Expert Typh Expert System Assist Physician to Diagnose Typhoid Fever Neglected Tropical Disease

Humberto Cuteso Matumueni, Alcides Romualdo Neto Simbo & Pedro A. Mogadouro do Couto

ABSTRACT

Today typhoid fever is becoming one of the most dangerous problems for the people living in this world. The shortage of medical specialists in developing countries has forced a large part of their population to die. The ExpertTyph Expert System has just been developed using Exsys Corvid software, a computer diagnostic tool to help an expert make a presumptive diagnosis of typhoid fever and the system will give a response similar to that a doctor or medical expert. To achieve this, a questionnaire was completed by health experts with professional experience and other knowledge gained from the literature as a basis for analysis, diagnosis and decision-making. Knowledge is represented by an integrated formalism that combines rules and facts. The ExpertTyph will be useful in rural areas where we have young medical experts with little or no medicine and especially in developing countries that is facing a shortage of doctors. Many times patients are in a huge queue. The tests carried out in two hospitals and compared the results of doctors and ExpertTyph. At the provincial hospital, one hundred seventy-six patients diagnosed ith ExpertTyph and ExpertTyph correctly identified 70/176 (40%) of patients with typhoid fever and 68/176 (37%) of patients without typhoid fever. That's 77% agreement and 23% difference. In Hospital May 1st has one hundred and seventy-three patients and 68/173 (39%) patients with typhoid fever and 70/173 (40%) patients not suffering from typhoid fever. It is 79% agreement and 21% difference.

Keywords: expert system, typhoid fever, neglected tropical disease, exsys corvid, experttyph.

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I. INTRODUCTION.

Artificial intelligence has several branches including Expert Systems, neural networks, fuzzy systems etc. An Expert Systems use a wide range of specialist knowledge, as a method, to solve problems. An expert refers to someone who has experience and skill in a certain area and in a nutshell, is sophisticated. Therefore, an expert has some knowledge or skill which is unknown or inaccessible to most people. The expert can solve problems which cannot be solved by others, or offers the most efficient solution to this problem [1], [2].

Today, an Expert System is used almost in all areas of human expertise to help users make decisions. Artificial Intelligence in medicine is primarily interested in building intelligent artificial programs that enable diagnosis and can also recommend treatment. An Expert Medical Systems are more likely to be found in clinical laboratories and educational institutions, for clinical surveillance, or in data-rich areas, such as intensive care facilities. What happens is that if they do the right thing, smart programs offer significant benefits. The use of an Expert System in medicine has been in full swing since the early 1970s, when MYCIN was designed to diagnose bacteria that cause grave infections. Many expert medical systems such as the PUFF system, developed to diagnose lung disease; ANGY helps

doctors diagnose coronary vessel narrowing by identifying and isolating coronary vessels in angiograms; BABY helps clinicians by monitoring patients in a neonatal intensive care unit. Rule-based Expert Systems, derived from Buchanan and Shortliffe's work on MYCIN, aim to capture human expertise and traduce in rules. There is compelling evidence that this rule can model the process of human thought. A set rules can be used to capture knowledge of the relevant domain of a human expert and can then be used to replicate the expert's problem-solving in that domain. Probabilistic Expert Systems are the result of research at the intersection of statistics and artificial intelligence [3], [4].

Rule-based Expert Systems include both conventional techniques, such as database management systems, and artificial intelligence techniques, such as knowledge-based systems. Database management is used to store, retrieve, and generally manipulate patient data, In contrast an Expert System is primarily used to perform diagnostics based on patient symptoms, and how patients are diagnosed experts reason and provide a solution [5].

II. EPIDEMIOLOGY, RISK FACTORS, AND DISEASE

2.1 What is typhoid fever?

Typhoid fever is a common illness in places with destitute sanitation and lack of clean water. Typhoid fever is a life threatening infection caused by the bacteria salmonella Typhi, lack of access to safe water and adequate sanitation, health education, proper hygiene among food handlers.

