunization activities based on real-time evidence could be a key factor in increasing SIA coverage in the future. Improvement in technology will still be needed, especially in verifying children's vaccination status to send the correct follow-up Short Message Service (SMS). Better systems for a more accurate way of diagnosing are also needed, to reduce human error.

Ye *et. al*. (2017), undertook a study of the transferability of influenza case detection systems between two large healthcare systems. This study evaluates the accuracy and transferability of Bayesian Case Detection systems (BCD) that use clinical notes from the Emergency Department (ED) to detect influenza cases. BCD uses natural language processing (NLP) to infer the presence or absence of clinical findings from ED notes, which are fed into a Bayesian network classifier (BN) to infer patients' diagnoses. Transferability of a BCD in this study may be impacted by seven factors: development (source) institution, development parser, application (target) institution, application parser, NLP transfer, BN transfer, and classification task. An ANOVA analysis was used to study their impacts on BCD performance. However, this system does not interact with users to diagnose the disease only for evaluation of the already diagnosed disease.

Sourabh, Preetam, Jyotiranjan, Vikas Bhatia, and Sonu, (2017) proposed the improvement of the health system for detecting Mumps in India. Training of all involved in the surveillance system to deal with outbreaks and prevent their occurrence is of utmost importance. The Essential Public Health Service framework has enabled them to categorize the deficiencies in the health system effectively. The identification of the level of improvement needed in each of the service areas might further prompt appropriate intervention to strengthen the health system and reduce the number of occurrences of various outbreaks in the future. However, the success of such analysis remains to be seen.

Fred, Immaculate, Simon, Henry, and Annet,(2017) developed a sensitive surveillance system within the Integrated Disease Surveillance and Response (IDSR) framework. Analysed Measles surveillance data to determine the effectiveness of the Measles case-based surveillance system and estimate its positive predictive value to inform policy and practice. This system provides routine reports of suspected Measles cases as part of the general system of aggregate summary reporting of notifiable diseases and other health events. During passive surveillance, data are collected from suspected Measles patients during visits to health centres and then reported routinely using weekly, monthly, and quarterly reports. This system only keeps data of reported victims and does not detect disease.

Hossain, Andersson, and Naznin, (2015) developed a belief rule-based inference methodology using evidential reasoning approach (RIMER), which is capable of handling various types of uncertainties has been used to develop an expert system to diagnose Measles under uncertainty. The results, generated, from the system have been compared with the expert opinion as well as with a Fuzzy Logic based system. In both cases, it has been found that the Belief Rule-Based Expert (BRBES), presented in this research, is more reliable and accurate. However, it can only diagnose Measles and cannot inform the user about possible home remedies for the disease.
Given the above literatures reviewed, there is no research, study, or framework that diagnoses and recommends remedies based on the available symptoms for the under-listed viral infections (Measles, chickenpox, and Mumps) respectively at a point in time. This is the gap that this research aims to bridge.

3.0 METHODOLOGY

3.1 System Architecture of the Expert System

The architecture of any system is a logical model, structured in a way that defines the organization and behaviour of the system. That is, a system architecture is a way for a formal representation of any given system. The architecture of the proposed system is shown in Figure 1.

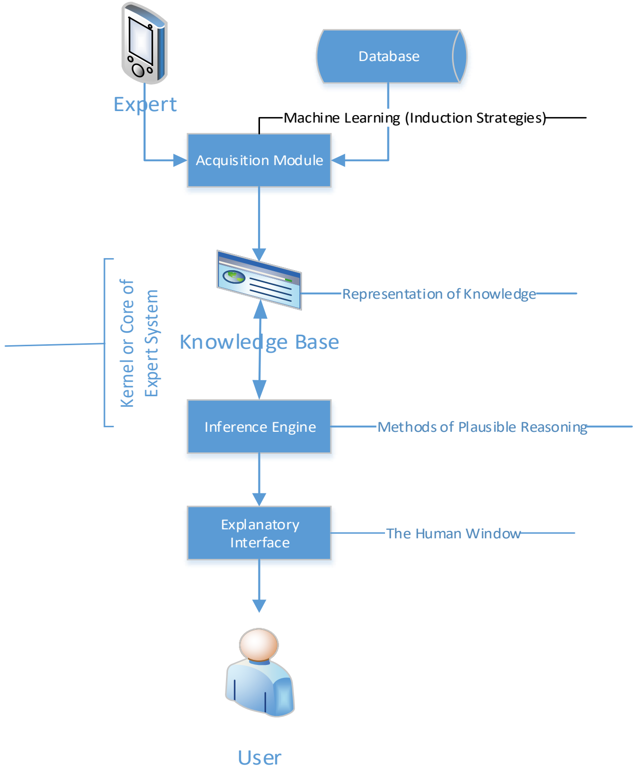

Figure 1: A Typical Expert System Architecture (Source: Forsyth, 1984)

