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KNOWLEDGE BASED EXPERT SYSTEM ON COVID-19 DIAGNOSIS IN NIGERIA

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ABSTRACT

The rapid spread of the coronavirus (COVID-19) pandemic posed unprecedented challenges to healthcare systems globally, particularly in developing nations like Nigeria. Limited access to diagnostic tools, overburdened healthcare personnel, and geographic barriers to healthcare delivery highlight the urgent need for innovative, scalable solutions. This study presents the design and development of an expert system integrated within a telemedicine framework for the early diagnosis of COVID-19 in Nigeria. The system leverages a rule-based approach, guided by clinical guidelines from health authorities such as the WHO and NCDC, to assess patient-reported symptoms and provide diagnostic suggestions. An expert system components framework was designed from which the signs and symptoms of COVID-19 Virus were collected into the knowledge base. The signs and symptoms of COVID-19 were collected through interview into the knowledge base using MYSQL database. The system was developed using a lightweight interface accessible via web platforms, the expert system offers an efficient, low-cost tool for preliminary screening, especially in underserved and remote areas. The system was able to correctly identify and classify user-reported symptoms (e.g., fever, cough, loss of taste/smell, breathing difficulty) based on predefined diagnostic rules.

1. Introduction

The development of an expert system integrated into a telemedicine platform becomes both a necessary and strategic solution. Such a system can serve as a preliminary diagnostic tool, enabling individuals to self-assess symptoms and receive guidance remotely. This not only reduces the burden on healthcare facilities but also helps in early detection and isolation of suspected cases, which is crucial for controlling the spread of the virus.

COVID-19 pandemic is a new strain discovered in 2019 and not previously known in humans. Coronaviruses are zoonotic which mean that they are spread between animals and humans. Specific studies showed that SARS-CoV was transmitted to humans from civet cats and MERS-CoV from dromedary camels (WHO, 2020). Many identified Coronavirus occur in animals not yet infected by humans. Respiratory symptoms, fever, cough, shortness of breath and trouble breathing are typical signs of infection. (Alsharman & Jawarneh,2020)

Scientists have warned for decades that such sarbecoviruses are poised to emerge again and again, identified risk factors, and argued for enhanced pandemic prevention and control efforts. Unfortunately, few such preventive actions were taken resulting in the latest coronavirus emergence detected in late 2019 which quickly spread pandemic ally. The risk of similar coronavirus outbreaks in the future remains high. In addition to controlling the COVID-19 pandemic, we must undertake vigorous scientific, public health, and societal actions, including significantly increased funding for basic and applied research addressing disease emergence, to prevent this tragic history from repeating itself. (Morens *et al.*, 2020). Its outbreak was characterized by fever, dry cough, and fatigue, occasional gastrointestinal symptoms happened in a seafood wholesale wet market, the Huanan Seafood Wholesale Market, in Wuhan, Hubei, China.

Morens *et al.* (2020) also opined that when a virus enters a human cell for the first time, it has very recently been transmitted from cells of some other host, that is, from another animal or, for example, an insect vector. Emergence of a pathogen between a vertebrate or an insect has been referred to as host-switching, sometimes described as a spill over event. Most of the human viral and non-viral infectious diseases that have existed for centuries measles, influenza, cholera, smallpox (eradicated in 1980), falciparum malaria,4dengue, HIV, and many others—originated by animal tohumanhost-switching. The complex genetic events that underlie host-switching differ greatly from pathogen to pathogen, but general mechanisms have been recognized for many.

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Hence, it may represent both a screening and diagnostic tool, which demonstrate remarkable importance in recent literature, mostly due to the higher deployment and development of digital technologies e.g. AI (Artificial Intelligence) using expert system, smartphones and digital connections. Appropriate tools allowing clinicians at reaching and periodically monitoring individuals who have difficulties attending specialist visits, especially patients affected by chronic disease. According to Shen *et al.*(2021), telemedicine platforms provide an opportunity of bringing patient and physician together digitally, without requiring physical contact relieving congested clinical services and avoids the risk of further infection. Telemedicine interventions provide at-home solutions allowing clinicians to tele monitor and assess patients remotely, thus minimizing the risk of infection, as in (Gomez *et al.,* 2021). It provides medical services at a distance, but some telemedicine gadgets may not be afforded my individuals except government and organizations. According to Oyeranti and Babajide (2020), the increasing cost of health care in developing Countries like Nigeria has called for a change in the way health activities are implemented.

Telemedicine with expert system will enhance early detection and evaluation of infected patients which will minimize the spread of the Virus. Expert system can be used to detect the early most common symptoms of COVID –19, which are fever, tiredness, and dry cough. Having aches and pains, nasal congestion, runny nose, sore throat, or diarrhoea are some other symptoms that can consider in the expert system (Dharshikgan *et al.,* 2020). The expert system helps patients to detect and diagnose the symptoms that may face in real-time, without losing a second. This kind of expert system not only detects the virus earlier but also reduces the workload of the frontline workers in the medical field to diagnose the potential patients. Earlier detection of the virus will lessen the mortality rate, patients would recover at a rapid rate since detecting the virus earlier would increase the recovery rate among the patients. This work was carried out generally to achieve the application of expert system in telemedicine for the diagnosis of corona virus in Nigeria. Specifically, to; Develop an Expert System for COVID-19 Diagnosis, Integrate the Expert System into a Telemedicine Platform using Python and Evaluate the System's Accuracy and Effectiveness

Alsharman & Jawarneh (2020) developed an expert system application telehealthcare practices in Taiwan by Min-Sheng General Hospital. The main function of the Telehealthcare Expert System (TES) developed in this research is to detect and classify events based on the measurement data transmitted to the database at the call center, including abnormality of vital signs, violation of vital sign measurement prescriptions, and malfunction of hardware devices (home gateway and vital sign meter). When the expert system detects an abnormal event, it assigns an "urgent degree" and alerts the nursing team in the call center to take action, such as phoning the patient for counseling or to urge the patient to return to the hospital for further tests. He discovered that**:** During 2 years of clinical practice, from 2009 to 2011, 19,182 patients were served by the expert system. The expert system detected 41,755 events, of which 22.9% indicated abnormality of vital signs, 75.2% indicated violation of measurement prescription, and 1.9% indicated malfunction of devices. On average, the expert system reduced by 76.5% the time that the nursing team in the call center spent in handling the events.