Communities without access to safe drinking water and adequate sanitation, and vulnerable groups, including children, are most at risk. However, the severity varies person to person, and severe cases can lead to serious complications and even death. It mainly occurs in the area with destitute sanitation, and a lack of potable water.

Typhoid fever is usually spread through contaminated food or water. Severe cases can lead to grave complications and even death. Even

when symptoms go away, people can still carry the typhoid bacteria, which means they can pass it to others through their stool. According to the most recent estimate as of May 2020, 11 to 21 million people contract typhoid and between 128,000 and 161,000 typhoid-related deaths occur each year worldwide. A similar but often less sedate disease, paratyphoid fever, is caused by Salmonella Paratyphi A and B (or more rarely Paratyphi C)[6],[7].

Poverty-stricken communities and vulnerable groups, including children, are most at risk. Travelers are at risk of developing typhoid fever in many typhoid endemic countries, particularly in Asia and sub-Saharan Africa. Elsewhere, travelers are generally at risk when exposed to underprivileged personal or food hygiene standards and meager water quality[8].

2.2 Symptoms and signs

People with typhoid fever carry the bacteria in their bloodstream and intestinal tract. The symptom includes prolonged high fever, fatigue, headache, nausea, abdominal pain, and constipation or diarrhea. Some patients may have a rash. Severe cases can lead to grave complications and even death. Typhoid fever can be confirmed by blood tests and only lives in humans.

III. ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEM

3.1 Artificial Intelligence

According to Russell and Norvig [9], Intelligence can be defined as a science which has the capacity to learn and understand, to solve problems and to make decisions. However, artificial intelligence is the display of intelligence by machines, and its principal purpose as a domain is to make machines do things that would require intelligence as if they done by humans. It has been successfully applied in the domain of logistics, data mining and medical diagnostics. However, the success of artificial intelligence has started to recover with the commercial success of Expert Systems.

3.2 Expert system

An Expert System is a computer program that uses knowledge of a problem specific to a given area and emulates the methodology and performance of an expert in the domain concerned. For this purpose, experts in the domain of the problem consulted and attempts made to code in formal language all the knowledge acquired during their experience, including heuristic methods and tips. An Expert System is a form of artificial intelligence program that simulates the knowledge and analytical skills of one or more human experts. Although a common strategy is to find only one expert, when an Expert System is more complex under construction or when the expertise is not well-defined, it may be necessary to use several experts. Conventional is designed for a very narrow domain with skills. This makes the performance of the system entirely dependent on the right choice of experts[10].

IV. METHODS AND MATERIALS

4.1 Methods

The study consists of an integrative review of the scientific literature, carried out in the databases as WHO medicine.

To concretize this study, we used a questionnaire empirically and conducted interviews with health professionals from two health institutes namely Hospital de Cabinda, and Hospital May 1st.

We examined the form of diagnosis and physician decision-making in a non-automated process and developed a series of questions to interview physicians with more than ten years' experience. Physicians are providing common, verifiable, consistent and reliable answers to the questions asked. The study is qualified as qualitative since it seeks to validate the system in terms the quality of the (diagnostic) responses presented. The study was developed according to the following stages:

Phase 1: Identification of problems

Our approach is to develop a decision support system for typhoid fever. In particular, we have designed this decision support system for rural or remote areas where experts are not available. This system facilitates diagnosis for medical personnel and even anyone to diagnose by answering the question.

Phase 2: Knowledge acquisition

We have collected the information with the help of experts and doctors, and we refer to books appropriate to sanitation or lack of social conditions.

Phase 3: Knowledge representation

There is more than seven rules successfully generated by acquiring knowledge.

Phase 4: Verification and validation of knowledge

The rule designed for the disease using the symptoms and signs added to the knowledge base. The whole symptom has always been checked to ensure that the symptom of a disease is corrected. The basis of the rule is designed with the consultation of symptoms with the doctor.