Components of the Expert System

i. Acquisition Module: This is the component of the expert systems that evolve strategies for acquiring knowledge in a human-readable form.

ii. Knowledge Base: This comprises of assertions or (facts) and rules (that is IF-THEN rules) format.

iii. Inference Engine: This consists of 'forward chaining' and 'backward chaining'. Forward chaining involves reasoning from data to hypotheses while backward chaining is concerned with changing data to either prove or disprove a particular hypothesis.

iv. Explanatory Interface: This is the human window. It is the explanation facility that operates within a human cognitive window.

3.1.1 Knowledge Base of the Proposed Medical Expert System

The program works by acquiring an in-depth knowledge of all the symptoms of viral infections under consideration from medical experts. Each new patient is asked yes/no questions concerning his/her symptoms, and his/her responses are subsequently recorded. The diagnosis works by matching symptoms of known infections with these recorded responses in decreasing order of complexity. The Knowledge Base contains information about four viral infections which are represented as a set of if-then production rules. The knowledge base is analogous to long-term human memory. The total ordering of production rules is carried out in the knowledge base as follows:

Measles is a viral infection whose symptoms include fever, cough, conjunctivitis, runny nose, and rash. So, it will be stored in a knowledge base in the form of a rule which is as follows:

```
hypothesis(Patient,Measles) :-
    symptom(Patient,fever),
    symptom(Patient,cough),
    symptom(Patient, conjunctivitis),
    symptom(Patient,runny_nose),
    symptom(Patient, rash)
```

