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Original Article

Expert System for the Timely Diagnosis of Infectious Diseases

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Abstract *- Infectious diseases such as COVID-19, dengue, diphtheria, etc., are spreading throughout the world, just like in Peru. Some of the symptoms of these diseases are similar. Rapid diagnosis is not available in this case, especially in regions with limited medical facilities. In addition, some people are unaware of the symptoms caused by these diseases. The objective of the research is to design a rule-based web expert system prototype using the Buchanan and Rational Unified Process (RUP) methodology and evaluate to determine the feasibility of building the system for early detection and timely treatment of infectious diseases such as COVID-19, Zika, Dengue, Diphtheria, Influenza, Chikungunya, and Monkeypox. The result was a prototype of an expert system with friendly and easy-to-use interfaces. In addition, the quality level of the prototype was evaluated through expert judgment, who analyzed the system's efficiency, usability, security, and functionality. After calculating the scores of the evaluated criteria, the total average was 4.74 out of 3, which is the minimum average for the feasibility of the expert system to be considered acceptable, considering the level of quality. In conclusion, it was possible to design and evaluate the expert system prototype. In addition, the results also show that it is feasible to build the proposed system for the early detection and treatment of infectious diseases for the benefit of people's health.*

Keywords *- Buchanan, Dengue, Expert system, Health, Infectious disease.*

1. Introduction

Infectious diseases are caused by microorganisms such as bacteria, viruses, etc. These infectious diseases can be spread in a variety of ways, including direct person-to-person contact, insect bites, etc. In addition, the diagnosis of infectious diseases is based on the doctor's experience, so it can be difficult for a patient to recognize the symptoms [1]. Moreover, identifying the type of disease can be complicated by overlapping symptoms, which can lead to misdiagnosis [2].

The SARS-CoV-2 virus, which is the source of one of the most recent infectious diseases, COVID-19, was first discovered in Wuhan, China. Hundreds of thousands of people have died, and millions have been infected with respiratory infections because of the rapid global spread of this disease [3-5]. Without a proper diagnosis, it is difficult to distinguish the symptoms of COVID-19 from those of other respiratory diseases [2]. Because the symptoms of this disease include high fever, cough, shortness of breath, etc., which are like those of other infectious diseases; however, infection and transmission can be prevented with accurate, prompt, and timely diagnosis [7,8].

In Peru, there are several infectious diseases, such as COVID-19, Zika, Dengue, Diphtheria, Influenza, Chikungunya, and Monkeypox, among others. These diseases are one of the major public health problems. Since the outbreak of this type of disease causes distress in people, especially those who are susceptible to such diseases, such as pregnant women, who were considered at elevated risk during the COVID-19 pandemic [9,10]. In addition, these diseases produce many similar and different symptoms. Some are so mild that a patient can recover without hospitalization, while others can cause death. In addition, some people are unaware of the symptoms caused by these diseases. In some areas of the country, particularly in rural and low-income areas, there are no accessible enough and high-quality public health facilities and services to allow timely diagnosis.

The research is important to offer a rule-based web expert system to provide an early diagnostic method for infectious diseases currently present in Peru. The expert system diagnoses the disease based on the patient's symptoms, which is beneficial for patients and medical staff of different health institutions (hospitals, clinics, etc.) by improving the early detection of infectious diseases for fast and efficient patient care.

The aim of the research is to design and evaluate a prototype rule-based web expert system for early detection and rapid treatment of infectious diseases. In this way, the system's feasibility will be determined by providing patients with a system that allows self-diagnosis and medical professionals with a system that supports the diagnosis of infectious diseases.

2. Literature review

Today, there are various tools to diagnose and predict infectious diseases thanks to emerging technology such as Artificial Intelligence (AI) and its various fields. One of the fields of AI is the expert system. Therefore the study of some solutions applied to the expert system for diagnosing infectious diseases is developed below.

Permana et al. [11] developed a mobile application for diagnosing infectious diseases such as typhoid, tuberculosis, dengue, measles, and malaria using Naive Bayes and Forward Chaining. After inputting the symptoms, the system infers the diagnosis using the Naive Bayes formula. The results obtained, according to the tests carried out using the System Usability Scale method, show a rating of 73.875% above the average, which indicates that the mobile application is accepted. Similarly, the performance of applying the Confusion Matrix method is up to 76%.

On the other hand, Istiadi et al. [37] point out that people's ignorance of how infectious diseases spread is the cause of infectious disease victims. Building expert detection systems and supplying guidance against infectious diseases is essential. In this regard, they created an expert system capable of finding six different infectious diseases of concern to the city of Malang using the Dempster-Shafer approach. The test had an accuracy rate of 88.5%. In addition, 85% of the users strongly agreed with the system's effectiveness, 76% agreed with its reliability, 76% agreed with its efficiency, 83% strongly agreed with its usability, and 79% agreed with its accuracy. There is a risk of contagion because some people are unaware of the symptoms and risks of these diseases. There is a risk of contagion because, it is true, some people are not aware of the symptoms and risks that these diseases cause.

Ramadhanti and Eviyanti [13] point out that children under five years of age have less immunity than adults. In addition, he ensures that a patient's health can be complicated and delay treatment if she does not notice the symptoms. As a result, they created an expert system that uses the certainty factor method to find the disease from the symptoms selected by the patient. The web-based expert system allows parents to learn about the disease affecting their young children. It also uses the certainty factor method to diagnose diseases that affect children under the age of five. in summary, it may be easier and faster for parents to consult the expert system from anywhere there is Internet access.

Achmadi et al. [14] emphasize how technological development can be used to improve human health and quality of life. They also argue that infectious diseases in children are extremely dangerous. Therefore, it is essential to create a system that can identify diseases. They created an expert system that uses the certainty factor method to identify tropical infectious diseases that affect children. Furthermore, the architecture of the expert system is based on a desktop system and MySQL for data storage. In the same way, the system uses the certainty factor method to determine the probability value of the disease. Using technology as an expert system to improve health is undoubtedly convenient.

