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KNOWLEDGE-BASED EXPERT SYSTEM TO ASSIST PHYSICIAN FOR DIFFERENTIAL DIAGNOSIS OF CHOLERA TROPICAL DISEASES

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ABSTRACT

This article presents an expert system designed to assist physicians in the diagnosis of tropical cholera diseases, particularly those related to cholera. The objective of this article is to develop a framework for the diagnosis and monitoring of health care for cholera. The system is based on a set of rules and knowledge from doctors specializing in these pathologies. The design methodology is based on the collection of this knowledge to build a base of rules adapted to the specificity of symptoms and geographical contexts linked to tropical diseases. This system will potentially help doctors and the health sector to make a quick decision when diagnosing cholera. The development tool chosen for implementation is Exsys Corvid, a platform for creating and testing expert systems. Once the system is developed, its performance and effectiveness are validated using the K. Cohen method, which makes it possible to measure the reliability and agreement between the recommendations of the expert system and the diagnoses made by doctors. This system thus offers valuable support in the early detection of cholera diseases, reducing the risk of spread and optimizing the management of medical resources.

Keywords: Expert System, Artificial Intelligence, Tropical Diseases, Cholera, Exsys Corvid

1. INTRODUCTION

In recent times, tropical regions around the world have witnessed a more pronounced impact of infectious diseases than temperate zones. The surge in infectious diseases in these tropical areas can be attributed to a confluence of environmental and biological factors that favor a wide range of pathogens, vectors, and hosts. Additionally, social factors have hampered efforts to control these diseases. The collective term for these infectious diseases is "tropical diseases", due to their increased prevalence compared to their non-infectious counterparts. Therefore, the field of tropical medicine has assumed increasing importance in the

research and management of these diseases. Notable examples of these tropical diseases include trypanosomiasis, malaria, cholera, tuberculosis, African sleeping sickness, Guinea worm disease, leprosy, and yaws.

Due to population variability and differences in the presentation of cholera, the diagnosis may be incorrect. In recent times, health care informatization makes it possible to build various clinical support systems; these are programs that can function as a human expert in a narrow problem area. The relationships between diagnoses and their symptoms are rarely unambiguous, so differentiating diagnoses sharing a range of overlapping symptoms is therefore inherently difficult. Most diagnostic systems take the form of a rule-based expert system: a set of rules is used to describe certain models. Observed data is collected and used to evaluate these rules.

If the rules are logically satisfied, the pattern is identified and a problem associated with that pattern is suggested. Each particular problem may require specific treatment.

Expert systems, defined as computer programs designed to solve real-world problems, typically involve the extraction of knowledge from experts specialized in specific domains Inusah et al. (2023),Yanase and Triantaphyllou (2019).

The difficult task of translating the knowledge of domain experts into a computer program is undertaken by knowledge engineers, who help determine the knowledge representation Castañeda et al. (2023). Recently, attention has focused on medical expert systems as complementary solutions to traditional approaches to solving medical problems. The growing demand for high-quality healthcare, coupled with the rapid expansion of medical knowledge, leaves doctors with little time to thoroughly treat each case while staying abreast of the latest developments Malbois and Clavien (2020).

Consequently, many medical decisions are based on spontaneous judgments, drawing on the spontaneous memory of doctors. Informatics tools, such as expert systems, play a crucial role in organizing, storing and retrieving relevant medical knowledge to treat complex cases and suggest appropriate diagnostic, prognostic and therapeutic decisions Kiryanov (2021). Expert systems integrate a knowledge base, containing specific facts and rules, and an inference engine, providing the reasoning ability necessary to draw conclusions Nascimento and Notargiacomo (2023). These systems also provide user interfaces and explanation features, allowing users to interact with the system and facilitating explanations or justification of conclusions Chromik and Butz (2021). The current research project explores the use of knowledge-based systems to create a comprehensive and formal representation of human knowledge, with the aim of capturing general knowledge and enabling reasoning and inference.