Chickenpox is a viral infection whose symptoms include fever, cough, headache, conjunctivitis, body ache, chills, and sore throat. So, it will be stored in a knowledge base in the form of a rule which is as follows:

```
hypothesis(Patient,chicken_pox) :-
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symptom(Patient,fever),
symptom(Patient,chills),
symptom(Patient,body_ache),
symptom(Patient,rash).

Mumps is a viral infection whose symptoms include low fever, headache, loss of appetite, and general fatigue. So, it will be stored in a knowledge base in the form of a rule which is as follows:

hypothesis(Patient,Mumps) :-
symptom(Patient, low fever),
symptom(Patient,headache),
symptom(Patient,loss_appetite),
symptom(Patient,swollen_glands),
symptom(Patient,fatigue).

3.2 Mathematical Modelling of the Proposed Medical Expert System

This shows the description of the system using mathematical concept and language, the process of developing a Mathematical model, is known as Mathematical modelling.

Let
M represents Measles,
C represent Chickenpox
Mn represents Mumps.

Let
λ be the rate at which the patient can have a fever
θ be the rate at which the patient can have a cough
γ be the rate at which the patient can have conjunctivitis
β be the rate at which the patient can have a runny nose
α be the rate at which the patient can have a rash
μ be the rate at which the patient can have a headache
ω be the rate at which the patient can have body ache
η be the rate at which the patient can have chills
υ be the rate at which the patient can have sore-throat
ρ be the rate at which the patient can have swollen glands

Therefore:

$$\frac{dM}{dt} = \lambda\,(M - (C + F + Mu)) + \theta\,(M - F) + \gamma\,(M - F) + \beta\,(M - F) + \alpha\,(M - C)$$

$$\frac{dM}{dt} = (\theta + \gamma + \beta)\,(M - F) + (\lambda + \alpha)\,(M - C) - \lambda\,(F + Mu) \quad \ldots\ldots \text{Eq. (1)}$$

Eq. (1) explains that given the disease Measles (M) at a given time t the system detects symptoms λ, θ, γ, β and α for Measles only.

$$\frac{dC}{dt} = \lambda\,(C - (M + F + Mu)) + \eta\,(C - F) + \omega\,(C - F) + \alpha\,(C - M)$$

Therefore:

$$\frac{dC}{dt} = (\eta + \omega)\,(C - F) + (C - M)\,(\lambda + \alpha) - \lambda\,(F + Mu) \quad \ldots\ldots \text{Eq. (2)}$$

Eq. (2) shows that given the disease Chickenpox (C) at a given time t the system detects symptoms λ, η, ω and α for Chickenpox only.

Therefore:

$$\frac{dMu}{dt} = \lambda\left(Mu - (C + F + M)\right) + \rho Mu$$

$$\frac{dMu}{dt} = (\lambda + \rho)Mu - \lambda(C + F + M) \quad \ldots\ldots \text{Eq. (3)}$$

Eq. (3) shows that given disease Mumps (Mu) at a given time t the system detects symptoms λ and ρ for Mumps only.

3.3 System Use Case Diagram of the Proposed Medical Expert System

Use case diagram is a software design methodology used to visually depict the user's interaction and user's capability or privileges with a particular system or the interaction between one system and another. This shown in Figure 2.

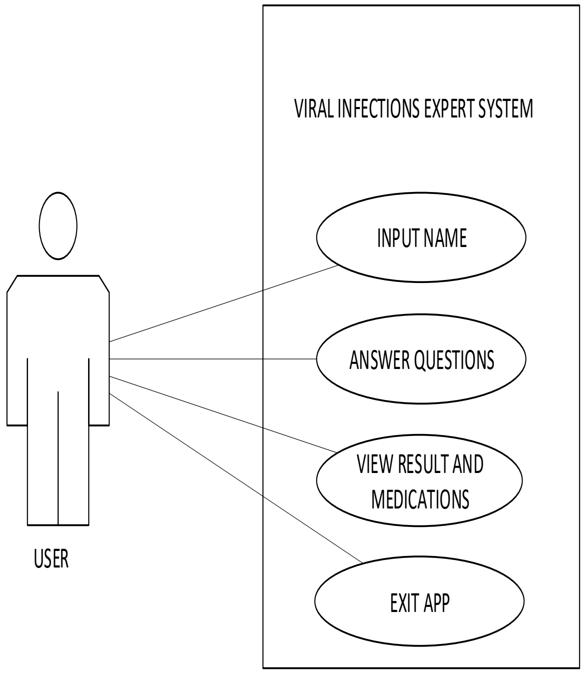

Figure 2: Use Case Diagram of the Proposed Medical Expert System

3.4 Algorithm of the Proposed Medical Expert System

A flowchart is a graphical representation of a system showing the sequential flow of the operational process of any given system. The flow chart of the proposed diagnostic system is shown in Figure 3 below.

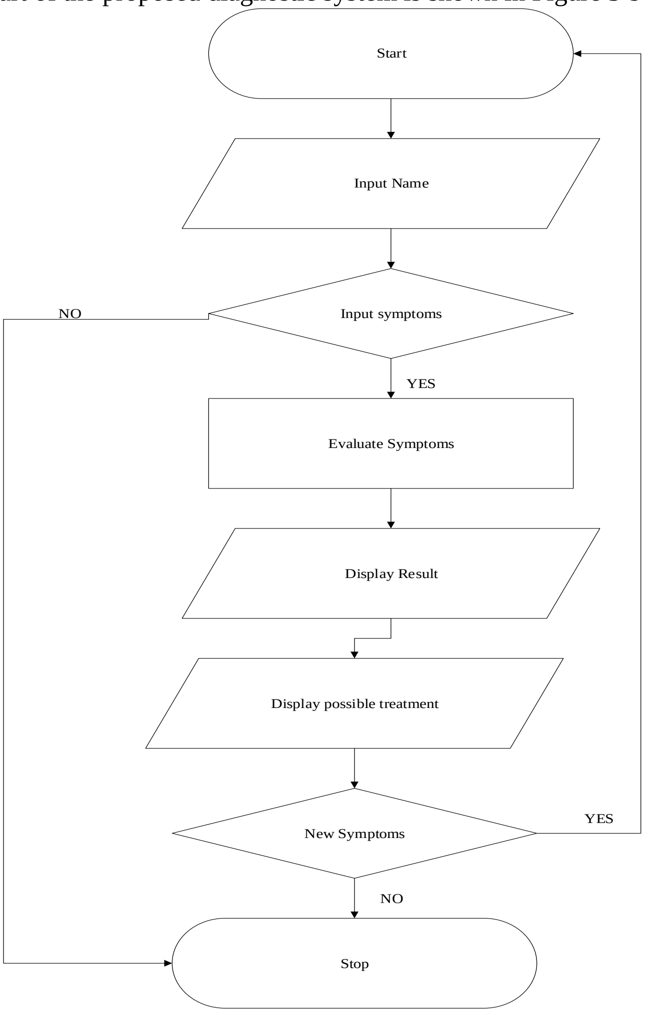

Figure 3: Flowchart of the Proposed Medical Expert System

Software Requirement and Programming Languages for the Proposed Medical Expert System
SWI-Prolog software was executed in the Windows operating system for the execution of the Expert system; however, it can also run on a different operating system, java run time environment which includes the java virtual machine installed and on bits operating system successfully execute the application. Prolog and java are the programming languages used for the implementation and the entire development of the application. Prolog was used for implementing the artificial intelligence component on knowledge base induction while java was used for a graphical user interface for user interaction with the system.

4.0 RESULTS AND DISCUSION

4.1 User Registration Page

