NIPES

Journal of Science and Technology Research

Journal homepage: www.nipesjournals.org.ng

Design and Implementation of Intelligent System for Detection and Analysis of Ebola Disease

[1]Adekunle M. Ibrahim, [2]Selimot Adekanye
Department of ICT, Osun State University, Nigeria
Corresponding Authors Email: [1]kunle_ibrahim2001@yahoo.com,[2]fempeg2013@gmail.com

Article Info

Received 27 April 2021
Revised 8 May 2021
Accepted 22 May 2021
Available online 04 June 2021

***Keywords*:**
Ebola Virus; Expert System; Machine learning; Intelligent system and Disease detection

https://doi.org/10.37933/nipes/3.2.2021.20

https://nipesjournals.org.ng

Abstract

Ebola virus disease is a hemorrhagic fever that has a near 100% fatality rate if not detected on time and properly managed. Between December 2013 and September 6, 2015, Africa and few other countries such as Italy and Spain witnessed the worst outbreak of the disease with 28,183 confirmed cases out of which 11,306 died. In an untiring effort to eradicate this pandemic, scientists have sought different measures for treating and caring for infected persons while also preventing further transmission of the disease. Hitherto, there still exist cases of transmission among humans especially patient-to-health care provider transmission. This project addresses the problem using visual programming language for diagnosing the disease. Requirement gathering exercise and specification was done through interviews with health care providers, site visit to Ebola treatment center and review of literature and Ebola registries. Expert system concepts with Visual Basic programming language were adopted in the development of the system. Reliable inferences were made regardless of the Ebola case scenario that was used in the testing of the expert system. The system showed that reduction in person-to-person transmission of Ebola virus disease can be achieved if probable suspects are identified and diagnosed on time using computer applications that eliminates physical contact with suspects or infected materials and fluids. For confirmed suspects, the system recommends laboratory test as a final proof of the infection. Using an interactive diagnosis expert system for detecting Ebola cases is a fast and safer avenue through which Ebola transmissions; especially human-to-human transmissions could be reduced.

1. Introduction

Ebola virus disease is a rare, infectious and generally deadly viral illness caused by a single stranded, negative-sense RNA virus of the species Zaire ebola virus, which is a type of species for the genus Ebola virus, family Filoviridae, order Mononegavirales with records of high mortality in humans and other primates [1-3]. The disease is often sporadic and visibly marked by hemorrhagic fever and severe internal bleeding. Ebola is introduced into human population through close contact with body fluids of infected animals such as chimpanzees, monkeys, etc. Ebola then spreads through human-to-human transmission by direct contact (through broken skin or mucus membrane) with bodily fluids of infected people and with surfaces and materials (e.g. bedding, clothing) contaminated with these fluids.

The early symptoms of Ebola known as the 'dry phase' is characterized by sudden and intermittent fever, vomiting, general weakness, severe pains especially on muscles and joints, headache, and sore throat [4,5]. Sadly, these early symptoms are intermittent resulting in delay of detection and isolation. Victims and relatives often mistake the signs for cold, malaria and other common ailments already known; hence the increased number of transmissions. The immediate and advanced stage of the virus is marked by more severe bleeding from the nose, gums and skin, bloody vomiting and stools, skin rash and difficulty swallowing [6]. The outbreak of Ebola Virus Disease (EVD) in West Africa is the worst epidemic that has befallen African countries in the past decade [3]. Many families have been completely wiped out as a result of Ebola deaths while few others have suffered major loss of household members including bread winners. Children are rendered orphans while happy parents are now childless. Between December 2013 and September 6, 2015, Ebola deaths stand at 11,306 out of 28,183 reported cases in 10 countries (Guinea, Liberia, Sierra Leone, Italy, Mali, Nigeria, Senegal, Spain, United Kingdom and United States of America) with Liberia and Sierra Leone having the highest number of reported cases and deaths [7-9]. In an untiring effort to combat this deadly virus, medical professionals have struggled to devise means of fighting the epidemic. In the process, so many have lost their lives.

It is noted that health-care workers are at risk of infection when caring for EVD patients, if they do not wear adequate personal protection equipment (PPE) and if they do not follow strictly, the recommended measures for infection prevention and control. Other risks for workers involved in health care and epidemic response to EVD include psychological distress, stigma, violence, long working hours, heat stress, and dehydration from using heavy personal protection equipment (PPE) and ergonomic problems from handling bodies and loads. These require specific measures for psychosocial support, security and work organization [9]. [10] observed that health workers are at the highest risk of being infected with Ebola virus disease even with their protective clothing because they are most certainly the primary contacts to infected patients. This also puts the family members and close associates of health workers at great risk of infection. In addition to the high fatality rate of Ebola virus, some other ailments present similar symptoms, coupled with fear of stigma and social rejection that come to patients and families when a diagnosis of Ebola is confirmed. There is urgent need for effective, accurate and fast diagnosis procedures. This will facilitate early management and quarantine process of infected patients. There is currently no proven treatment for EVD, the only available treatment currently focuses on supportive-care, such as addressing the symptoms to improve the patient's chance of survival [11]. [12] developed an auxiliary diagnosis system that analyzed polysomnographic (PSG) data and provided a medical doctor with diagnosis consistent with the PSG data. The system featured a knowledge-based built with CLIPS (C Language Integrated Production System) and provided the functionality of updating the rules in the knowledge-base after the system has been deployed. The system is heavily platform dependent and this can limit its usability, since it was built for only Windows operating system. [5] showcased that part of measures that must be put in place by scientists in order to overcome this epidemic is the use of different diagnosis and treatment methods for the disease. Most of the approaches are based on medical laboratory tests and other public health practices; this however does not show reduction in the risk of exposure and transmission. In the light of this, we propose to develop an expert system (a question-and-answer based interactive system) that is capable of giving a timely and reliable diagnosis of the virus. The system must be capable of identifying probable Ebola cases among people who have direct or indirect contacts (exposures) to Ebola victims or infected objects. These include tracking the history of individuals to and from countries with Ebola outbreaks and epidemics and possibly if there is any exposure to Ebola patients, personal contacts, standard of hygiene and hand washing practices. An effective expert system that will leverage the burden and risk of detecting Ebola Virus disease suspects and infected persons is a goal this paper describes.