4.2 Materials

4.2.1 Data collection

In this phase, a set of tables will be built to model domain knowledge. These tables constitute a hierarchy, because each condition or action in a table can be constructed in a lower action condition or sub-table, respectively. An appropriate method will simplify the construction process and increase both its efficiency and effectiveness. Depending on the characteristics of the problem domain, several methods can be distinguished [11], dealing with comparable steps in analyzing the problem.

Table 1: Expert´s opinions of typhoid fever (highly probable)

Typhoid Fever				
+++ Highly Probable				
1° Group	2° Group	3° Group	4° Group	5° Group
Acute fever	Acute fever	Acute fever	Acute fever	Acute fever
Constipation	Constipation	Colica Abdor	Constipation	Constipation
Diarrhea	Diarrhea	Asthenia	Diarrhea	Diarrhea
Vomiting	Vomiting		Colica Abdor	Colica
				Abdominal
Chills	Colica Abdm		headache	headache
headache			Asthenia	Chills
Artrhalgia				Asthenia
Nausea				
Asthenia				

Table 1 shows the results of the questionnaire filled out by the doctors and health professionals divided into five groups; the decision table gives different opinions on the confirmation of highly probable typhoid fever.

Table 2: Expert´s opinions of typhoid fever (Probable)

Typhoid Fever			
++ Probable			
Malaise	Anorexia	Malaise	Constipation
headache		headache	Asthenia
Nausea		Constipatio	headache
Asthenia		Asthenia	Chills
Chills		Colica	Nausea
		Abdominal	
Anorexia			Malaise
			Anorexia

Table 2 shows the results of the questionnaire completed by the doctors and health professionals divided into four groups; the decision table gives different opinions on the confirmation of probable typhoid fever.

Table 3: Expert´s opinions of typhoid fever (Less probable)

Typhoid Fever		
+ Less Probable		
Malaise	Malaise	Constipation
Chills	Chills	Chills
Diarrhea	Diarrhea	Diarrhea
Constipation	Anorexia	Malaise

Table 3 shows the results of the questionnaire filled in by the doctors and health professionals divided into three groups; the decision table gives different opinions on the confirmation of less probable typhoid fever.

Table 4: Expert´s opinions of typhoid fever(Improbable)

Typhoid Fever
Improbable
Vomiting
headache
Nausea

Table 4 shows the results of the questionnaire filled in by the doctors and health professionals divided into one group; the decision table gives different opinions on the confirmation of improbable typhoid fever.

4.3 Decision table

Decision making depends on the selection of symptom and signs observed by the doctor; sometimes there is identical, redundant and contradictory actions between opinion´s doctors. To avoid these elements, we have used the decision table which avoids the three elements described below:

- Simplify the table.
- Determine if there are rule that represent impossible situations. If so, delete these columns. There are no impossible situations in this example.
- Determine if there are any rule that have the same actions. If yes, determine if they are identical rule except for one condition; all possible values of this condition are present in the rule of these columns[12]

Table 5: Decision table

Conditions/Rules	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	Else
Constipation	S	S	N	S	S			S	S	S	N	S	
Asthenia	S	N	S	S	S	S	N	S	S				
headache	S	N		S	S	S	N	S	S				
Acute fever	S	S	S	S	S								
Chills	S	N			S	S	N	N	S	S	S	S	
Vomiting	S	S											
Artrhalgia	S	N											
Nausea	S	N				S	N		S				
Diarrhea	S	S	N	S	S				S	S	S		
Colica_Abdominal	N	S	S	S	S			S	N				
Malaise					S	N	S	S	S	S	S		
Anorexia					S	S	N	S	N	S			
ACTIONS													
Highly probable	X	X	X	X	X								
Probable						X	X	X	X				
Less probable										X	X	X	
Improbable													X
	A	A	B	B		C	C	D	D	E		E	
	1		2		3		4		5		6		7