In addition, Rachmatulloh et al. [15] point out that many people are still unaware of the dangers, prevention methods, and therapies for liver diseases. Therefore, using the method of Bayes' theorem, they developed an expert system for diagnosing liver diseases from the listed symptoms. The result is a web expert system based on Bayes' theorem for diagnosing liver diseases. In addition, the expert system helps in rapid diagnosis from any location, as the system only requires an Internet connection.

Uka et al. [35] created an expert system to treat infectious diseases caused by Staphylococcus aureus. Also, to quickly identify and find Staphylococcus aureus bacteria on human skin. They used a top-down design approach, using Java as the programming language and MySQL as the database. The result was a computer program that helps medical professionals quickly identify and treat Staphylococcus aureus bacteria on human skin. Similarly, the expert system will facilitate clinical and hospital decision-making. In fact, with the help of an expert system, decision-making can be improved, and the disease can be treated in a timely manner.

In [17] emphasize the importance of information systems in all fields to support disease diagnosis and prognosis, especially in medicine. To diagnose and predict diseases of internal organs, they created an expert system to optimize decision-making to help new, inexperienced doctors. Finally, they make some observations showing when and how the proposed expert system for diagnosing and prognosticating diseases of internal organs will be available. Expert systems really help new and inexperienced doctors to make decisions with confidence and are especially useful in this regard.

According to the author Yulisman [18], the bites of Aedes aegepty and Aedes albopictus mosquitoes are the main means of transmission of the contagious disease hemorrhagic fever. The symptoms of this disease, such as fever, are usually detected much later. Therefore, he designed and developed a web-based expert system that could diagnose the disease and offer solutions based on the knowledge of the expert physician. To build the system, he used the PHP programming language and MySQL as the database and adapted the cascade model in the development of the expert system. The results show that the system is capable of diagnosing diseases. It also provides data and suggestions based on the medical staff's experience.

In [19] points out that skin diseases are common in tropical countries such as Indonesia and that lack of knowledge about their prevention and treatment can lead to serious diseases. In this context, they developed a web-based expert system capable of diagnosing human skin diseases using the Bayesian method to detect diseases early and reduce their incidence. In addition, 20 users who tested the system proved it could accurately identify skin diseases. They conclude that the expert system can be used as a surrogate to quickly and accurately diagnose human skin diseases.

Leman [32] points out that pulmonary tuberculosis is an infectious and seriously dangerous disease caused by the bacterium Mycobacterium. In addition, he emphasizes the importance of early detection of this disease. In this regard, he created an expert system that can identify pulmonary tuberculosis disease from the signs and symptoms provided by users, using the knowledge base maintained in a database using Paradox software, which is based on rules with the Dempster-Shafer method and Bayes' theorem. The results show that the system can diagnose diseases and provide advice based on the symptoms provided by the user.

In conclusion, the authors of the scientific articles present expert systems capable of identifying infectious diseases based on the given symptoms. However, with reference to the above solution, it was found that the expert system proposed by most of the authors studied can diagnose a single infectious disease. To fill this gap, the research will allow the implementation of an expert system that can detect and diagnose various infectious diseases at an early stage.

3. Materials and Methods

3.1. Buchanan Methodology

Based on the waterfall life cycle shown in Figure 1, the Buchanan methodology is used to create expert systems. It is further divided into five sequential phases or stages: 1 Identification, the tasks to be performed by the expert system are identified after the problems have been identified. Moreover, the participants and their functions are identified. 2 Conceptualization, interviews, surveys, etc., are used to collect knowledge. Then the system variables are defined. 3 Formalization, the system's architecture is defined, and the knowledge base rules are developed. 4 Implementation, the rules representing the knowledge base are implemented. 5 Testing and evaluation are performed to validate the accuracy and to detect errors in the inference mechanisms.

3.2. Tools to Develop the Prototype

3.2.1. Figma

It is a cloud-based cross-platform tool that allows the designing of interfaces and prototype applications in real-time. According to the author [21], it is an online design tool that makes it easy for users or team members to apply designs without downloading software collectively.