2. Methodology

The design of this Ebola diagnostic Expert System (ES) began with consultations and interviews with public health and research experts at the LAUTECH Teaching Hospital, Osogbo and OAU teaching hospital Ile-Ife in Osun State. From these exercises, the information gathered from relevant literatures has served as the source for the design and implementation of different techniques in this research. Visual Basic 6.0 was chosen as the programming language for the development of this expert system. The reason for choosing this programming language was based on the submission of [12] that Visual Basic is a rapid application development tool that allows programmers to create simple GUI applications for solving complex problems. The dataset obtained is unstructured and contains some information that are not necessary for this work such as name, patient ID, address, email etc. The inclusion of these columns can introduce error into our computational model with some irrelevant information. Hence, there is need for preprocessing, a situation where the data could be divided into useful columns such as clinical history columns that contain all the symptoms to be used in this work.

Figure 1 shows the diagrammatic representation of the steps involve in the development of an intelligent system to diagnose Ebola patients. This section presents the data and its analysis, it also presents the performance metric for the selection of accurate, precise and sensitive model that best predict tendency of the disease. The proposed system consists of three main sections. These sections are; the Knowledge base, The Reasoning, or Inference Engine and The User Interface. The knowledge base represents an expert system that contains the domain knowledge, which is usually provided by human experts and translated into rules and strategies. In this study, the design of the knowledge base is in form of rule-based, heuristics or probabilities. In a rule-based expert system, the knowledge is represented as a set of rules where each rule specifies a relation, recommendation, directive, strategy or heuristic. IF *condition* THEN *action* has been structurally used in this study. The next stage in this development is inference engine, this is the brain of expert system because it determines which rule antecedents are satisfied by facts. In order to give valid analysis and inference for a problem in this study, the Inference engine begins by asking the user questions, applying the questions to facts and relationships in the knowledge base and then draws suggestions, predictions and answers. The last stage establishes communication between the users and the expert system.

The dataset used in this research comprises of records of patients with Ebola virus; the general representation of the data possesses similar structure in the form of a table with every column representing patient data and row corresponds to each patient. The description of the dataset involves many symptoms that can be found in Ebola patient. Larger percentage of the datasets was used for training the model while the developed model was tested by making prediction against the test set. Additionally, the use case diagram for the development of intelligent system for Ebola disease detection is presented in Figure 2.