Israa *et al* (2019) developed an Automated Telemedicine and diagnosis system (ATDS), which is an expert system used for diagnosing many ailments such as malaria and others for prescription of drugs. ATDS is made up of knowledge database. The end user makes use of it to determine if they are suffering from one ailment or the by entering the ailment symptoms. Once the system receives the information from the user, an instant drug prescription and diagnosis is made. After series of testing with different data the performance of ATDS was optimal. He concluded that. ATDS involves the giving of health care to patients by using internet, from anywhere and anytime. There is no need for the doctor and the patient to meet. The driving purpose ATDS was to provide immediate health care services at one's comfort and convenience. ATDS reduces the big cost common to patients who visit the hospital on regular basis. ATDS diagnosed ailment and instantly provide the correct diagnosis and drugs prescription.

Kyado *et al.* (2024) developed a Covid-19 Self Diagnosis system (CSDS) to provide tools for overcoming the unequal distribution of medical laboratories/ equipment at Covid-19diagnosis centers in both rural and urban areas in Nigeria. (CSDS) is an expert system that is used forCovid19 diagnoses. The system determines if an end-user is infected with Covid-19 by accepting Covid19-symptoms from the user. The expert system successfully demonstrated self-diagnosis of COVID-19 in Nigeria, especially where access to medical professionals is limited. The rule-based system proved capable of identifying COVID-19 symptoms accurately and suggesting whether a patient should seek further medical care or not.

Ho *et al.* (2022) developed a method called the robust design-based expert system which was proposed to. The technical process of this system consists of data initialization, configuration generation, a genetic algorithm (GA) framework for feature selection, and a robust mechanism that helps the system find a configuration with the highest robustness. He said that his system will finally obtain a set of features, which can be used to predict a pandemic based on given data. The robust mechanism can increase the efficiency of the system. The configuration for training is optimized by means of a genetic algorithm (GA) and the Taguchi method. The effectiveness of the proposed system in predicting epidemic trends is examined using a real COVID-19 dataset from Japan. For this dataset, the average prediction accuracy was 60%. Additionally, 10 representative features were also selected, resulting in a selection rate of 67% with a reduction rate of 33%. The critical features for predicting the epidemic trend of COVID-19 were also obtained, including new confirmed cases, ICU patients, people vaccinated, population, population density, hospital beds per thousand, middle age, aged 70 or older, and GDP per capital. The main contribution of this paper is two-fold: Firstly, this paper has bridged the gap between the pandemic research and expert systems with robust predictive

performance. Secondly, this paper proposes a feature selection method for extracting representative variables and predicting the epidemic trend of a pandemic disease. The prediction results indicate that the system is valuable to healthcare authorities and can help governments get hold of the epidemic trend and strategize their use of healthcare resources.

Bokolo (2020) conducted a study on "Application of telemedicine and e-Health technology for clinical services in response to Corona virus 2019 pandemic" he discussed Telemedicine and eHealth as the use of information and communication technology (ICT) embedded in software programs with high speed telecommunications systems for delivery, management, and monitoring of healthcare services. Findings from this study present the significance of telemedicine and current applications adopted during the pandemic.

Montelongo *et al.* (2021) conducted the analyses of teleconsultations from a countrywide telemedicine service (Telessa'udeRS-UFRGS, TRS), that provides physician-to-physician remote support during the COVID-19 pandemic in Brazil. He performed a descriptive analysis of the tele consultation incoming calls and a text analysis from the call transcripts. His findings indicate that TRS tele consultations in Brazil experienced an exponential increment of 802 % during a period of 6 days, after the first death due to COVID-19 was reported. However, the number of tele consultations cases decreased over time, despite the number of reported COVID-19 cases continuously increasing.

In order to track patients in coronavirus (COVID-19) like pandemic, Nisar (2021) proposed a novel model based on hybrid advance technologies, which is capable to trace and track COVID-19 affected with high accuracy. The hybrid technologies include, cellular, cyber and low range wireless technologies. Which is capable to trace patients through call data record using cellular technology, voice over internet protocol calls using cyber technology and physical contact without having a call history using low range wireless technologies. The proposed model is also capable to trace COVID-19 suspects. In addition to tracking, the proposed model is capable to provide surveillance capability as well by geo tagging the patients. In case of any violation by the patients an alert is sent to the concerned department. He concluded that the proposed model is cost effective and privacy preserved as the entire process is carried out under the umbrella of a concerned government department. The potential outcomes of the proposed model are tracking of COVID-19 patients, monitoring of isolated patients, tracking of suspected ones and inform the mass about the safest path to use.

2. Research Methodology

This study adopts a design and implementation-based research methodology, incorporating both qualitative and quantitative techniques to develop and evaluate an expert system integrated with telemedicine for COVID-19 diagnosis. COVID-19 signs/symptoms were collected from the expert domain (The doctors, nurses, and researchers who are working with COVID–19 cases, this knowledge were obtained from interviews with experts, into the knowledge acquisition unit by the expert engineer. Through the development of a rule-based expert system. The system was designed to simulate the decision-making capabilities of a medical expert using predefined diagnostic rules. This knowledge obtained from interviews with experts, regarding data on symptoms were classified into two categories; common and chronic symptoms. These were changed into questions as shown in table 2, which were further converted into symptoms questions as in table 1. This knowledge from the expert domain were inculcated into the knowledge base of the expert system by the expert engineer. Then the interference engine is able to combine both symptoms to determine whether the patient is suffering from COVID-19 (Dass *et al.*, 2020). A forward-chaining reasoning mechanism was implemented to evaluate user input against the rule set and provide a likely diagnosis. Python was used for logic, HTML/CSS/JS (for web interface), or Dart (if Flutter was used).