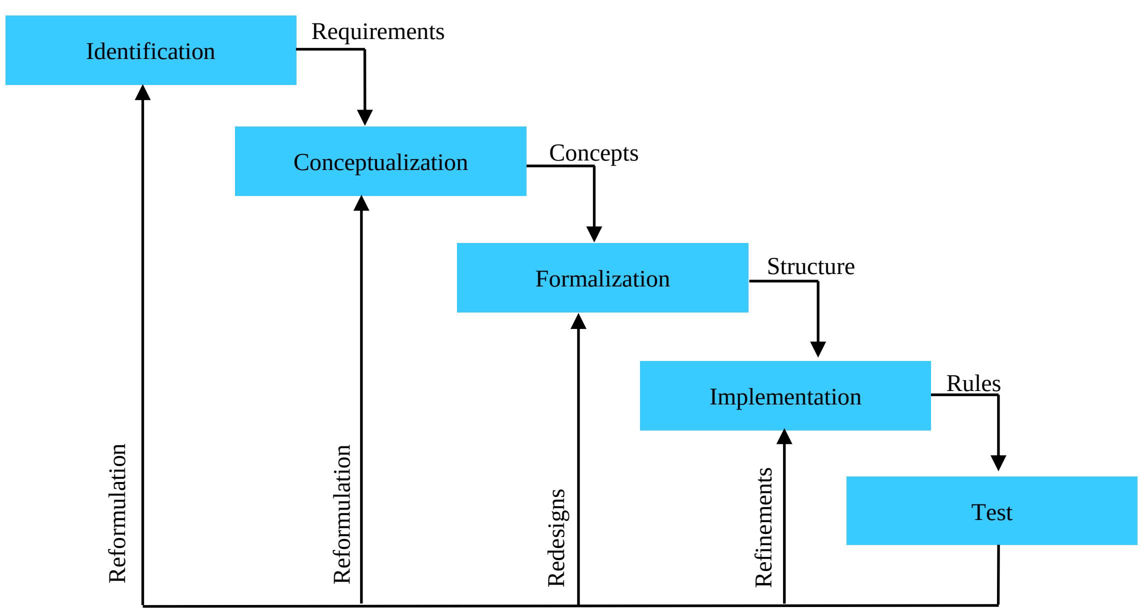

Fig. 1 Buchanan Methodology Flow

Table 1. Participants and their roles

Participants	Role
Knowledge engineer	It is responsible for representing knowledge by developing the expert system prototype.
Expert in the area covered	He provides his knowledge of infectious diseases to the Knowledge Engineer.
User	A person who has symptoms of possible infectious diseases and requires a diagnosis.

Table 2. Expert System Tasks

Task	Description of the task
Record symptoms and disease	Allow entering the symptoms related to the infectious disease to create a knowledge base.
Edit symptoms and disease	Allow editing of the symptoms related to the infectious disease to keep the knowledge base updated.
Eliminate symptoms and disease	Allow eliminating the symptoms related to the infectious disease to keep the knowledge base clean.
Perform diagnosis	Diagnose the infectious disease based on the symptoms provided by the user.
Show result	Show the user the result obtained and allow export.

3.2.2. Python

Python is a high-level, object-oriented, cross-platform, and multi-paradigm language. The authors [22] state that this language increases productivity and performance because it facilitates development by allowing the use of high- and low-level APIs. Furthermore, Python is free and open source and is gaining popularity for reducing complexity and shortening design time, as pointed out by authors [24, 33].

3.2.3. Django

Django is a high-level, cross-platform Python framework that makes building secure and maintainable web applications fast and easy. As they point out in [25], it is a framework that facilitates the creation of web applications using the Model Template View (MTV) development pattern.

3.2.4. PyCharm

PyCharm Community is an integrated development environment (IDE) for the Python programming language. According to the author [34], this IDE provides code inspections, error highlighting, code recovery functionality, and quick fixes. Also, as he points out in [27], it is an IDE specifically designed for Python that is free and open source.

3.2.5. Firebase

It is a digital tool offered by Google to facilitate the creation of web or mobile applications. As mentioned in [28], it is a cloud platform and a database service. It is also cross-platform compatible, enabling dynamic user integration.

3.2.6. PostgreSQL

PostgreSQL, also known as Postgres, is a relational database management system (RDBMS). It is an extremely reliable, object-oriented, relational database manager, etc. As mentioned in [29,30], PostgreSQL is an open-source database manager, so it is free.

3.3. Development of the Methodology

3.3.1. Identification

In this phase, the problem was identified, and a solution was described. The participants and their respective roles in creating the expert system were also identified. The tasks to be performed by the expert system were also described.

Problem

Peru has several infectious diseases, some of which have similar symptoms and others that are different. Consequently, contracting one of these infectious diseases risks spreading and transmitting the infection, making it more difficult to treat. In addition, some people are unaware of the symptoms produced by these infectious diseases, contributing to the lack of timely diagnosis to mitigate the disease.

Solution

Given the problem, it has been proposed to create a prototype of a rule-based web expert system. To provide fast and efficient treatment, this expert system will be able to identify and diagnose infectious diseases quickly.

In this way, it contributes to people in low-income rural areas who have limited access to medical care for timely diagnosis of infectious diseases.

Participants and their Roles

As shown in Table 1, three participants and their respective roles in developing the expert system for diagnosing infectious diseases were identified.

Expert System Tasks

As shown in Table 2, five tasks have been identified that the expert system must perform in order to function correctly and diagnose the infectious disease.

Table 3. Qualitative information about the model

Symptom	Abbreviation	Infectious Disease
Fever	FB	COVID-19, Monkeypox, Diphtheria, Influenza, Zika, Chikungunya
Nasal congestion	CN	COVID-19
Cough	TS	COVID-19, Diphtheria
Fatigue	CS	COVID-19, Chikungunya
Loss of taste or smell	PGO	COVID-19
Throat pain	DG	COVID-19, Influenza, Diphtheria
Headache	DC	COVID-19, Monkeypox, Dengue, Zika
Diarrhea	DRA	COVID-19
Difficulty breathing	DR	COVID-19, Diphtheria
Chest pain	DP	COVID-19
Intense headache	CL	Monkeypox, Zika, Chikungunya, Influenza
Inflammation de ganglions	IG	Monkeypox
Low back pain	DL	Monkeypox
Muscle pain	DM	Monkeypox, Dengue, Influenza, Zika
Fatigue	FT	Monkeypox
Lack of energy	FE	Monkeypox
High fever	FA	Dengue, Influenza
Eye pain	DO	Dengue
Articulation's pain	DAR	Dengue, Zika
Erythema	ETM	Dengue
Watery nasal discharge and/or blood	SNS	Diphtheria
Shaking chills	SCL	Diphtheria
Difficulty to swallow	DT	Diphtheria
Hoarseness	RQ	Diphtheria
Dry cough	TSC	Influenza
Sneezing	STD	Influenza
Rhinitis	RTS	Influenza
Rashes	EC	Zika
Conjunctivitis	CJT	Zika
Nausea	NS	Chikungunya
Vomiting	VMT	Chikungunya
Myalgias	MLS	Chikungunya
Exanthema	ETM	Chikungunya
Joint inflammation	IA	Chikungunya