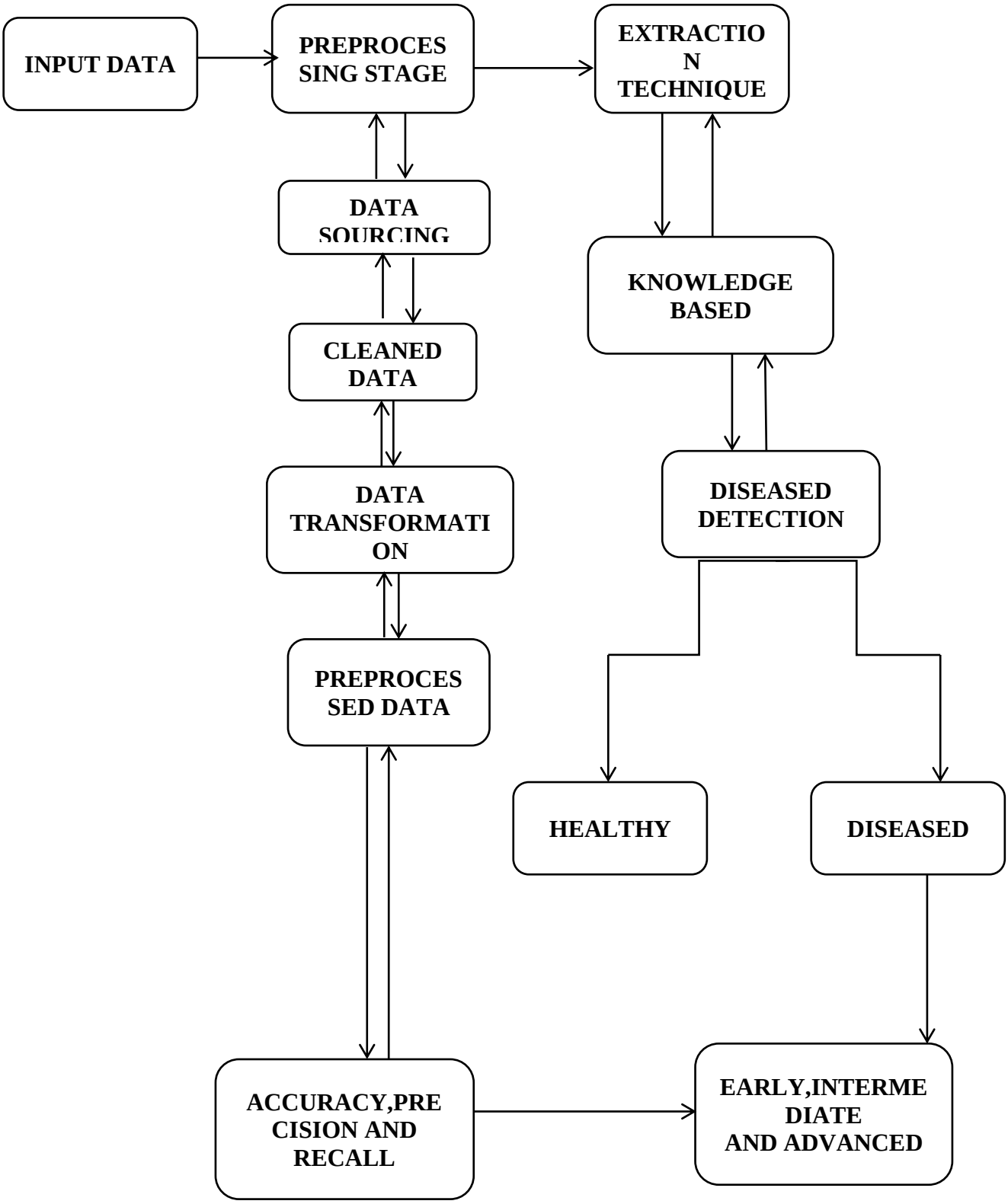

Figure 1: Architecture diagram on how to detect Ebola virus Disease

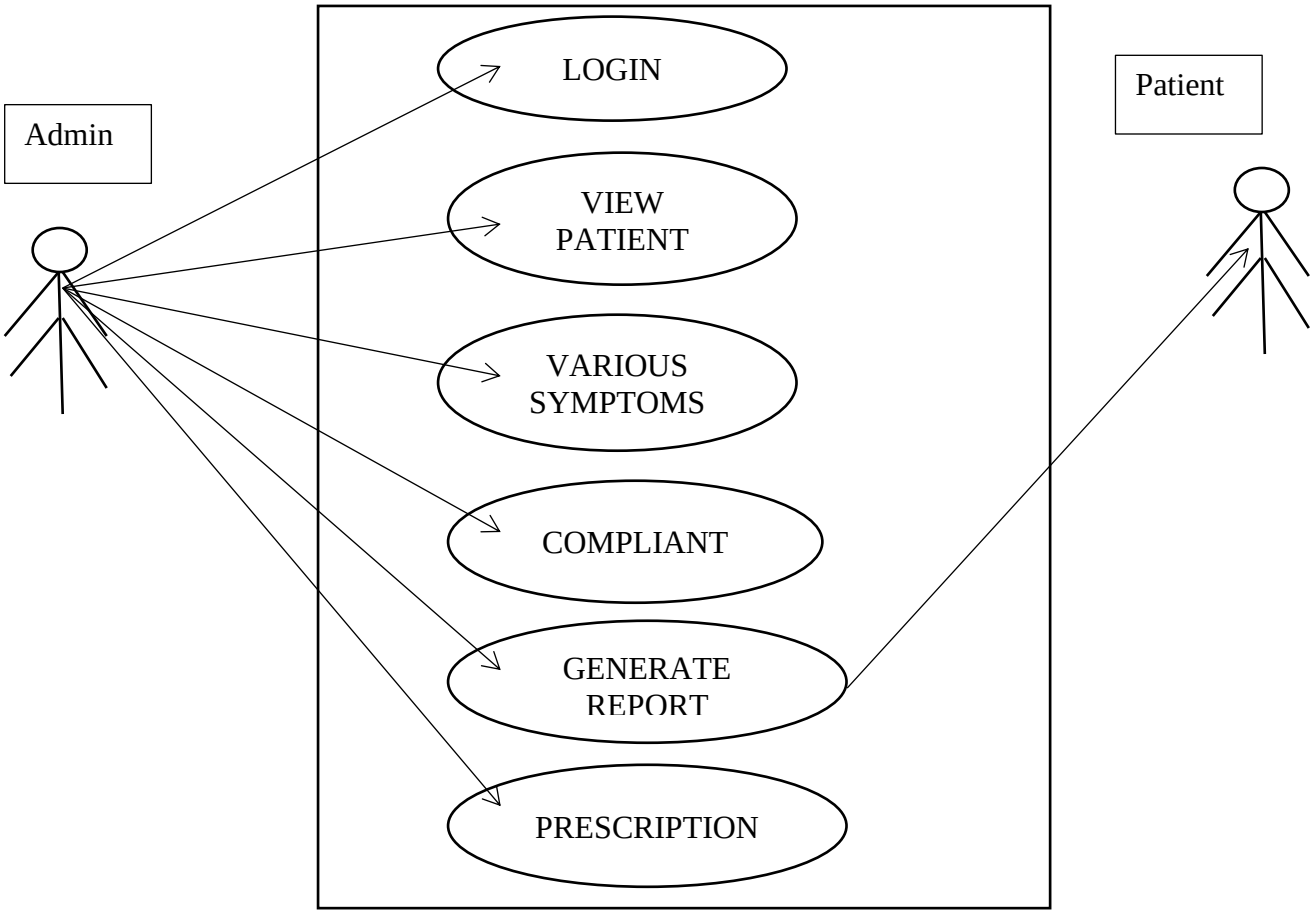

Figure 2: Use case for an expert system to diagnose an Ebola patient

Figure 2 represents a list of actions or event step to typically define the interactions between a role (known as the unified modeling language (UML) as an actor) and a system to achieve a goal. The actor can be a human or external system with the following features:

1. Administrator: he/she serves as an intermediary between the system and the patient.
2. **Patient Data**: The most important feature in the development of the system is patient data; it is the symptoms shown by each patient that will enter into the system for processing and classification.
3. Prognosis: Prediction is made using the inputted patient data to decide which of the disease the patient is carrying.
4. Result: This is the output data of the system, which can be prescribed by the doctor to the patients.
5. Primary Health care: This is a place where the infected persons are being treated

3. Results and Discussion

A user friendly interface with robust features for accurate detection and classification has been developed through this process (Figure 3). In this system, the entities include; User ID and Password, once the correct User ID and password are input, a message box will be displayed requesting to know the