2. LITERATURE REVIEW

2.1. MEDICAL EXPERT SYSTEM

A medical expert system is a computer application using artificial intelligence and knowledge derived from medical experts to facilitate medical decision-making and diagnosis. These systems mimic the decision-making process of human medical experts by analyzing patient data, symptoms, medical history, and other relevant information Sayed (2021). They use this information to generate diagnostics and provide results.

2.2. CHOLERA

Cholera is an infection of the small intestine caused by a bacteria called VibroCholerae and represents a major public health problem in the tropics.

A very dangerous category of diseases, most notably cholera, is an exceptionally aggressive disease characterized by severe acute watery diarrhea. The onset of symptoms occurs within 12 hours to 5 days after ingestion of contaminated food or water Muzembo et al. (2022). Cholera can affect people of all ages and can be fatal within hours if not treated quickly.

Although many people infected with cholera do not have symptoms, the bacteria can be present in their stool for 1 to 10 days after infection, posing a risk of contaminating the environment and potentially infecting others. Of those who experience symptoms, the majority experience mild or moderate effects, while a minority may develop acute watery diarrhea leading to severe dehydration, which can be fatal if left untreated World (2021). It is crucial to emphasize that cholera can progress rapidly, particularly in areas where access to health care and clean water is limited. Dehydration poses a significant risk, which can lead to serious complications. Prompt medical intervention and rehydration therapy are imperative for effective treatment of cholera.

Cholera manifests itself with symptoms such as severe diarrhea, vomiting and dehydration. Physical manifestations include muscle cramps, rapid heart rate, low blood pressure, electrolyte imbalances, pale, cool skin, sunken fontanelle (in infants), and shock.

2.3. TYPE OF CHOLERA

1) Non-Complicated Cholera

Condition:

The patient presents with watery diarrhea, vomiting, and mild dehydration.

Explanation:

This rule is triggered when the patient shows classic signs of cholera, such as large volumes of watery stools and vomiting. The mild dehydration suggests that the case has not progressed to severe complications, and oral rehydration therapy (ORT) may be sufficient.

2) Complicated Cholera

Condition:

The patient presents with severe dehydration, hypotension (low blood pressure), and electrolyte imbalance.

Explanation:

This rule identifies cases where the cholera infection has progressed to a more dangerous state, with significant fluid loss and possible organ dysfunction. Immediate intravenous rehydration and electrolyte management are required.

3) Cholera with Shock

Condition:

The patient shows signs of shock, including very low blood pressure, weak pulse, cold extremities, and confusion.

Explanation:

This rule indicates the most severe form of cholera, where the patient is at risk of organ failure and death. Immediate medical intervention, including intravenous fluids and possibly vasopressors, is necessary.

4) Cholera Asymptomatic (Carrier State)

Condition:

The patient shows no symptoms but has a history of exposure to cholera or has been in an endemic area.

Explanation:

This rule applies to individuals who may carry the cholera bacteria without showing any clinical signs of the disease. Though they are asymptomatic, they can still spread the bacteria and should be monitored and educated on preventing transmission.

Additional Rules for Better Accuracy (Optional)

5) Rule for Severe Vomiting without Dehydration

Condition:

If the patient presents with vomiting but does not exhibit significant dehydration, a different diagnosis might be necessary.

Explanation:

This rule helps the expert system identify cases where vomiting may be unrelated to cholera, avoiding misdiagnosis.

6) Rule for Cholera History with Mild Symptoms

Condition:

The patient shows mild gastrointestinal symptoms and a history of cholera exposure.

Explanation:

This rule helps flag cases where cholera may still be a concern despite mild symptoms, ensuring that further testing (e.g., stool culture) is carried out.