Table 1: Common and Chronic symptoms

Common (Acute) Symptoms	Chronic (Long-term / Post-COVID Symptoms)	Possible Medical Implications
Fever or chills	Persistent fatigue	Immune system overreaction, chronic inflammation
Dry cough	Chronic cough	Lung tissue damage, post-viral airway hyperreactivity
Shortness of breath	Breathing difficulty (long-term)	Pulmonary fibrosis, reduced lung capacity
Fatigue (tiredness)	Ongoing fatigue (chronic tiredness)	Post-viral fatigue syndrome, reduced productivity
Muscle or body aches	Joint or muscle pain	Musculoskeletal inflammation, arthritis-like symptoms
Headache	Brain fog (memory/concentration issues)	Neurological impairment, reduced cognitive function
Sore throat	Sleep problems (insomnia)	Ongoing upper airway irritation, sleep disorders
Loss of taste or smell	Prolonged loss/changes in taste or smell	Olfactory nerve damage, reduced quality of

		life
Runny nose or congestion	Dizziness or fainting (orthostatic issues)	Autonomic nervous system dysfunction (POTS)
Nausea or vomiting	Chest pain or palpitations	Cardiovascular strain, myocarditis risk

2.1 Designing the knowledge base

The Knowledge Base was built using the IF-THEN rule**s** by collecting expert knowledge from interviews with experts, into the knowledge acquisition unit by the expert engineer. Through the development of a rule-based expert system structuring it as facts and rules, and implementing it with a rule engine .as in table 2.

Table 2: Facts (Symptoms & Attributes)

Symptom	**Attribute/Range**	**Description**
Fever	Temperature ≥ 38°C	Common sign of viral
Cough	Dry/persistent	Key COVID-19 symptom
Shortness of breath	Mild / Severe	Indicator of lung involvement
Fatigue	Mild / Severe	General viral symptom
Loss of taste/smell	Present / Absent	Strong predictor of COVID-19
Headache	Mild / Severe	Non-specific but relevant
Sore throat	Present / Absent	May overlap with flu
Diarrhea	Present / Absent	Gastrointestinal manifestation
Chest pain	Mild / Severe	May indicate complications
Duration of symptoms	Days (≤14)	Helps in temporal diagnosis

Tab 3.3. Rules (IF–THEN)

Rule ID	IF Condition (Symptoms)	THEN Conclusion
R1	IF fever AND cough AND loss of smell	THEN High likelihood of COVID-19
R2	IF fever AND sore throat AND runny nose	THEN Likely flu, not COVID-19
R3	IF shortness of breath AND chest pain	THEN Severe COVID-19 – urgent referral
R4	IF fatigue AND headache AND diarrhea	THEN Possible COVID-19 (moderate)
R5	IF no fever AND only runny nose	THEN Common cold – low COVID-19 likelihood
R6	IF fever AND cough AND comorbidity (e.g., diabetes, hypertension)	THEN High-risk COVID-19 patient
R7	IF fever persists > 14 days	THEN Recommend further investigation (long COVID)

2.3 Building the Inference Engine of the system

The Inference Engine was built by the reasoning mechanism of the expert system. It applies rules in the Knowledge base (KB) inputted facts to derive conclusions. This system uses Forward Chaining (data-driven reasoning) because it begins with patient-reported symptoms and applies rules until a diagnosis is reached. the Inference Engine was built by;

(i) Collecting symptoms (facts) from the patient.
(ii) Match facts against rules in the Knowledge Base.
(iii) Apply THEN conclusions
(iv) Add new conclusions into working memory.
(v) Repeat until no more rules apply or a final diagnosis is reached.

2.4 Expert System Components Interaction Framework

The expert system components interaction Framework is built from the typical components of an expert system as shown in figure 1. According to framework, the COVID-19 Self Diagnoses expert system consists of different components. A knowledge base, an inference engine and a user interface. The signs and symptoms of COVID-19 are gathered from different sources, these symptoms were then pre-processed and arranged into tables at the acquisition unit and sent into the knowledge base. The inference engine analyzes the rules and knowledge accumulated in the knowledge base and provides a logical conclusion. The inference engine reasons about the COVID-19 symptoms in the knowledge base. The engine selects a rule for testing and examines whether the condition(s) of this rule are valid or not. The user interface is a program that controls the interaction between the user and the expert system. The working of these components makeup an expert system from which the users are able to interact with the system effectively.