status of the patient either new or old. For new patient, a new bio data form will prompt on the window in which the new patient has to supply all the necessary bio-data information needed. Such information includes; Name, Age, Address, Marital Status, Gender, etc.

Also, for old patient which has been using the expert system before, the existing bio data form of the patient will prompt on the window. The USER ID form that represents an intelligent system to diagnose Ebola virus (Figure 3) and Patient Status message box in Figure 4 are presented below.

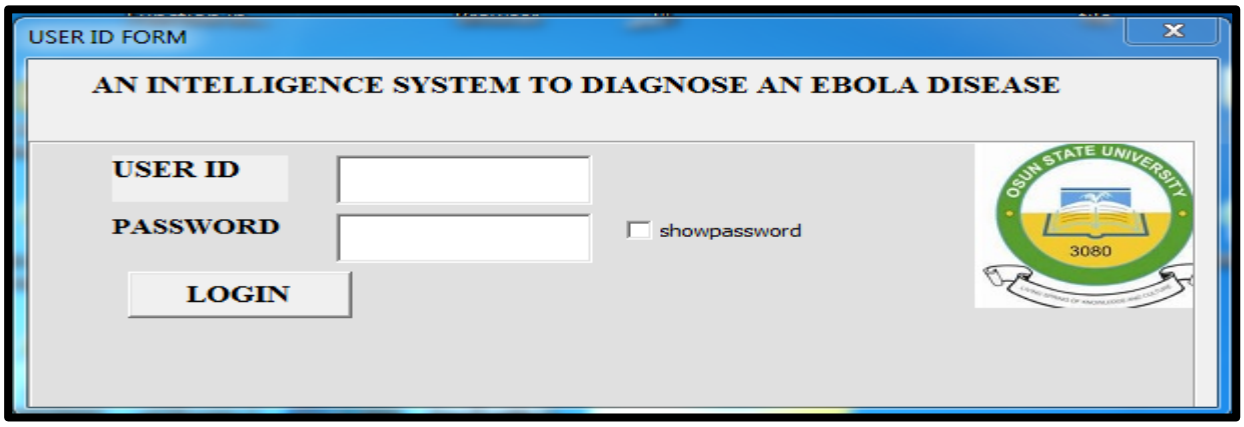

Figure 3: Intelligent system for detecting Ebola patient

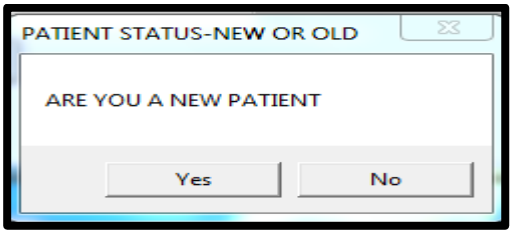

Figure 4: Patient' Status Message Box

The input requirements here are the various data fields to be captured from the patient. The data collection interface is user friendly and can capture the patient's bio data as well as other information needed. The investigation interface captures the patient's responses to symptoms. This study classified symptoms of Ebola Virus Disease (EVD) into three: the early symptoms, the intermediate symptoms and the advanced systems. A probable suspect is said to show early symptoms of Ebola if his/her response is "Yes" (which could be Mild or Severe) to any of the following signs of illness. Example of a patient whose responses are "yes" to all the early symptoms is shown in Figure 5.