3. METHODOLOGY

The objective of this research work is to help the doctor in the diagnosis of cholera by an Expert system called Expertcolera capable of temporarily replacing a doctor in the event of absence. We carefully observe the clinical manifestation of cholera symptoms in patients. Medical history records regarding cholera are also collected from doctors, being our case study. The data collected includes patients' personal information, clinical records and diagnostic information, 20 patients are selected, aged 2 to 41 years old. Following this, techniques were used to develop a rules-based expert system for cholera diagnosis. A rule-based expert system is a system that contains a set of rules used to describe certain patterns. Observed knowledge is collected and evaluated using these rules. If the rules are logically satisfied, the pattern is identified and a problem associated with that pattern is suggested. Each particular problem (symptom and sign) may require specific treatment. These rules do not take into account the uncertainty and imprecision of human-observed knowledge and reasoning, as well as real-world knowledge, characterized by incompleteness, inaccuracy and inconsistency. The rule- based approach uses IF-THEN type rules. The IF-THEN rules take the following form: IF there is a flame THEN there is a fire.

3.1. RESEARCH DESIGN

A typical rules-based system has four basic components:

1) A list of rule bases, which is a specific type of knowledge base.
2) An inference engine or semantic reasoner, which infers information or takes action based on the interaction of inputs (user symptoms or signs) and the rule base. The interpreter executes a production system program by performing the following match- resolve-act cycle:

- Matching: In this phase, the left limbs of all productions are compared to the contents of working memory. As a result, a set of conflicts is obtained, consisting of instantiations of all satisfied productions. An instantiation of a production is an ordered list of working memory items that satisfies the left side of the production.
- Conflict Resolution: In this phase, one of the production instantiations of the conflict set is chosen for execution. If no production is satisfied, the performer stops.
- Act: In this phase, the production actions selected in the conflict resolution phase are executed. These actions can modify the contents of working memory. At the end of this phase, execution returns to the first phase.

3.2. THE PROPOSED SYSTEM ARCHITECTURE

Typically, patients visit hospitals to complain about their illnesses and ExpertColera users ask patients about their illnesses and search the database for symptoms and signs. If the symptoms match those in the database, the user gives the prescription to the patient. The proposed framework for the ExpertColera Expert System is shown in Figure 1. In this figure, the different modules that work together to actually realize a complete rule-based expert system is presented.

Figure 1

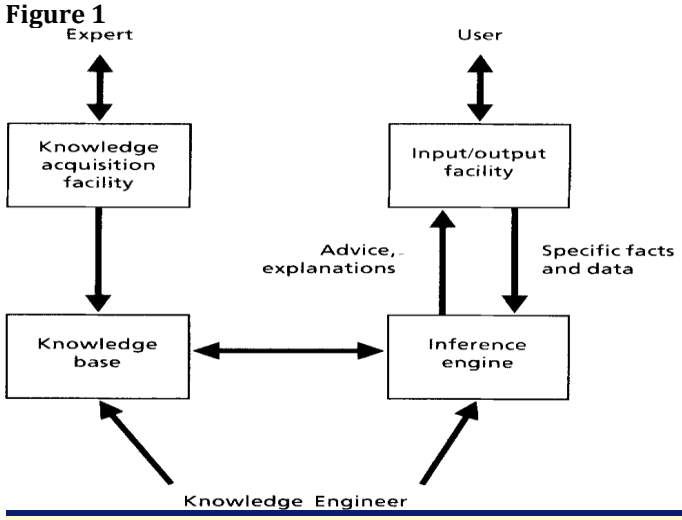

Figure 1 Basic Structure of an Expert System Feigenbaum and McCorduck (1983)

Note that three basic players are depicted in Figure.1:

the user of the system, the domain expert, and the knowledge engineer. The knowledge engineer is the system builder, that is, the expert in AI techniques who structures the expert's knowledge so that it can be shared by the user. There are

some very interesting issues regarding the creation, structuring, and sharing of knowledge, some of which can be phrased in terms of questions about who the players are and how they interact. One kind of question is whether the user need be as expert as the expert who supplied the knowledge.

That is, can systems be created for use by individuals less experienced or expert than the domain expert? The answer to this question is, "Yes," and there are examples in medicine Tartarisco et al. (2012) and engineering Dzemydiene et al. (2010) of systems designed to be used by practitioners of related but not identical expertise in the first case, and by relative novices in the other.