Table 4. Knowledge rules

Knowledge rules	
Rule 1	**IF** FB is "No" and CN is "No" and TS is "No" and CS is "No" and PGO is "No" and DG is "No" and DC is "No" and DRA is "No" and DR is "No" and DP is "No" and CL is "No" and IG is "No" and DL is "No" and DM is "No" and FT is "No" and FE is "No" and FA is "No" and DO is "No" and DAR is "No" and ETM is "No" and SNS is "No" and ECL is "No" and DT is "No" and RQ is "No" and TSC is "No" and ETD is "No" and RTS is "No" and EC is "No" and CJT is "No" and NS is "No" and VMT is "No" and MLS is "No" and ETM is "No" and IA is "No" **THEN** No infectious disease.
Rule 2	**IF** FB is "Yes" CN is "Yes" and TS is "Yes" and CS is "Yes" and PGO is "Yes" and DG is "Yes" and DC is "Yes" and DRA is "Yes" and DR is "Yes" and DP is "Yes" **THEN** infectious disease is "COVID-19"
Rule 3	**IF** FB is "Yes" and DC is "Yes" and CL is "Yes" and IG is "Yes" and DL is "Yes" and DM is "Yes" and FT is "Yes" and FE **THEN** infectious disease is "Monkey Pox"
Rule 4	**IF** FB is "Yes" and TS is "Yes" and DG is "Yes" and DR is "Yes" and SNS is "Yes" and ECL is "Yes" and DT is "Yes" and RQ is "Yes" **THEN** infectious disease is "Diphtheria"
Rule 5	**IF** FB is "Yes" and DG is "Yes" and CL is "Yes" and DM is "Yes" and FA is "Yes" and TSC is "Yes" and ETD is "Yes" and RTS is "Yes" **THEN** infectious disease is "Influenza"
Rule 6	**IF** FB is "Yes" and DC is "Yes" and CL is "Yes" and DM is "Yes" and DAR is "Yes" and EC is "Yes" and CJT is "Yes" **THEN** infectious disease is "Zika"
Rule 7	**IF** FB is "Yes" and CS is "Yes" and CL is "Yes" and NS is "Yes" and VMT is "Yes" and MLS is "Yes" and ETM is "Yes" and IA is "Yes" **THEN** infectious disease is "Chikungunya"
Rule 8	**IF** DC is "Yes" and DM is "Yes" and FA and DO is "Yes", and DAR is "Yes" and ETM **THEN** infectious disease is "Dengue"

3.3.2. Conceptualization

For the acquisition of knowledge in this phase, information and data from the website of the World Health Organization (WHO), the Pan American Health Organization (PAHO), the Ministry of Health of Peru (MINSA), and other sources were used. As can be seen in Table 3, this led to the identification of qualitative data (symptoms and associated diseases) to be used in the knowledge representation.

3.3.3. Formalization

Knowledge Rules

In this section, a set of knowledge rules has been formulated. The results of diagnostic tests for infectious diseases can be derived from these proposed rules. As shown in Table 4, eight rules are presented from over a hundred formulated rule bases, formalized using IF (user-entered facts, symptoms) and THEN (the facts reveal the presence of infectious disease, conclusion).

Architecture

Figure 2 shows the basic architecture of the proposed expert system. The expert system will be hosted in the cloud. The patient and the doctor will access through the Internet connection to use the system.

3.3.4. Implementation

The Figma platform was used to create the prototype of the expert system. The prototype must perform the actions shown in Figure 3, the case diagram. The user-patient is the patient who performs his self-diagnosis, and the user-doctor manages the symptoms (adds, edits, deletes, and searches the system) and diagnoses the patient. In addition, to manage the symptoms, the authorized doctor-user must be logged in, that is, registered in the system. In the same way, both the medical user and the patient user must be logged in to manage their profiles and consult the previous records of their diagnoses. If the diagnosis is performed without the need to record the diagnosis in history, then you do not need to log in to perform the diagnosis.