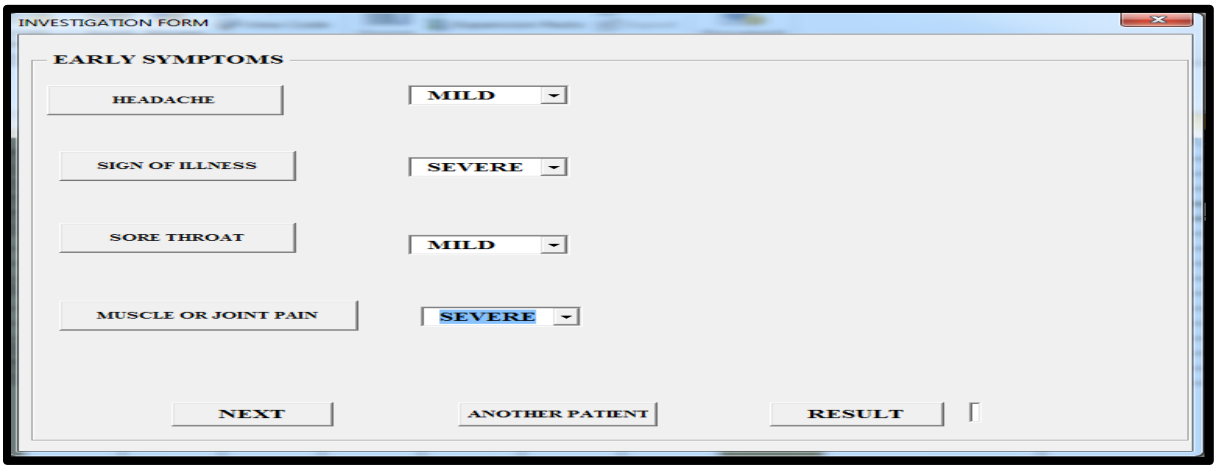

Figure 5: Demonstration of Early symptoms for patient with Ebola virus

But a probable suspect is said to show no early symptoms of Ebola if it is ”No” that is “Nil” to all of the symptoms, that is headache is selected to be “Nil”, sign of illness is selected to be “Nil”, sore throat is selected to be “Nil” and the muscle or joint pain is also selected to be “Nil”. Example of a patient whose responses are “Nil” to all the early symptoms is shown in Figure 6:

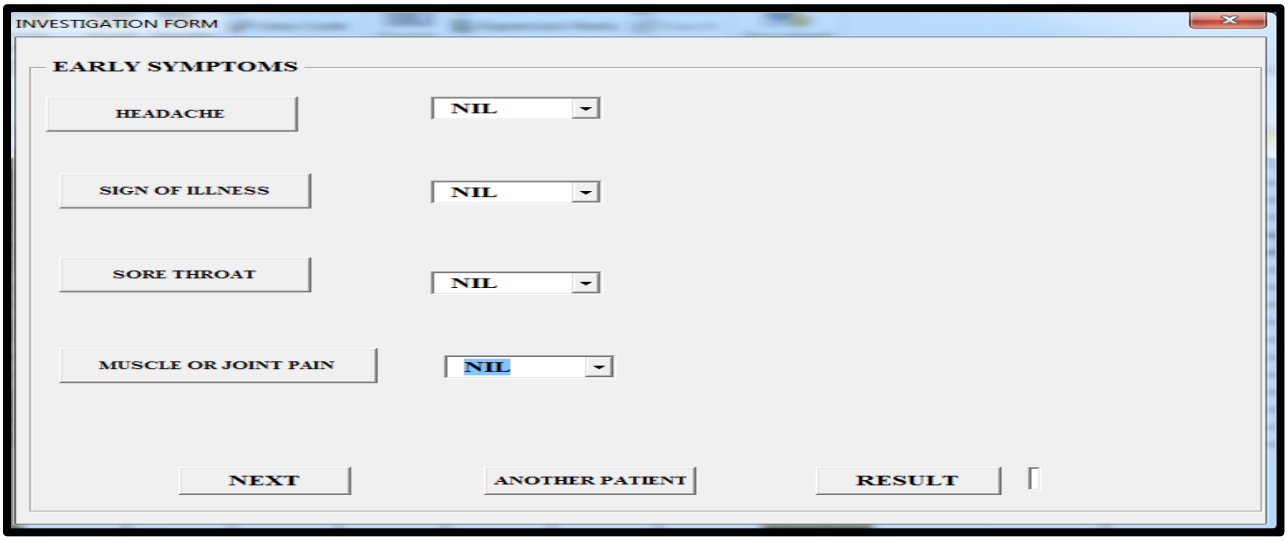

Figure 6: Example of Patients with no early symptoms

However, a probable suspect is said to show no Advanced symptoms of Ebola if it is ”No” that is “Nil” to all of the symptoms, that is Fever is selected to be “Nil”, Stomach pain is selected to be “Nil”, and Lack of appetite is selected to be “Nil”. A probable suspect is said to show an advanced symptoms of Ebola if it is ”Yes” that is “Mild or Severe” to any of the symptoms, Example of a patient whose responses are “Yes” to all the Advanced symptoms is shown in Figure 7.