Another question is whether the domain expert can also be the knowledge engineer? Or, can a domain expert build his own expert system? The answer to this question is not entirely without controversy, as some AI researchers imply that the process would not work, that an expert would not be able to successfully particulate his knowledge on his own Medjahed et al. (2012), whereas others claim that there is no a priori, logical reason that would prevent a domain expert from being his own knowledge engineer Mishra et al. (2013). There are two pragmatic dangers worth noting, however. One is that domain experts wishing to build their own system must learn a lot about knowledge representation, as will become clearer subsequently, and they should not underestimate the enormity of the task.

3.3. KNOWLEDGE ACQUISITION PROCESS

The knowledge base constitutes the brain of an Expert System, because all the facts essential to the construction of the rules contained in the knowledge base. This knowledge constitutes the main source of rules for Expert Systems. The most important source of knowledge acquisition for the ExpertColera Expert system was consultation with general practitioners, medical website on the Internet, medical books, research articles and journals. Knowledge based on the acquisition of disease symptoms Erman et al. (1984), Rajdeep and Sugata (2012). Knowledge is represented in the form of rules.

From the knowledge received from doctors, we selected 6 rules which were defined for the rule base of the decision-making unit and presented as follows:

Rule 1:

IF the patient exhibits watery diarrhea, vomiting, and mild dehydration, THEN classify the case as Non-Complicated Cholera.

Rule 2:

IF the patient exhibits severe dehydration (dry skin, sunken eyes, reduced skin turgor), hypotension (low blood pressure), and/or signs of electrolyte imbalance (low sodium, potassium),

THEN classify the case as Complicated Cholera.

3) Cholera with Shock Rule 3:

IF the patient exhibits symptoms of shock (very low blood pressure, weak and rapid pulse, cold/clammy skin, confusion),

THEN classify the case as Cholera with Shock.

4) Cholera Asymptomatic (Carrier State) Rule 4:

IF the patient shows no symptoms of diarrhea or dehydration but has a history of cholera exposure (e.g., recent travel to an endemic region or contact with an infected person),

THEN classify the case as Cholera Asymptomatic (Carrier). Rule 5:

IF the patient exhibits vomiting but does not show signs of dehydration (normal skin turgor, normal blood pressure),

THEN consider the possibility of another gastrointestinal disorder (such as food poisoning or viral gastroenteritis).

Rule 6:

IF the patient has mild diarrhea and a history of cholera exposure,

THEN classify the case as Potential Cholera (to be confirmed by laboratory testing).

3.4. SYSTEM TESTING WITH SOFTWARE EXSYS CORVID

Figure 2

Figure 2 Presentation Page

Figure 3

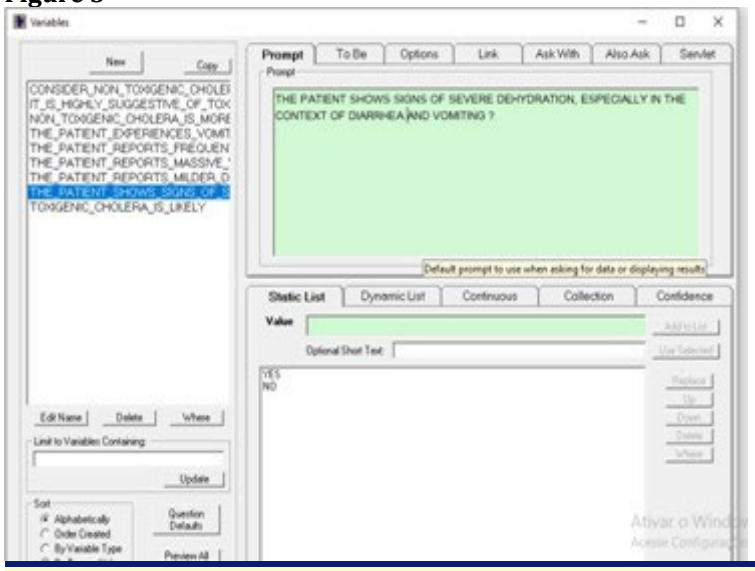

Figure 3 Create Rules in System Expert

Figure 4

Figure 4 The Diagnostic Center Interface is Shown in Figure 4.