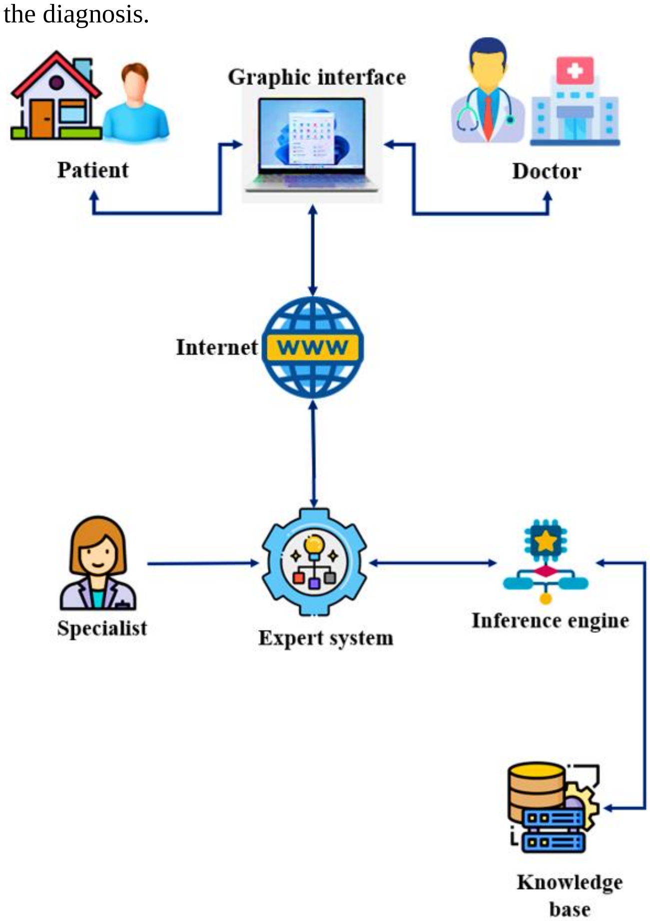

Fig. 2 Expert system architecture

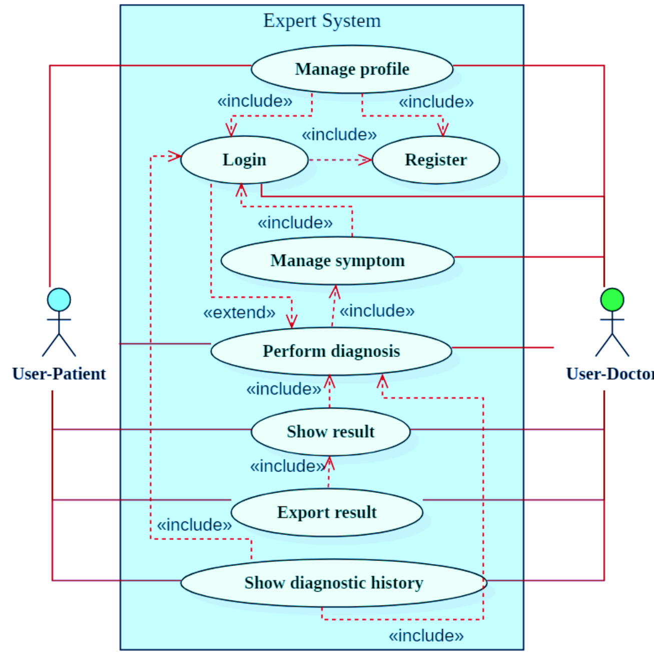

Fig. 3 System use case diagram

3.3.5. Test

The evaluation of the functionality, usability, security, and efficiency of the prototype designed by simulating the expert system in Figma has been carried out. In this way, determine the system's feasibility to move to the construction phase using Python and its Django framework and Firebase to implement the knowledge rules formulated during the formalization phase.

4. Results

4.1. User Interface

4.1.1. Main or Home Menu

Figure 4 shows the main menu or start of the expert system. Here is a description of the seven different infectious diseases that can be diagnosed, such as COVID-19, Dengue, Chikungunya, Zika, and Monkeypox. There is also a button that makes it easy to start the diagnosis.