Table 6: Simplify the table

Conditions/Rules	R1	R2	R3	R4	R5	R6	R7	Else
Constipation	S	_	S		S	_	S	
Asthenia	_	S	S	_	S			
headache	_	_	S	_	S			
Acute fever	S	S	S					
Chills	_	S		_	_	S	S	
Vomiting	S							
Artrhalgia	_							
Nausea	_			_	_			
Diarrhea	S	_	S			S	S	
Colica_Abdominal	_	S	S		_			
Malaise				_	S	S	S	
Anorexia				S	_	_		
ACTIONS								
Highly probable	X	X	X					
Probable				X	X			
Less probable						X	X	
Improbable								X
	1	2	3	4	5	6	7	

The table 3 shows the decision table has seven rule after reducing the repetition which the following: three for highly probable, two for probable and two for least probable.

V. DEVELOPMENT OF EXPERT SYSTEM

5.1 System modeling

A formal model of the proposed system is built using the Unified Modeling Language (UML). UML is a modeling system that provides a set of conventions for describing software engineering in terms of objects [13]. It provides diagrams offering different perspective views of system components. For our case, a use case diagram graphically illustrates the interactions between the system, the external system and the user. Use case diagrams play a major role in system design as they serve as a roadmap for building the structure of the system. It also defines who will use the system and how the user expects to interact with the system. The use case diagram of an Expert System is shown in Figure 2.
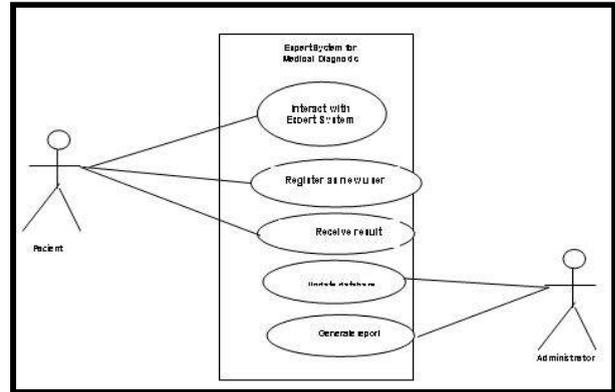

Figure 1: Use case diagram

Table 10: Use Case description

Use case name	Description	actor(s) involved
Register into Expert System	This describes the first event that must occur for a user to have full access to the Medical Expert System	Administrator
Interacts with the Expert System	This describes the event where the user interacts with the system, that is, gives response to the questions asked by the Expert System.	User
Receives treatment	This use case describes the scenario where the user is being diagnosed and given treatment.	User
Update database	This describes the scenario where the Administrator updates the database in terms of the symptoms and prescription tables.	Administrator
Generate Report	Reports of daily use of System are generated	Administrator

The table describes the interface between the user and the administrator.

right

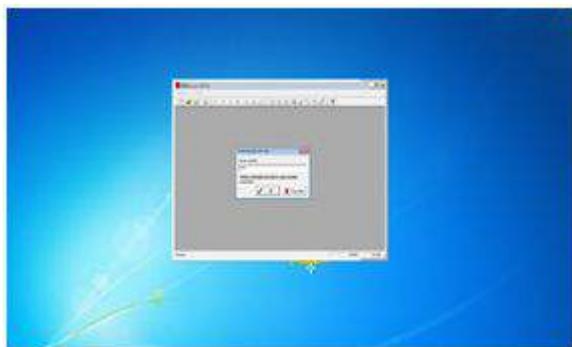London Journal of Medical and Health Research

Figure 4: Principal menu
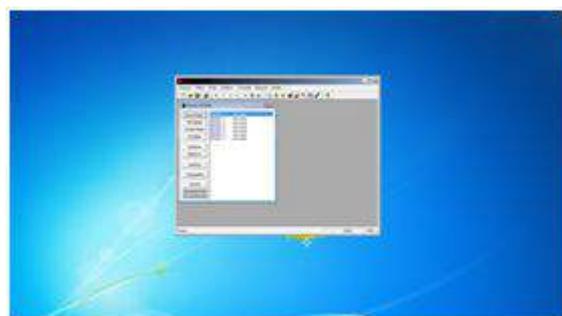

Figure 3: Input dados

Figure 5: Select symptoms

Figure 6: Results

VI. RESULTS

Table 1: Results of Evaluation (Hospital of Cabinda)