Figure 5

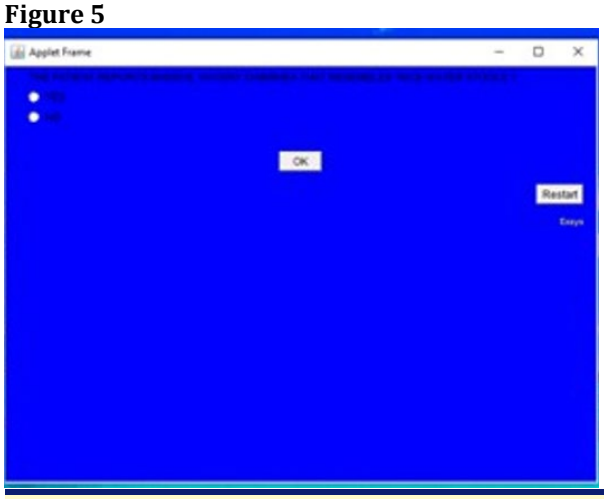

Figure 5 Patient Registration Page

Figure 6

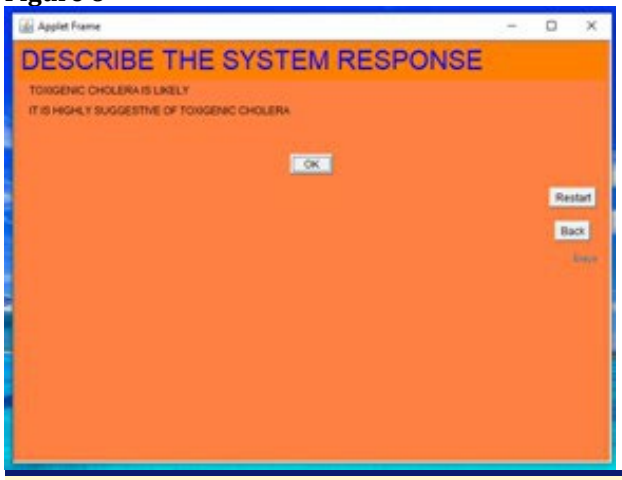

Figure 6 Report Page for the Proposed Expertcolera Expert System

4. DISCUSSION OF RESULTS

To evaluate the precision of the expert system, tests were carried out using the K. Cohen comparison method, a statistical index measuring the concordance between the diagnosis proposed by the system and that of expert doctors. Testing showed strong agreement, indicating that the system was capable of diagnosing cholera with high accuracy. The Expertcholera system shows remarkable potential to provide rapid and accurate diagnosis in resource-limited settings, where traditional diagnostic tools may be inaccessible. This not only saves lives but also improves the effectiveness of responses to cholera epidemics. Cohen (2023)

"The test results revealed a Kappa index of 0.82, which shows almost perfect agreement between the expert system's diagnosis and that of the doctors."

The test results showed that Expertcholera is capable of differentiating cases of simple cholera from more complicated ones, allowing faster and more appropriate treatment. This system is particularly useful in countries where medical infrastructure is limited.

5. CONCLUSION

The development of a rules-based expert system for the diagnosis of tropical cholera diseases represents a significant advance in improving patient care, particularly in areas where these diseases are endemic. The integration of medical knowledge through a well-defined rule base allows the system to offer reliable and adapted diagnostic recommendations. Thanks to the use of Exsys Corvid, the design and testing of the system was carried out in an efficient and structured manner. Validation via the K. Cohen method demonstrated a high degree of concordance between the system's diagnoses and those of physicians, thus confirming the viability of the system as a decision support tool in clinical environments. This system could, ultimately, become a valuable ally for practitioners, allowing rapid detection of cholera diseases, which is essential to limit their spread and improve patient survival rates.

CONFLICT OF INTERESTS

None.

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