The system provides a graphical user interface for easy interaction with the users. The system displays a form for the user to register before the system can recognise the user with the login credentials pre-registered in the database for that particular time. This is shown in Figure 4 below. The first page will guide the user to navigate seamlessly through the system.

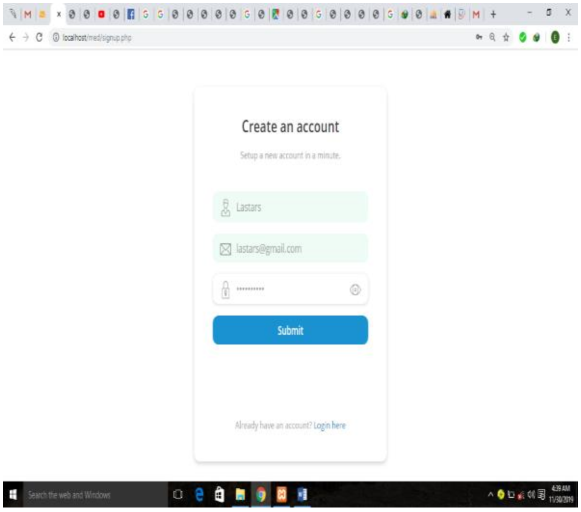

Figure 4: User Registration Page

4.1.1 User Login Page

The system displays a login page to authenticate authorized users and reject unauthorized users. This is shown in Figure 5 below. The first page will guide the user to navigate seamlessly through the system.

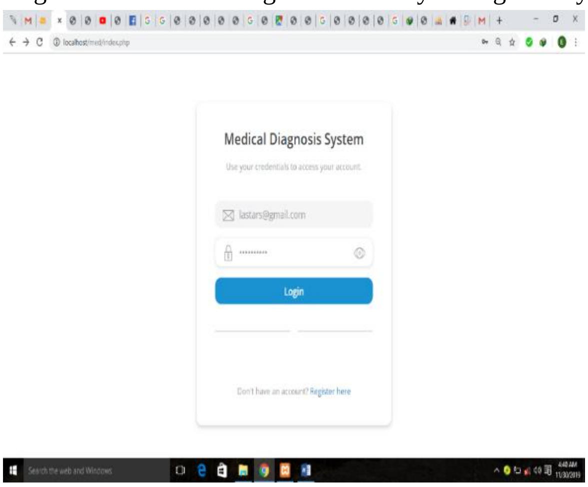

Figure 5: User Login Page

4.1.2 Main Menu

The system implements the main menu where only authorized users can have access to the system. This is shown in Figure 6 below. This page allows users to start the inference engine and carry of diagnoses on humans.

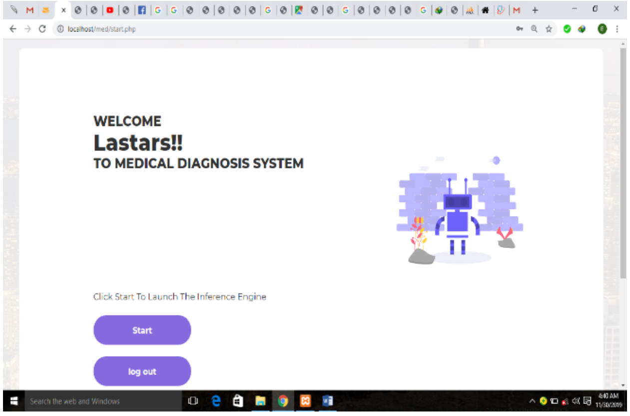

Figure 6: Main Menu

4.2 Patient Result for Measles

For diagnosis of Measles, the system detects common symptoms stored in the knowledge base for Measles. Figure 7 below shows the system questions asked and result display for Measles and recommended remedy.

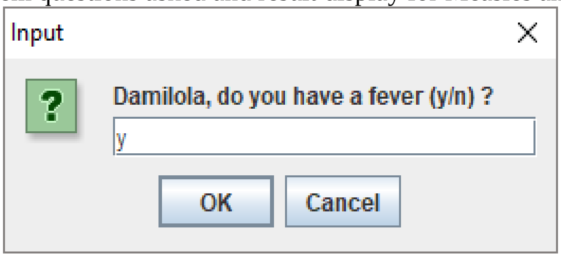

Figure 7: Display Question for Fever

Figure 7 above shows the user input for the question "do you have a fever". The user inputted y(yes), the system displays the next question about all diseases that have fever as its symptom.

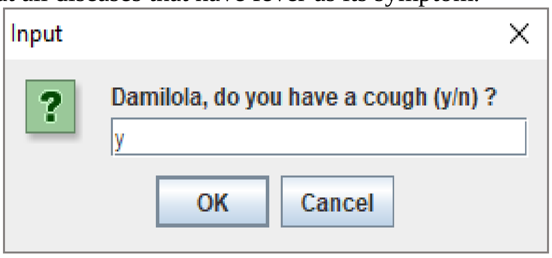

Figure 8: Displays Question for Cough

Figure 8 above shows the user input for the question "do you have a cough". The user inputted y(yes), the system displays the next question about all diseases that have fever and cough as their symptoms.

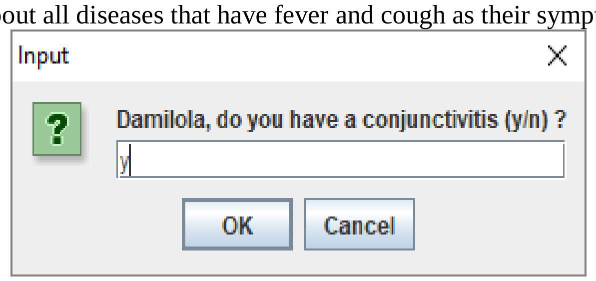

Figure 9: Display Question for Conjunctivitis

Figure 9 above shows the user input for the question "do you have conjunctivitis". The user inputted y(yes), the system displays the next question about all diseases that have fever, cough, and conjunctivitis as its symptoms.

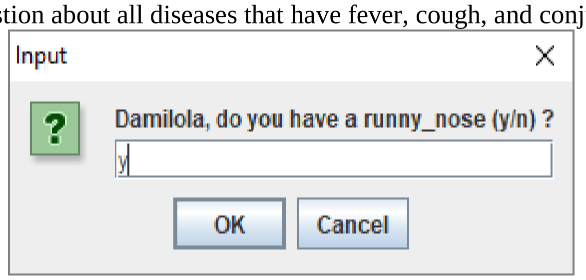

Figure 10: Display Question for Runny Nose

Figure 10 above shows the user input for the question "do you have a runny nose". The user inputted y(yes), the system displays the next question concerning all diseases that have a fever, cough, conjunctivitis, and runny nose as its symptoms.