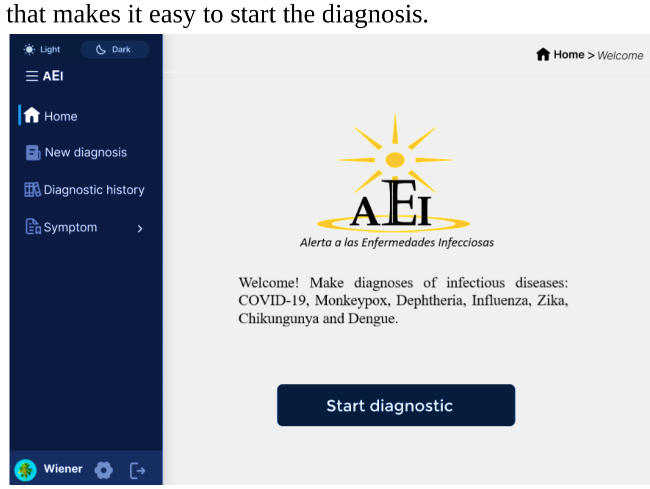

Fig. 4 Main or home menu interface

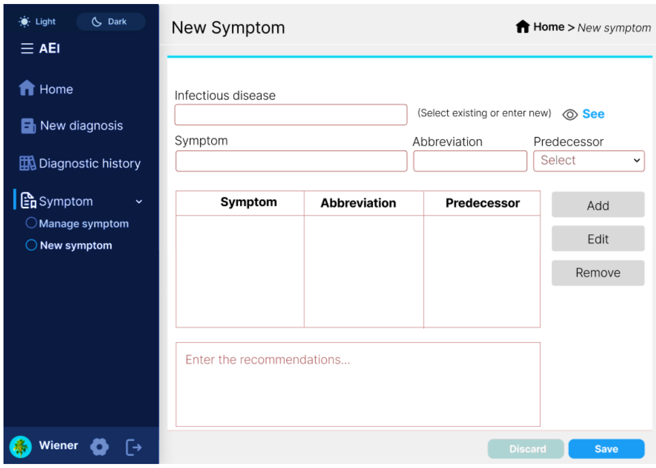

Fig. 5 New symptoms registration interface

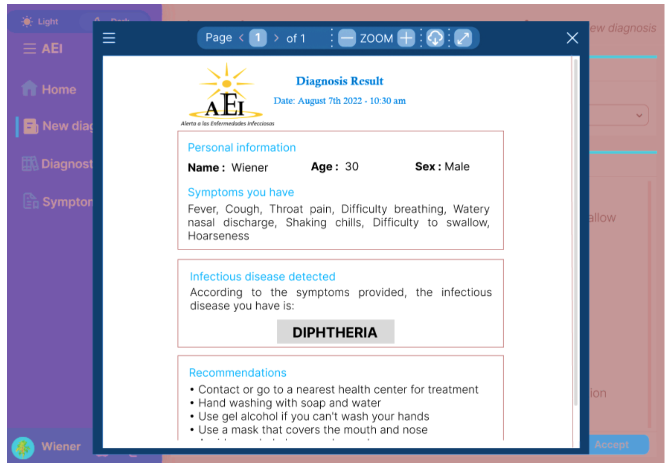

Fig. 7 Result interface

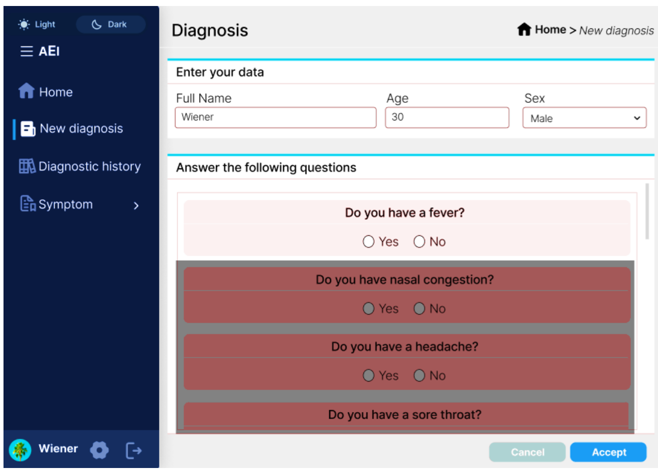

Fig. 6 Diagnostic Interface

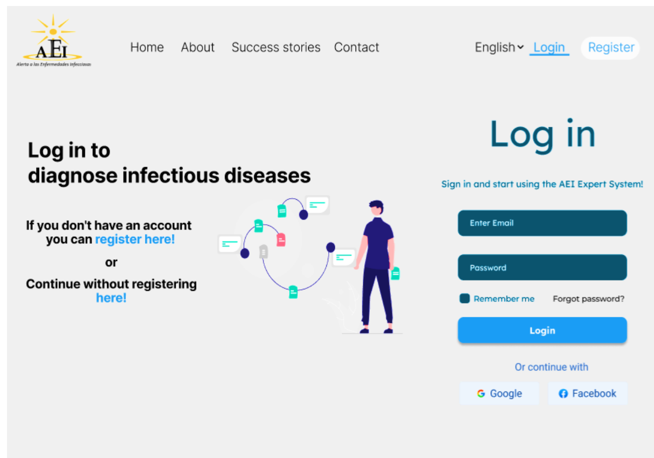

Fig. 8 Login and register interface

4.1.2. Registration of New Symptoms

Figure 5 shows the symptom registration interface and the corresponding disease. This module allows the medical user to enter new symptoms into the expert system's knowledge base to obtain an accurate diagnosis. To do this, the authorized user must enter the new infectious disease or select an existing one in the display option. Then it should enter the new symptom, its abbreviation and predecessor, and then add it to the list of symptoms (you can add one or more symptoms for the same disease). In case of a wrong symptom, you should select and edit or delete it from the list. Finally, depending on the disease, it is necessary to add recommendations for actions that the person should take until he/she receives medical attention and treatment for the disease.

4.1.3. Diagnosis

Figure 6 shows the diagnostic interface. This module allows users to create a new diagnosis of an infectious disease. To do this, they must enter their data, such as full name, age, and gender (optional). Then, provide the expert system with the symptom you present or have, answering each of the questions provided by the expert system.

Then press the Accept button so the expert system will make inferences based on the answers and display the diagnosis result.

4.1.4. Diagnostic result

Figure 7 shows the diagnostic results interface. It displays the user's data, the selected symptoms, and the infectious disease detected from the symptoms provided by the user. In addition, you have the option to download the result in PDF format.

4.1.5. Sign In and Register

Figure 8 shows the login screen. This is where users can validate their information to enter the system; by entering their email and password or by signing in with their Google or Facebook accounts.

If do not have an account, one can create a new one by entering the create new account interface by pressing the Register option. They can also proceed without logging in but will have the diagnostics-only option enabled.

Table 5. Evaluation criteria

Criteria	Aspect
Efficiency	Optimize resources
	It provides a fast response time
	Shows accurate results
Usability	Easy to use
	Intuitive, simple and fast
	Easy to access and navigate
Security	Authentication mechanism
	Control of data by the user
	Symptom control by an authorized user
Functionality	Readable
	Facilitates interaction
	Suitability

Table 6. Scoring scale

Scale	Score
Very low	1
Low	2
Regular	3
High	4
Very high	5

4.2. Evaluation by Expert Judgment

Ten experts carried out the evaluation of the prototype prior to the simulation of the system in Figma. Criteria such as efficiency, security, and usability were used, considering the different aspects, as shown in Table 5. In addition, the Likert scale was used for the evaluation, as shown in Table 6. After obtaining the evaluation, the mean or average of each aspect of the evaluated criterion was calculated using SPSS Statistics software. Finally, the overall average of each evaluated criterion was calculated. The results obtained are presented below.

4.2.1. Determine the Quality of the Criteria by the Aspects Evaluated

The quality level of the criterion was calculated by taking the average of all factors evaluated for each criterion. The average of the efficiency criterion was examined and calculated, as shown in Figure 9. The fast response time aspect has a higher average, while the resource optimization and accurate results aspects have averages of 4 and 5, respectively. This indicates that the quality of the prototype's efficiency is acceptable in terms of the aspects evaluated.

On the other hand, Figure 10 shows the evaluation of the usability of the expert system. The results prove that the average value of each evaluated aspect is 5. Similarly, as Figure 11 shows, the average value of each evaluated aspect of system security is 5. As a result, the quality of security and usability criteria of the system is very acceptable.

The maximum average obtained from the system's functionality, as shown in Figure 12, is also 5, corresponding to ease of interaction. On the other hand, the average of the Legibility and Suitability aspects is 4.5 and 4.6, respectively, indicating that the system's functionality quality in the evaluated aspects is acceptable.