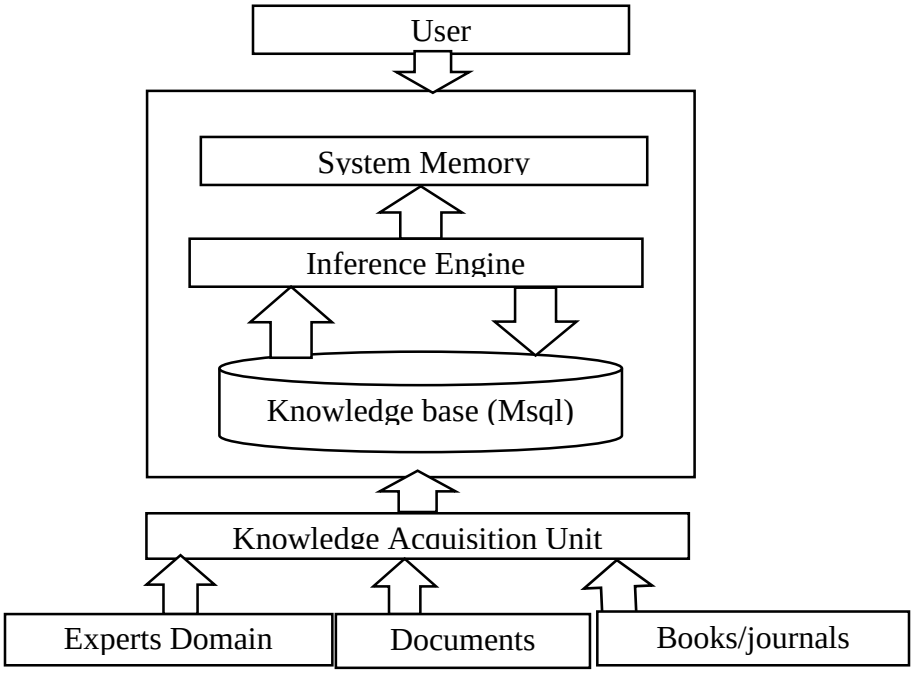

Figure 1: Expert System Components Interaction Framework

2.4.1 Knowledge acquisition Unit

This is a unit where knowledge from the experts are collected and organized into the knowledge base of the COVID-19 Self Diagnoses as shown in figure 2.

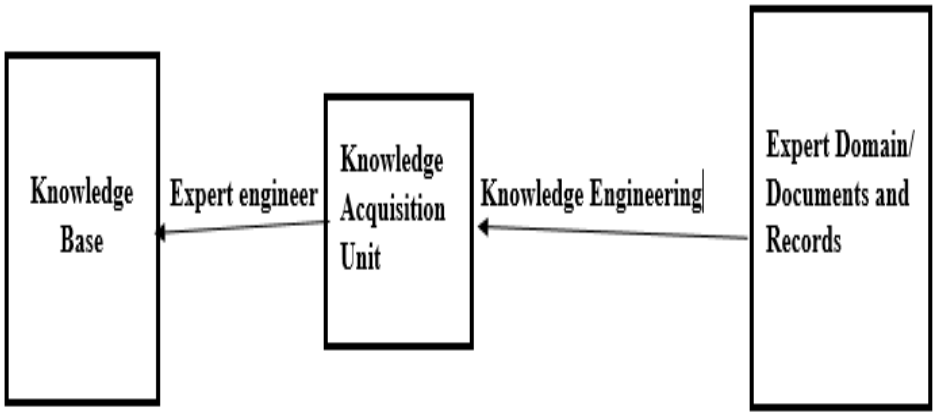

Figure 2: Knowledge Acquisition Unit

2.5 System Development Tools

Java Programming language was used for the Interface design, MySQL was used as the knowledge base to store the signs and symptoms of COVID-19, while glassfish4 was used as the server

3. Result and Discussion

3.1 COVID-19 Self Diagnosis Admin Login Page

This chapter displays the views of the Knowledge Acquisition Interfaces and Patients COVID-19 self-diagnoses interfaces. The knowledge engineer log into the system for information update as shown in figure 3.

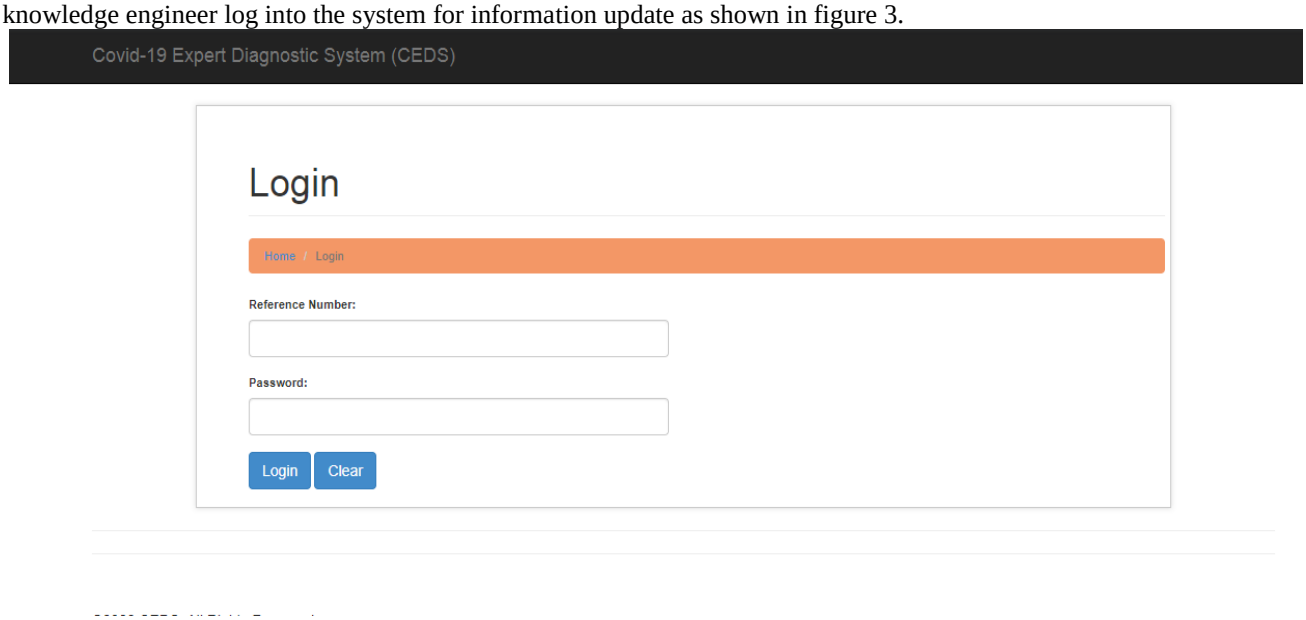

Figure 3: COVID-19 Self Diagnosis Admin Login Page

3.1.1 Domain Disease Interface and Views

The signs and symptoms of COVID-19 were collected into the COVID-19 Self- Diagnosis system knowledge base. The engineer populates the knowledge base with the COVID-19 facts (signs and symptoms of COVID-19 through the acquisition interface, as shown in fig. from the facts, the inference engine reasons about the COVID-19 symptoms in the knowledge base and make decisions.