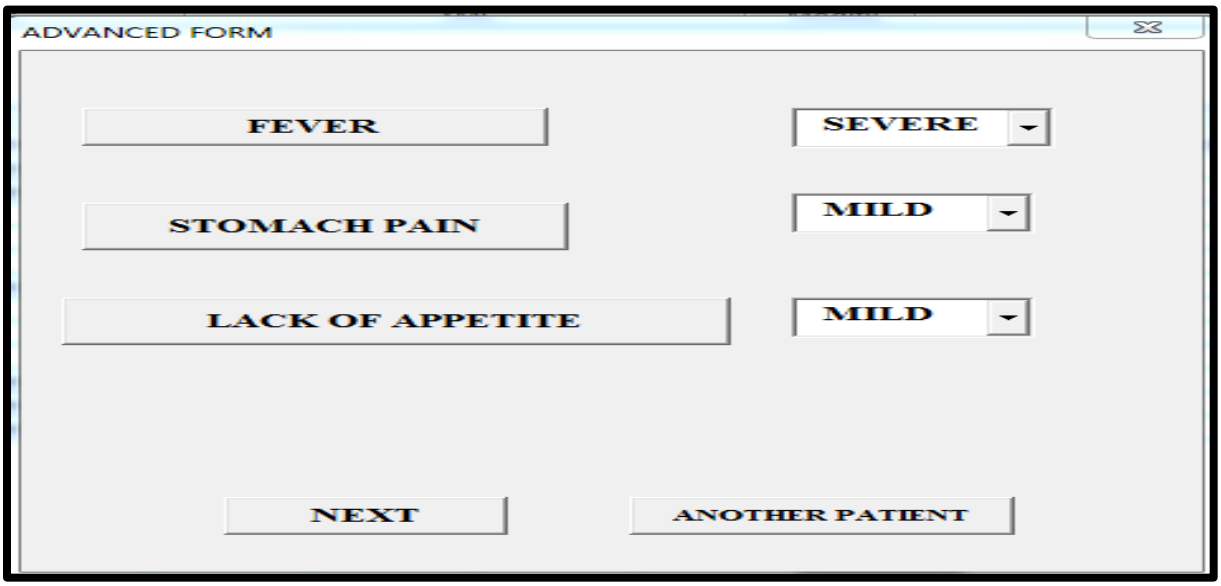

Figure 7: Patient with ALL advanced symptoms of Ebola virus

A probable suspect is due for a contact test if all the aforementioned (Early, Intermediate, and Advance symptoms) are positive. The contact test would then be conducted to know if such a patient visited any of the towns where Ebola Virus has been detected and probably made any direct or

indirect physical contacts with Ebola Patient. Figure 8 shows example of a patient whose response is yes to visitation to "any of the town where there is Ebola Outbreak in the past 21 days" but could not confirm having direct or indirect physical contact with Ebola patient.

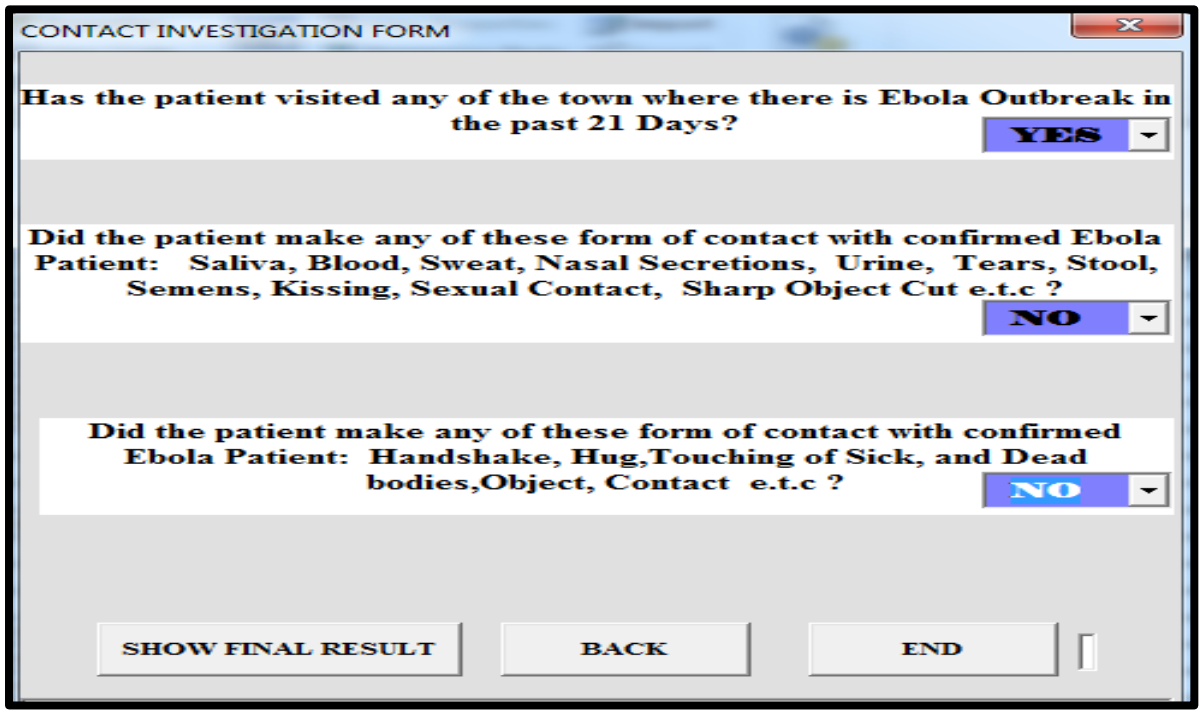

Figure 8: Contact Investigation: Case Visitation But No Direct or Indirect Contact

A probable suspect is said to show a contact symptoms of Ebola, if the patient makes no visitation to any infected town but one way or the order had contact, directly or indirectly with any confirmed Ebola patient. Example of a patient whose responses is "No" to visitation to "any of the town where there is Ebola Outbreak in the past 21 days" but had either direct or indirect physical contact with Ebola patient can be seen in Figure 9.