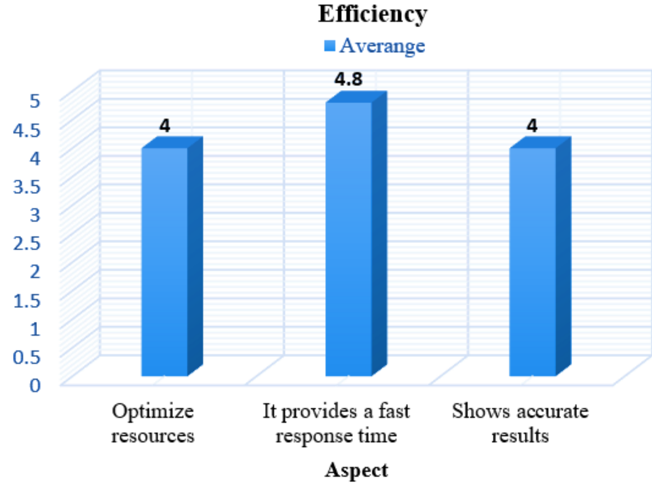

Fig. 9 Average of efficiency rating scores

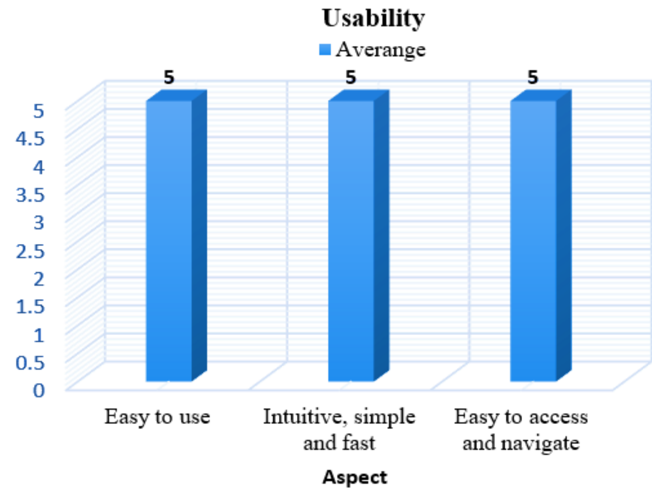

Fig. 10 Average of usability rating scores

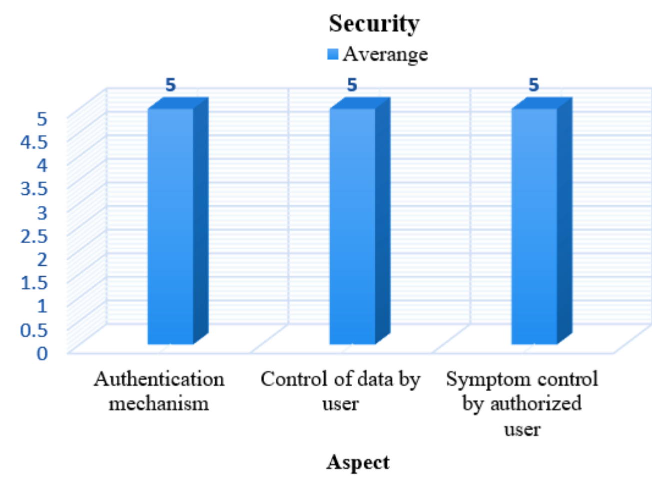

Fig. 11 Average of Safety rating scores

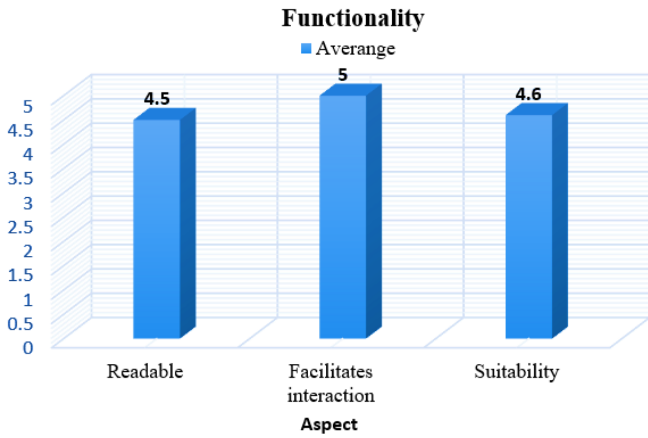

Fig. 12 Average of functionality rating scores

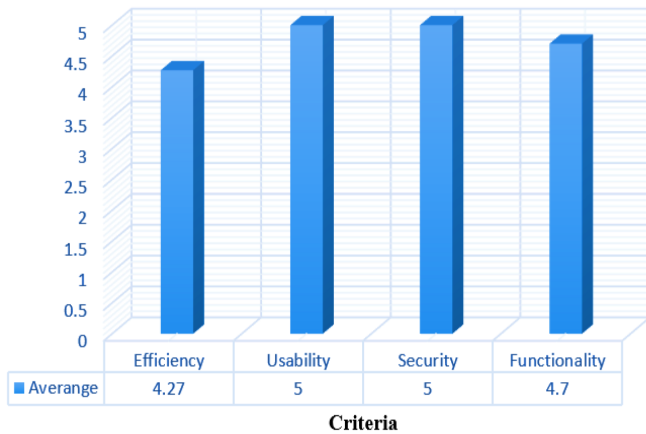

Fig. 13 Average of evaluated criteria

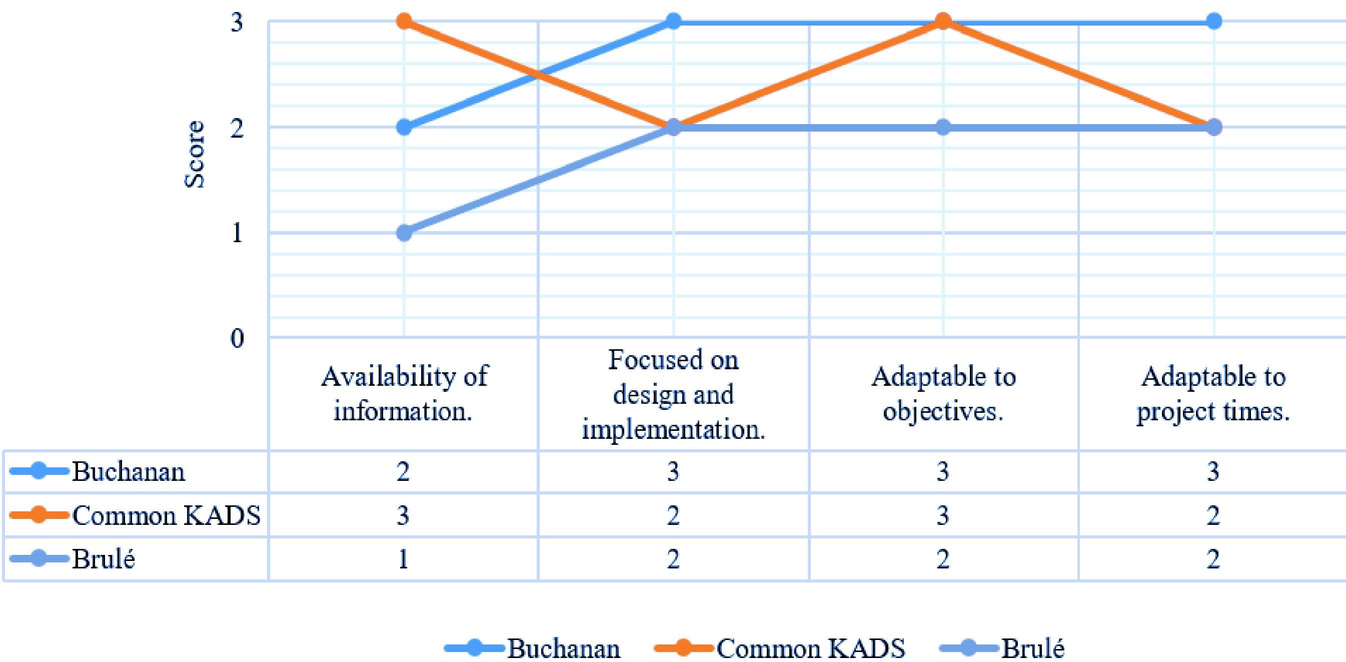

Fig. 14 Evaluation of the methodology

4.2.2. Determine the Quality and Feasibility of the Prototype based on the Evaluated Criteria

The quality of the prototype was determined by taking the average of the evaluated criteria. As can be seen in Figure 13, each of the criteria: efficiency, usability, security, and functionality; has an average score of 4.27, 5, 5 and 4.7, respectively. According to the results obtained, it is shown that the quality of the expert system is acceptable. The general average was also calculated, and the result was 4.74. Furthermore, for the expert system to be feasible, the total average score of the expert system must be greater than 3.

4.3. Evaluation of the Methodology

To determine which methodologies are appropriate to develop the proposed expert system prototype, the evaluation was carried out between Buchanan, CommonKADS and Brulé. The evaluation was done on a scale from 1 to 3. Where 1 means that the methodology is not applicable to the development of the prototype. Meanwhile, 3 denotes favourable for the development of the project. According to Figure 14, the combined scores for the Buchanan, CommonKADS, and Brulé methodologies are 11, 10, and 7, respectively. In conclusion, the Buchanan methodology received the highest score in the results, which indicates that it is the best option for building the proposed expert system.

5. Discussion

The design of an expert system for the early diagnosis of infectious diseases was built using the Buchanan and RUP methodologies. For his part, [18] used the cascading methodology and the PHP programming language to build the expert system.

Similarly, the proposed expert system is designed with the ability to identify seven infectious diseases. However, [15], [16], [20] present in their research an expert system capable of identifying a single disease. Thus, they limit the capacity that the expert system can have. Regarding the method, the proposed expert system uses a rule-based methodology in terms of its operation. Instead, the systems proposed by the authors [11], [19] are based on the Naive Bayes method, and from [13], [14] is a certainty factor and in [20] is Bayes theorem.