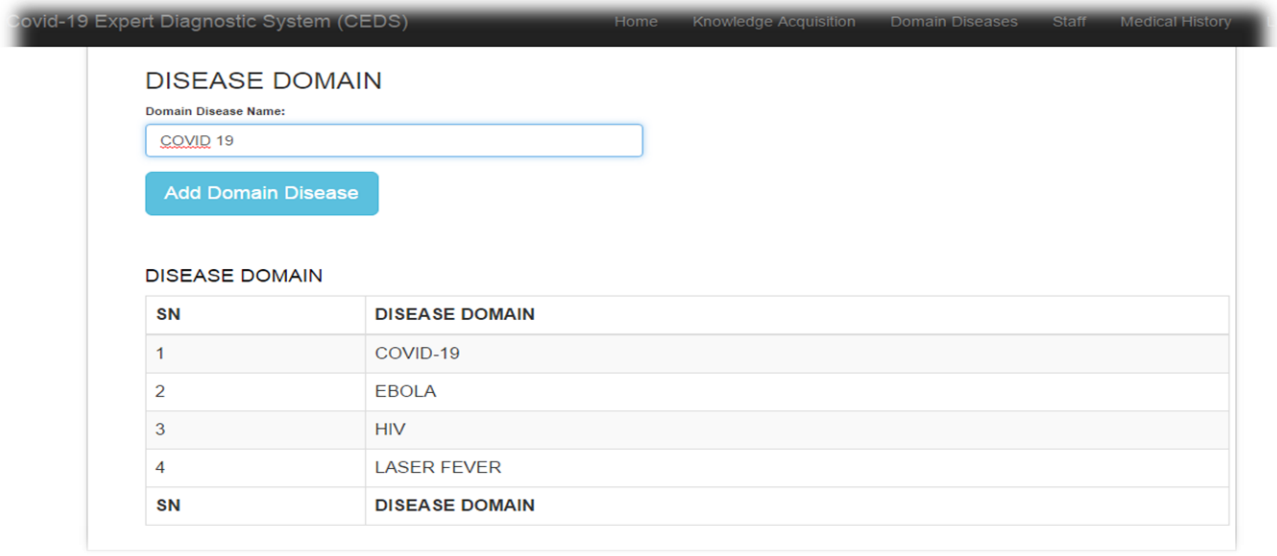

Figure 4: Domain Disease Interface and View

3.1.2 *Signs/Symptoms acquisition interface and view*

The knowledge COVID-19 Signs/Symptoms Questions) acquired from the expert domain are built into the knowledge base through figure 5. The questions are sent into the knowledge base using the acquisition interface.

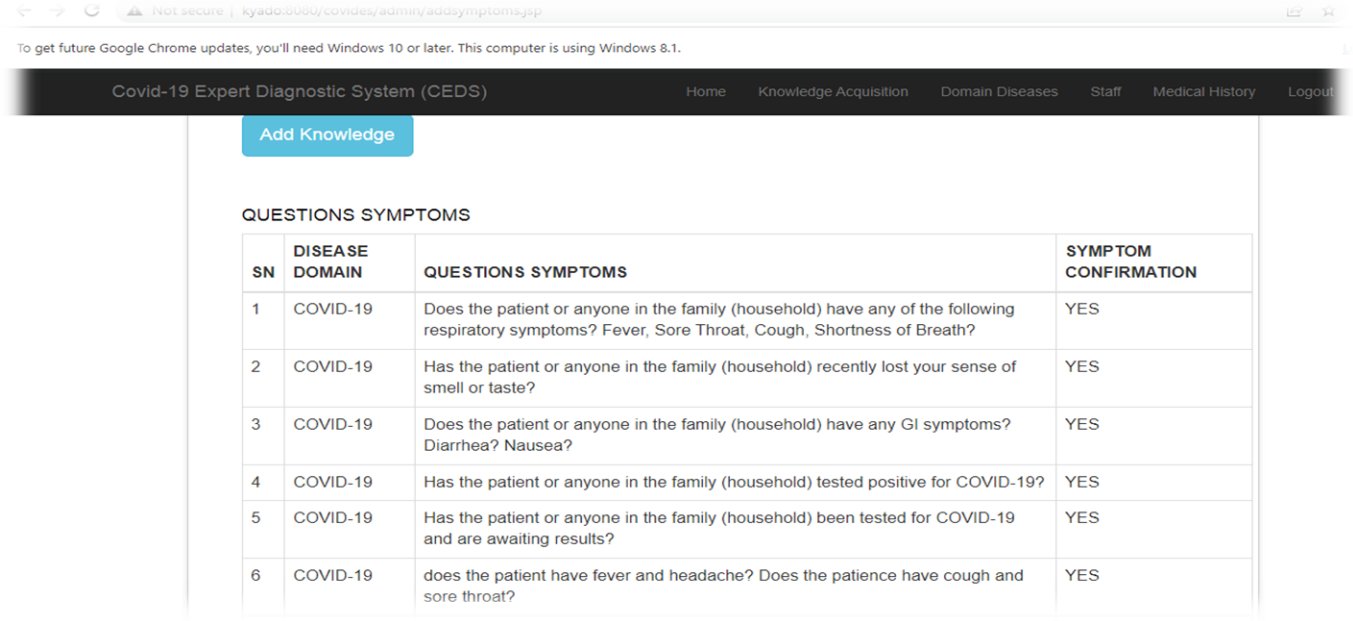

Figure 5: Signs/Symptoms Acquisition Interface

3.2 Patient's Personal Information View

The patient supplies his/her personal data and COVID-19 symptoms as shown in figure 6 below shows both the views of the added symptoms and the domain diseases