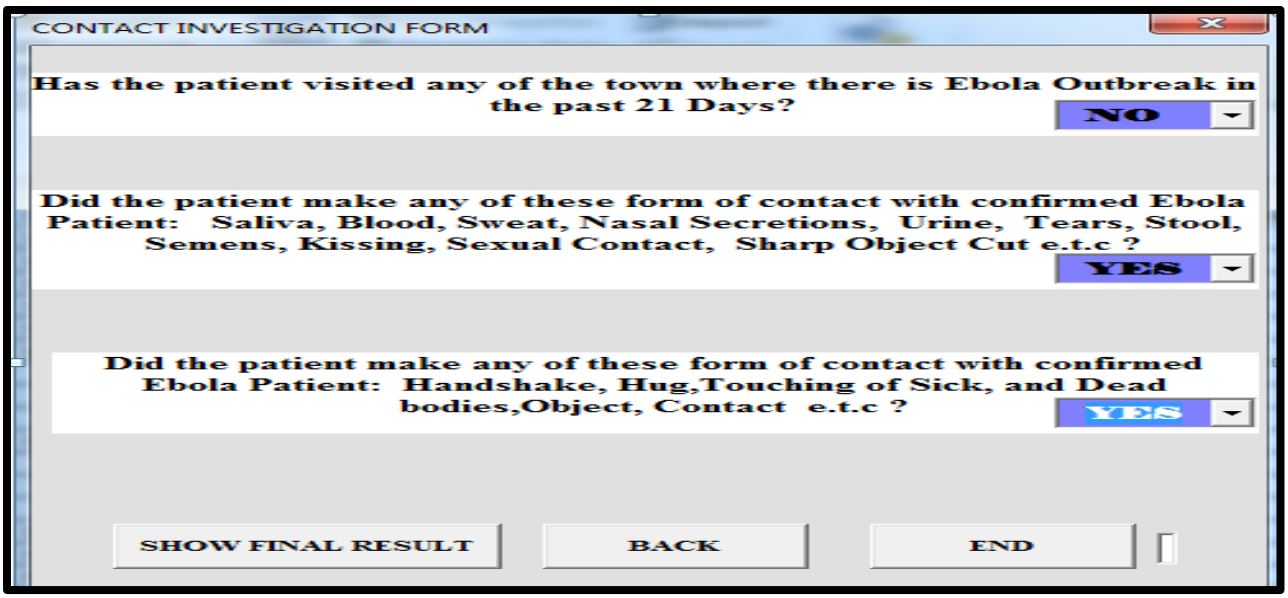

Figure 9: Contact Investigation: Case of No Visitation But With Contact

The summary of the results of our investigation has been represented in the form of IF THEN RULES structure for the development of the knowledge base as presented in Table 1.

Table 1: KNOWLEDGE BASED RULES IN THE FORM OF IF THEN ELSE STRUCTURE USED FOR THE DEVELOPMENT OF INTELLIGENT SYSTEM

S/N	CONDITION	ACTION
1	If (the patient visited where there is Ebola Outbreak in the past 21 Days)= "YES" OR if the patient make contact with confirmed Ebola Patient: = "YES" OR if the patient make any of these form of contact with confirmed Ebola Patient: Handshake, Hug, Touching of Sick, and Dead bodies, Object, Contact "YES" THEN	There is VERY HIGH likelihood of Infection, hence further laboratory tests are HIGHLY recommended
2	If (the patient visited any of the town where there is Ebola Outbreak in the past 21 Days) = "YES" OR if the patient make any of these form of contact with confirmed Ebola Patient: Saliva, Blood, Sweat, Nasal Secretions = "YES" OR if the patient make any of these form of contact with confirmed Ebola Patient: Handshake, Hug, Touching of Sick, and Dead bodies, Object, Contact = "NO" Then	"There is HIGH likelihood of Infection, hence further laboratory tests are HIGHLY recommended"
3	If (the patient visited any of the town where there is Ebola Outbreak in the past 21 Days)= "YES" OR if the patient make any of these form of contact with confirmed Ebola Patient: Saliva, Blood, Sweat, Nasal Secretions = "NO" OR if the patient make any of these form of contact with confirmed Ebola Patient: Handshake, Hug, Touching of Sick, and Dead bodies, Object, Contact = "YES" Then	There is HIGH likelihood of Infection, hence further laboratory tests are HIGHLY recommended
4	If (the patient visited any of the town where there is Ebola Outbreak in the past 21 Days) = "YES" OR if the patient make any of these form of contact with confirmed Ebola Patient: Saliva, Blood, Sweat, Nasal Secretions = "NO" OR if the patient make any of these form of contact with confirmed Ebola Patient: Handshake, Hug, Touching of Sick, and Dead bodies, Object, Contact = "NO" Then	There is likelihood of Infection, though NO EVIDENCE of CONTACT but further laboratory tests are recommended
5	If (the patient visited any of the town where there is Ebola Outbreak in the past 21 Days)= "NO" OR if the patient make any of these form of contact with confirmed Ebola Patient: Saliva, Blood, Sweat, Nasal Secretions = "YES" OR IF the patient make any of these form of contact with confirmed Ebola Patient: Handshake, Hug, Touching of Sick, and Dead bodies, Object, Contact = "YES" Then	There is STRONGLY likelihood of Infection, though there is no visitation, hence further laboratory tests are recommended
6	If (the patient visited any of the town where there is Ebola Outbreak in the past 21 Days) = "NO" OR if the patient make any of these form of contact with confirmed Ebola Patient: Saliva, Blood, Sweat, Nasal Secretions = "YES" OR IF the patient make any of these form of contact with confirmed Ebola Patient: Handshake, Hug, Touching of Sick, and Dead bodies, Object, Contact = "NO" Then	There is likelihood of Infection, though, there is no evidence of visitation, hence further laboratory tests are recommended.