The prototype was evaluated by expert judgment; after calculating the points, the total average was 4.74 above the minimum average. The system usability scale method was used in [12] for evaluation and resulted in a rating of 73.875% above average. In addition, to determine the quality of efficiency, usability, security and functionality of the system, the average was calculated and obtained at 4.27, 5, 5, 4.7, respectively, which indicates that the quality of the evaluated criteria of the system is acceptable. On the other hand, in [13], they determined the percentage where 85% of users strongly agree with the effectiveness of the system, 76% agree with its reliability, 76% agree with its efficiency, 83% % strongly agree with its usability, and 79% agree with its accuracy.

However, it is important to emphasize that this type of expert system, either with the ability to identify one or more infectious diseases, is especially useful because it allows users to identify the type of infectious disease they are suffering from in a timely manner. In this way, prompt treatment can be given to reduce the spread of infection and disease transmission.

6. Conclusion

In conclusion, it has been possible to design and evaluate the prototype of the Expert System for early detection and treatment of existing infectious diseases in Peru, such as COVID-19, Diphtheria, Influenza, Monkeypox, Zika, Chikungunya and Dengue. The expert system allows the patient and physician to quickly perform the test to identify the disease and begin treatment in a timely manner. As shown in the results section, a web application was designed with friendly, intuitive, and necessary interfaces to enter the required data and interact to identify the diseases presented by the patient and visualize the results.

The expert system was developed using the Buchanan methodology and supported by the RUP software development process. Expert judgment was used to evaluate the quality and feasibility of the prototype, and the results indicated that it was acceptable and feasible since the total average is 4.74, higher than the minimum average, which is 3, to determine the quality and feasibility of the prototype as acceptable.

One of the researchers' limitations was information gathering, as they did not have an infectious disease specialist to collect detailed data on the diseases. They also lacked users who could evaluate the prototype for quality analysis and the feasibility of the expert system. It is recommended that in the future, the proposed expert system be developed together with a mobile application for Android and iOS. In this way, it will be easier for users to perform the test to determine the type of infectious disease they need to be treated for.

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