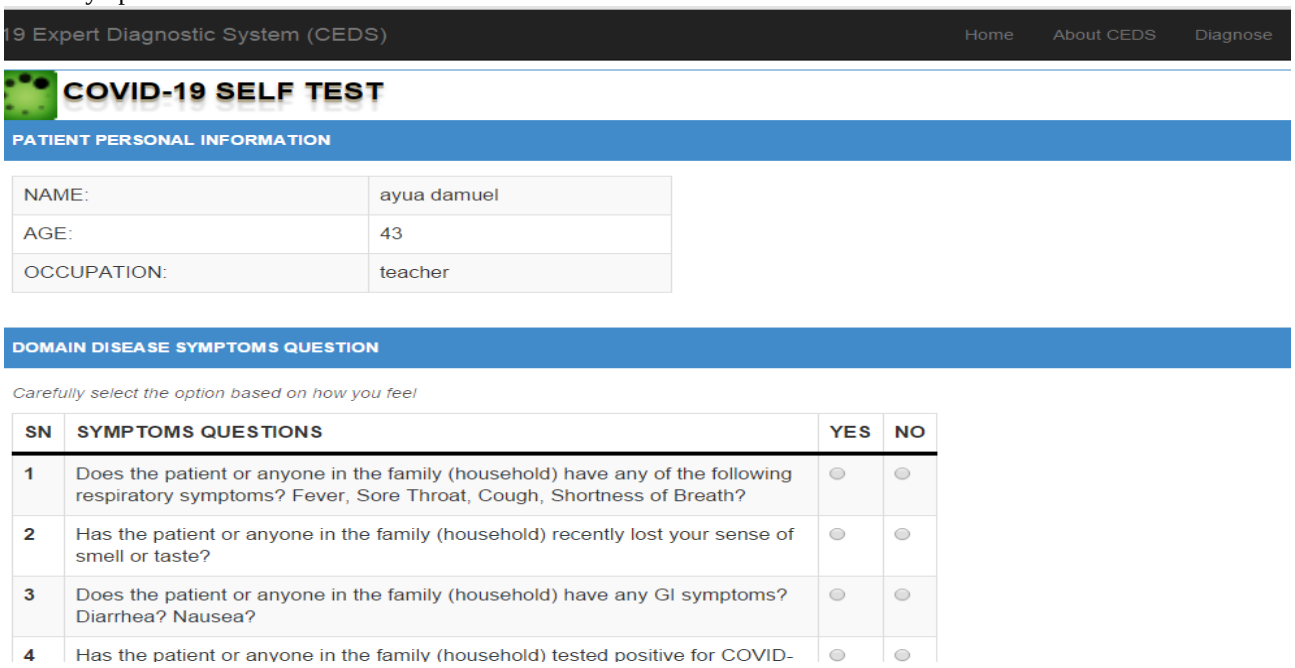

Figure 6: Symptoms Questions View

3.3 COVID-19 Self Diagnosis

After inculcating the signs/symptoms into the system by the system, the patient's proceeds for COVID-19 self-test using the system. The inferential engine is able to deduce base on the rule whether a patients Medley, Highly or the patient is not infected

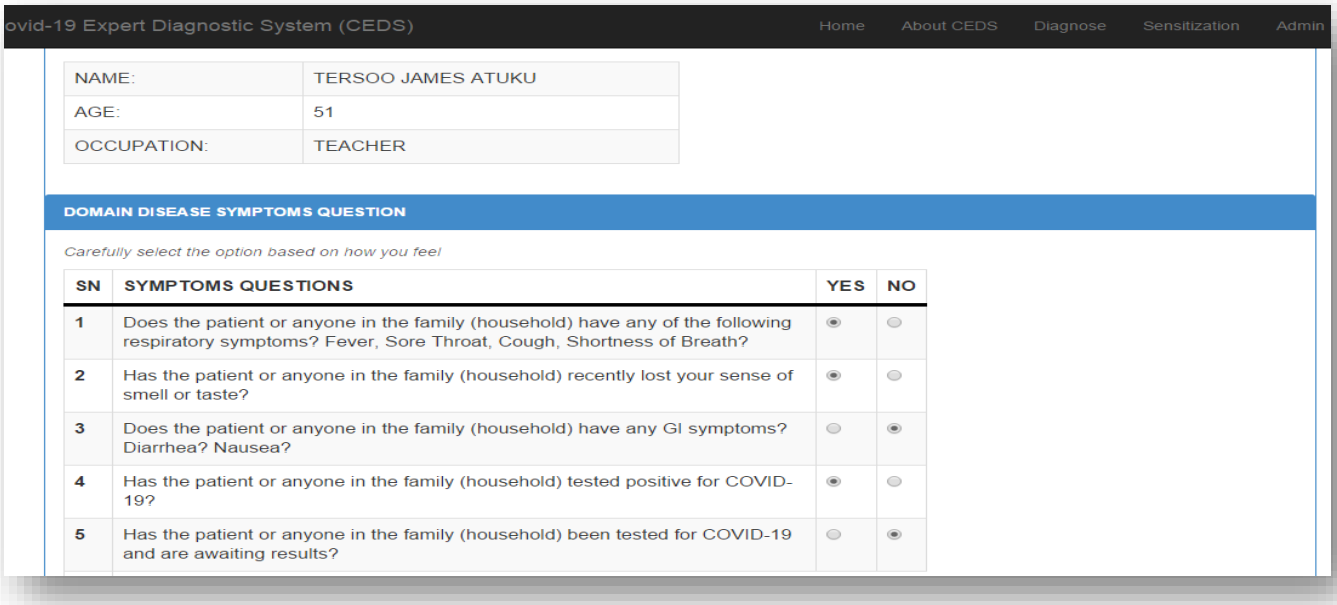

Figure 7: Patients Diagnosis Page

3.3.1 Covid 19 Result Page

After the patients have answered the question supplied by the system based on the COVID-19 signs/symptoms experienced, the system determines the Corona Virus Status of the patients and the level of infection as the case may be.