The developed system has been able to make inferences on probable Ebola suspects through the use of investigative pre-coded questions in the knowledge base. Communication between the user and the system is done using the question-and-answer interface. With the use of the developed knowledge base, the system was able to classify symptoms of Ebola Virus Disease (EVD) into three: the early symptoms, the intermediate symptoms and the advanced systems.

4. Conclusion

The rate of Ebola transmission can be reduced with the use of the Ebola diagnosis system developed in this paper. The test cases showed reliable inferences from different scenarios. The system showed that reduction in person-to-person transmission of Ebola virus disease can be achieved if probable suspects are identified and diagnosed on time using computer applications that eliminates physical contact with suspects or infected materials. With the suspect of Ebola, the Expert System recommends laboratory test for final confirmation of the expert system diagnosis. The use of Expert Systems in medicine has enhanced the quality of healthcare delivery services by health professionals. Quick intervention and reduced repercussions are the usual visible benefits of a good medical application. Expert System for the diagnosis of Ebola Virus Disease shares this objective. A cost effective and reliable Expert System for EVD diagnosis is a necessity in the fight against its transmissions and mortality rates. The system also promotes effective management of Ebola suspects and patients. The choice of 'Nil', 'Mild' and 'Severe' responses make the system simple enough for any user with basic IT knowledge to use, thereby reducing the cost of hiring and training of professionals on how to use the system. Finally, there is no doubt in the size of the system and its impact on the speed of the computer because of the simplicity of the codes.

References

[1] S. Baize, E. Leroy, A. Georges, M.C. Georgescourbot, M. Capron, I. Bedjabaga, J. Lansoudsoukate, E. Mavoungou (2017). Inflammatory responses in Ebola virus infected patients. Clinical. Expert. Immunology. Vol. 128, No. 1, pp.163–168.

[2] S. Tunmibi, O. Adeniji, A. Aregbesola., & A. Dasylva. (2013). A Rule Based Expert System for Diagnosis of Fever. International Journal of Advanced Research. Vol. 1, No. 7, pp.343-348.

[3] B.C. Prasadl, P. Krishna and Y. Sagar (2011). An approach to develop expert systems in medical diagnosis using machine learning algorithms (asthma) and a performance study. International journal on soft computing.Vol. 34, pp.26-33.

[4] S.O. Williams and O.M. Olatunji (2013). Hybrid Intelligent System for the Diagnosis of Typhoid Fever. Journal of Computer Engineering & Information Technology. Vol. 2, No. 2, pp. 2-9. 46.

[5] Centers for Disease Control and Prevention. Ebola (Ebola Virus Disease). Updated October 8, 2014. http://www.cdc.gov/vhf/ebola/index.html. Accessed 10/08/2020.

[6] F. Shuaib, R. Gunnala, E.O. Musa, F.J. Mahoney, O. Oguntimehin, P.M. Nguku (2014). Ebola virus disease outbreak -.Morbidity and Mortality Weekly Report. Vol. 63, No. 39, pp.867-872.

[7] World Health Organization. Ebola Virus Disease. Updated September 2014. http://www.who.int/mediacentre/factsheets/fs103/en/. Accessed 20/04/2021.

[8] Wiriyasuttiwong, W., & Narkbuakaew, W. (2009). Medical Knowledge-Based System for Diagnosis from Symptons and Signs. International Journal of Applied Biomedical Engineering, 2(1), 54-59.

[9] Oguntimilehin, A., Adetunmbi, A. O., & Olatunji, K. A. (2014). A Machine Learning Based Clinical Decision Support System for Diagnosis and Treatment of Typhoid Fever. International Journal of Advanced Research in Computer Science and Software Engineering, 4(6), 961-969.

[10] Gostin LO, Lucey D, Phelan A. (2014), The Ebola Epidemic: A Global Health Emergency. 12(11):1095-1096.

[11] Currie J, Grenfell B and Farrar J (2016) Infectious diseases. Beyond Ebola Science 3(5), 815-816

[12] Fred, A., Filipe, J., Partinen, M., & Paiva, T. (2000). An Expert System for the Diagnosis of Sleep Disorder. Studies in Health Technology and Informatics, 127-147.