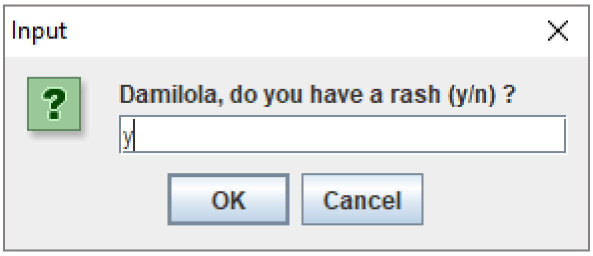

Figure 11: Display Question for Rash

Figure 11 above shows the user input for the question "do you have rash". The user inputted y(yes), the system displays the next question about all diseases that as fever, cough, and conjunctivitis as its symptoms. The system detects if a particular disease has all the symptoms, if yes it then displays this prompting.

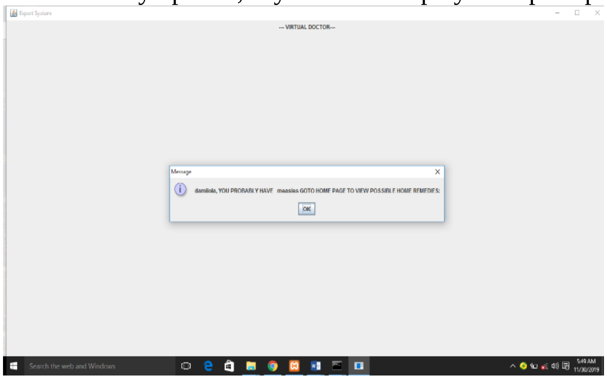

Figure 12: Diagnosis Result for Measles

Figure 12 above shows the diagnosis result of the aforementioned symptoms as Measles. Once the user clicks on the button the patient is taken back to the homepage to view the remedy.

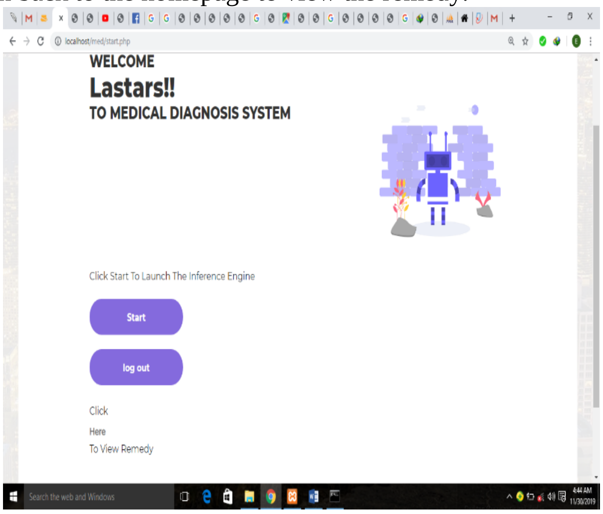

Figure 13: Home Page for Remedy

Clicking on the **here** button displays the home remedy page as shown in Figure 13 above.

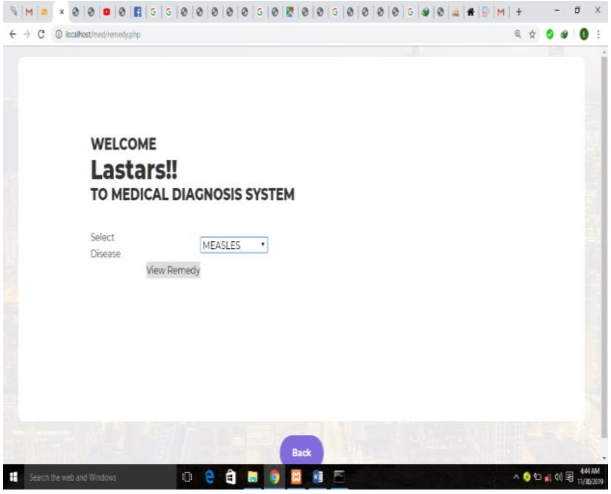

Figure 14a: Measles Home Page for Remedy Selection

In Figure 14a above, the diagnosed disease is selected (Measles) and by clicking on **view remedy** the expert system can access available home remedies for Measles as shown in Figure 14b below.

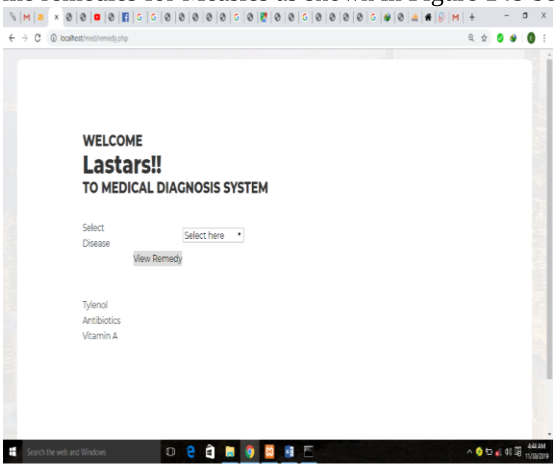

Figure 14b: Home Page for Viewing Remedy for Measles

5. 1 Conclusions

A Medical Expert system that is efficient and reliable in diagnosis and remedy of viral infection was implemented taking into consideration (Measles, Chickenpox, and Mumps). The system was designed with the capability to receive the patient's symptoms and display the patient's status, based on the assessment or evaluation of the inputted symptoms. The system is user-friendly, easy to navigate, and highly interactive.

5.2 Recommendation

The implementation of the designed system is based on the case of common symptoms. Thus, future research of similar systems should consider the case of newly detected symptoms and more viral infections can be added to the knowledge base.

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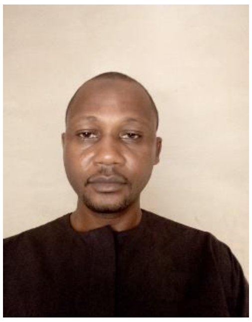
Authors Biography



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