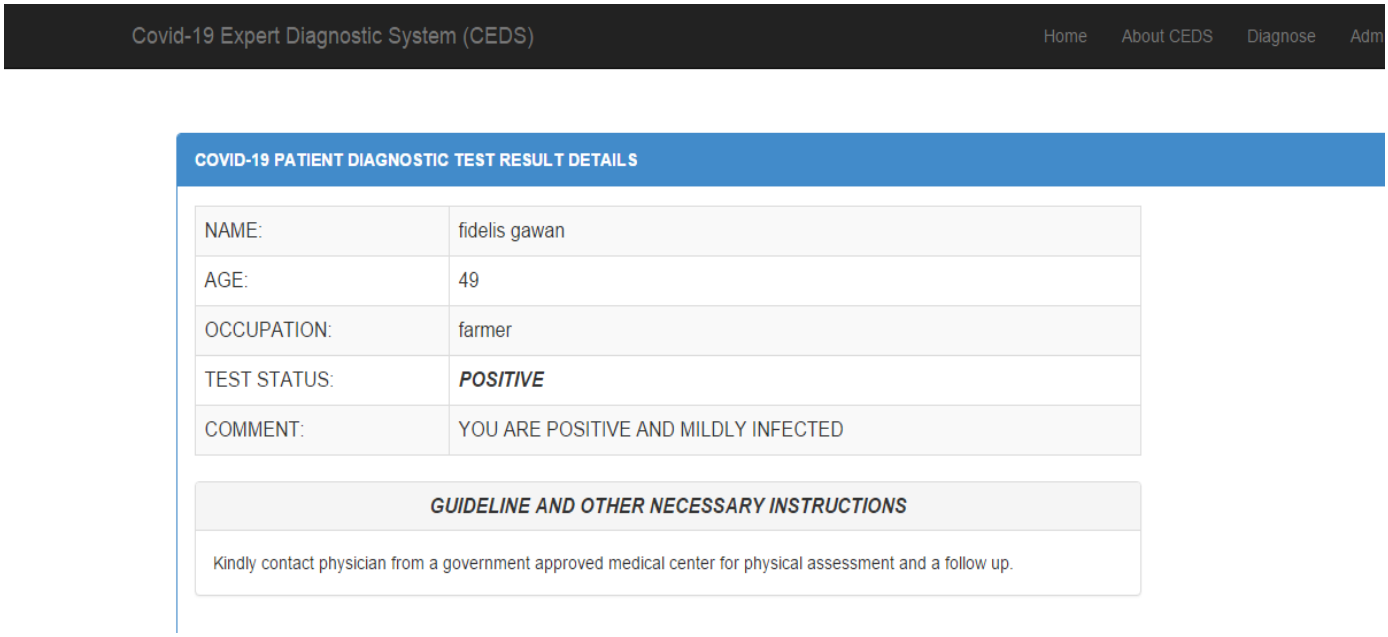

Figure 8: Patient's COVID-19 Result Page

3.4 COVID-19 Patients Result Advice Page

The patient receives advice base on the result and the level of infection as shown in figure 9.

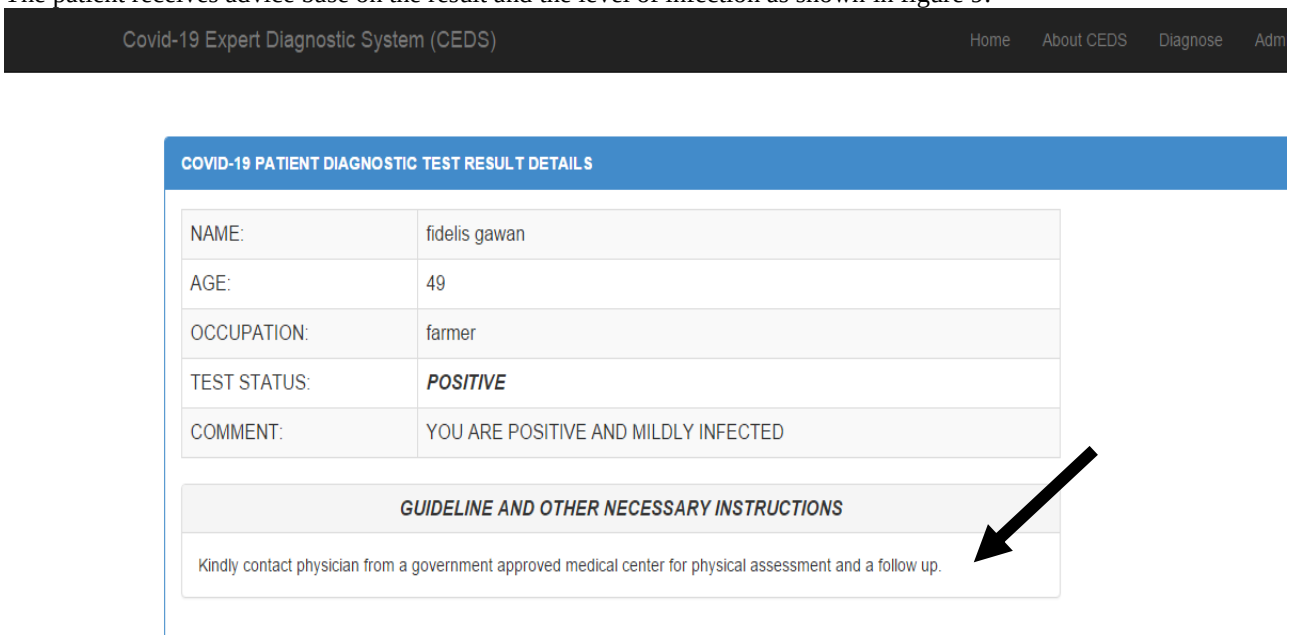

Figure 9: COVID-19 Result Counselling Page:

If the result is positive the patient is advice to kindly contact a specialist physician from the nearest government approved COVID-19 Isolation center for further investigation and treatment as the case may be.