		Diagnosis of Doctor		
	Diagnosis Result	Yes	No	Total
Diagnosis of an Expert System	Yes	68	20	88
	No	15	70	85
	Total	83	90	173
	Observed agreement	0,79		
	Expected agreement	0,49		
	Kappa Cohen	0,60		
	Moderate	0.41-0.60		

Table 1 shows from the tests carried out at the Cabinda hospital, the proposed an Expert System worked satisfactorily with a success rate of about 77% 40% of patients who suffer and 37% of patients who don´t suffer typhoid fever, let 77% agreement of the doctor's results.

Table 2: Results of Evaluation (Hospital of May 1st)

		Diagnosis of Doctor		
	Diagnosis Result	Yes	No	Total
Diagnosis of an Expert System	Yes	70	15	85
	No	26	65	91
	Total	96	80	176
	Observed agreement	0,76		
	Expected agreement	0,49		
	Kappa Cohen	0,53		
	Moderate	0.41-0.60		

Table 2 shows, according to the tests carried out at the Hospital of May 1st, the proposed an Expert System worked satisfactorily with a success rate of 39% of the patients who suffered and 39% of the patients who don´t suffer typhoid fever, let 79%.

There is a concordance between results of the doctor and expert system.

VII. DISCUSSION

According to the tests carried out in the two Hospitals, the proposed an Expert System worked satisfactorily with a success rate of around 77% and 79% in real cases. Confidence values provided are also found to be in reasonable relative order. The proposed an Expert System has made it possible to select patients and establish a diagnosis, but it does not work well in particular cases outside its area of knowledge.

It will be possible to improve the success rate in real cases as new knowledge is discovered and integrated into the knowledge base of the system.

Cohen's kappa calculation was performed to verify the reliability between Observed agreement and Expected agreement for an Expert System and the expert. Cohen's kappa was introduced as a measure of tuning to avoid the problems described above by adjusting the observed proportional tuning to account for the degree of tuning expected by chance. Cohen's Kappa is an index of interpreter reliability commonly used to measure the degree of agreement between two sets of scores or dichotomous scores. The proportion of subjects for which there is agreement tells us nothing at all [14].

To examine to what extent there is agreement other than that expected by chance, we need a different method of analysis: Cohen's kappa. Expected agreement (P_e) proportion of units where there is agreement, Observed agreement(P_o) proportion of units that should agree, by chance called Expected agreement. The cases obtained from the medical record of the provincial hospital of Cabinda and of Hospital May 1st, as presented in tables 1 and 2.

The model validity criterion had the best content for a certain diagnostic of the median diagnostic levels (k = 0.41 - 0.60) for typhoid fever.

The system can only be used for typhoid fever, no other diseases and in the next few days it will be possible to create a page web for telephone, Smartphone and tablet. Typhoid fever evaluates the performance of the system by practically testing it on 176 and 173 new cases of typhoid fever, where the system was able to estimate the diagnosis correct 77% and 79% in both hospitals.

VIII. CONCLUSION

In this article we have been able to developing an Expert System that will help physician diagnose patients suffering typhoid fever. The aim of ExpertTyph is to make a prescriptive diagnosis based on symptoms and signs of the patient, to have a result similar to that of doctors. An ExpertTyph presents advantage for rural populations since there is scarcity of doctors and still helps young doctors to have experience of the disease. The system developed with the help of experts who have more than ten years experience in this domain.

The results obtained from this Expert System only don't show the possibility of controlling and reducing the spread of typhoid fever through an environmental diagnostic approach, but also show the future perspectives of an Expert System of different sub-domains of the artificial intelligence to various researches on infectious and tropical diseases neglected especially in underprivileged countries.

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