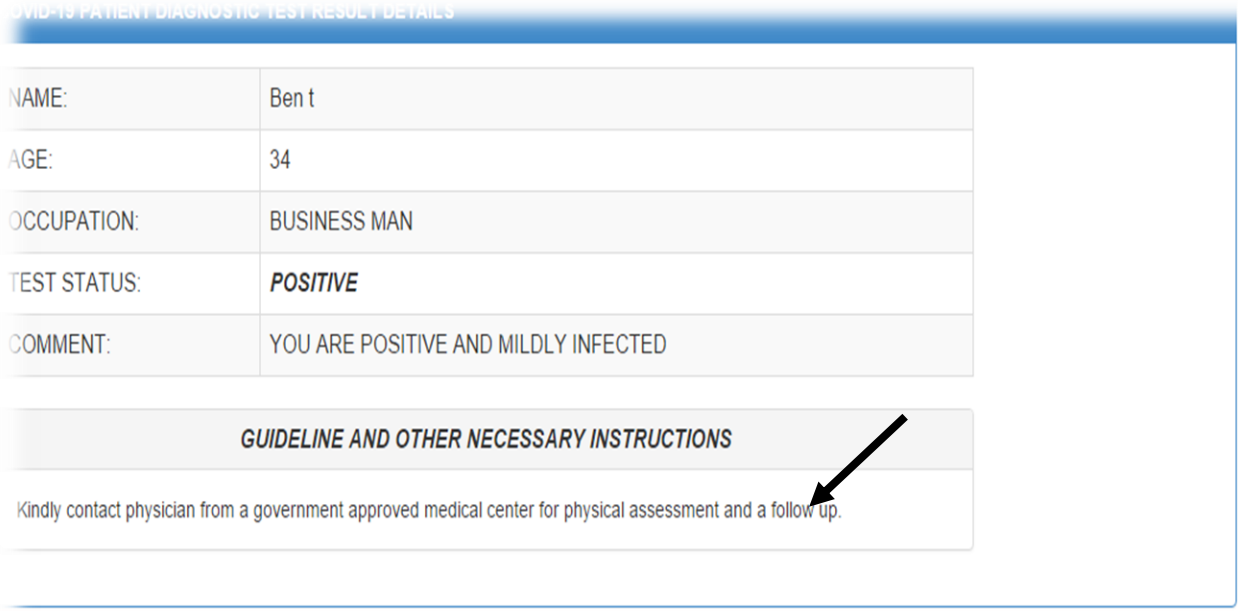

Figure 10: Patients Positive Result Counselling Page

The system was subjected to simulated testing, using data and symptom sets derived from real-world COVID-19 cases as identified by domain experts. Through this, we assessed how effectively the expert system could classify symptomatic inputs and provide a diagnosis suggestion. The rule-based inference engine accurately assessed user-provided symptom combinations. For instance, when a user selected "fever," "cough," and "loss of smell," the system confidently returned a likely COVID-19 diagnosis. This was in alignment with the clinical heuristics encoded in the knowledge base. The expert rules (e.g., IF fever AND cough AND loss_of_smell THEN suspect COVID-19 were verified through expert validation, ensuring consistency with WHO and NCDC protocols.

Feedback from test users indicated that the diagnosis process was fast (less than 1 minute on average), and users appreciated the clear, simple language of the questions. The layout of the interface, including drop-downs for gender, and yes/no checkboxes for symptom history and travel exposure, allowed seamless navigation.

From a public health perspective, the system has substantial utility. It offers a first layer of defence by enabling individuals to self-screen at home. This contributes to decongesting hospitals, as only high-risk or symptomatic individuals would need physical testing or hospitalization. By flagging probable COVID-19 cases early, it promotes quicker isolation and intervention, thereby helping in transmission control.

In regions like rural Nigeria, where physician density is low and testing capacity limited, this system acts as a scalable triage mechanism. Community health workers could deploy the tool on tablets or mobile phones during outreach programs, effectively extending the diagnostic reach of the healthcare system. The rule-based engine allows for easy addition or modification of rules should symptoms evolve or should other diseases be incorporated. For example, co-circulating diseases like malaria and flu were already partially modeled, and the system could differentiate based on symptom overlaps (e.g., absence of cough or presence of vomiting might indicate malaria).

4. Recommendation for Future work

It can be integrated with electronic medical records (EMRs), national health surveillance systems, or expanded to include other disease models. For future versions, data analytics features can be embedded to help track the frequency of symptom reports by location, thereby contributing to real-time disease surveillance. Misreporting or misunderstanding questions could lead to incorrect diagnosis suggestions. Additionally, it lacks adaptive learning—once the rule set is defined, it doesn't evolve unless manually updated.

There is also the challenge of differentiating COVID-19 from other illnesses with similar symptoms in cases of co-infection. For now, the system handles this with simple exclusion rules, but future integration with probabilistic or Deep Learning models could improve diagnostic specificity.

5. Conclusion

This study highlights the critical role of artificial intelligence, particularly expert systems, in enhancing healthcare delivery during public health crises such as the COVID-19 pandemic. By integrating a rule-based diagnostic system within a telemedicine framework, the solution provides a scalable, accessible, and cost-effective tool for early detection and management of coronavirus cases in Nigeria. It addresses key challenges such as limited access to medical personnel, geographic barriers, and the risk of virus transmission during in-person consultations. The system not only empowers individuals with preliminary diagnostic capabilities but also supports healthcare workers by reducing the burden of routine assessments. As Nigeria continues to strengthen its health infrastructure, especially in remote and underserved communities, this innovation represents a meaningful step toward digital, intelligent, and inclusive healthcare. Future work may focus on integrating machine learning for adaptive diagnostics and expanding the system to cover other infectious diseases, further contributing to national and global health resilience. The system was able to correctly identify and classify user-reported symptoms (e.g., fever, cough, loss of taste/smell, breathing difficulty) based on predefined diagnostic rules.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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