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Rules-based Expert System to Assist Physicians in Pre-laboratory Screening for the Diagnosis of Pulmonary Tuberculosis Disease in Rural Areas

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ABSTRACT

Worldwide more than 1.5 to 2 million deaths from tuberculosis occur each year. Healthcare professionals face many challenges in delivering good healthcare with unattended automation in hospitals where multiple patients require physician attention. The expert system we have built is designed to help medical experts in the process of pre-laboratory screening for pulmonary tuberculosis. The architecture consists of a rule base, a patient knowledge base. These units interact with the inference engine, which receives patient data through a user interface. The result of the usability rating reveals that the system has a usability rating of 5.6 on a scale of 1-7. This is an indication of above average system performance. Our Tuberculosis Diagnosis Expert System is an effective solution for implementing a rule-based expert system designed with Exsys Corvid.

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Introduction

In general, health professionals prefer to settle in urban areas for financial reasons and to enjoy better working conditions. In rural or remote areas, professionals may feel more isolated, which can affect their work and the follow-up of patients. A new generation of physicians seeks a more favorable balance between work and family life, preferring multidisciplinary practices and part-time jobs.

Primary care with the objective of creating efficient instruments that bring quality of life and health to the population, defined as strategic areas for action throughout the national territory, in addition to other focuses of care, tuberculosis control. The nurse has a fundamental role in these strategies, including: search for diagnosis of cases and treatments; search for prevention; administration in controlling that disease.

Tuberculosis is an infectious and contagious disease, caused by Mycobacterium tuberculosis, a bacterium also called Koch's bacillus, which has had its epidemiological chain and treatment both known for a long time, but persists as a public health problem in many countries[1].

The forms of presentation of tuberculosis are varied and can be manifested in several foci in the human body, such as: lungs, larynx, bones, meninges, brain, ganglia, kidneys and others. The most common is the pulmonary form[1].

The disease was constantly associated with conditions of poverty, which makes it a priority in underdeveloped or developing countries. However, this assertion does not exclude the occurrence of cases in developed countries, in view of the high incidence of tuberculosis coinfection with HIV and other diseases that weaken the immune system[1]. It is considered by the World Health Organization (WHO), since 1993, as a global emergency, and has been highlighted as a priority area in several countries [2].

According to the WHO report, tuberculosis remains the main cause of menace in the health of men and women in morbidity and mortality [1,2]. In the world, one in three, representing 2 to 3 billion of individuals, is infected with Mycobacterium Tuberculosis, do not 5 to 15% without susceptibility to active tuberculosis of the live [3]. According to the WHO, in 2014, it is estimated that 9.6 million people are suffering from malaise due to tuberculosis, approximately 1.5 million people are suffering from sickness illness, don't 1.1 million seronegative people and 400,000 HIV patients [3].

Tuberculosis is present in all of the country, and most of the persons living with tuberculosis in the low-income and intermediate-income countries, in particular in the regions tell us that Africa is under the influence [2].

Tuberculosis constitutes tougher among a large menace for the economic envelope, more than 90% of the ten tuberculosis survivors cheers the adults of the groups of the most products [3].

In this article, four of us have a general overview of tuberculosis and have an accent on the diagnosis of tuberculosis. In preparation

of the material, we have collected it in the journals and scientific journals relevant articles on tuberculosis. This article has just been written to develop software to help healthcare professionals in the diagnosis of tuberculosis.

Literature Revision

Tuberculosis

Tuberculosis (TB) is a disease caused by a slow-growing, strict aerobic, acid-fast bacillus (AFB) that is airborne. For more than three thousand years, this bacterium has increasingly affected the world population. In the 1990s, TB was considered by the World Health Organization (WHO) as a health problem of global emergency, in view of the increase in incidence and mortality from a treatable and curable disease [4].

Pulmonary Tuberculosis

It is the most common form of the disease and begins with the fixation of M. tuberculosis in the pulmonary alveoli. After penetrating the host, that is, the patient, through the upper airways (nose and throat), this bacterium reaches the lungs and begins its multiplication process, which generates tissue necrosis.

Expert System

Expert Systems correspond to a branch of the Artificial Intelligence that deals with knowledge specific for troubleshooting. The knowledge in this type of system is stored in bases called databases. The knowledge and favors the solution of problems that are presented to users through user interfaces.

An expert system is a computer system that simulates the decision-making ability of a human expert. This means that the system must act, in all respects, like the human expert [5].

Expert systems have three main components: a user interface which poses questions to the user and provides an answer; the knowledge base which contains facts and rules in a specific knowledge domain; and the inference engine whose job it is to infer answers or solutions by examining the user's input and the contents of the knowledge base. A knowledge engineer is responsible for taking knowledge from the human expert and writing it as a set of computer rules.

Methods

The study consists of an integrative review of the scientific literature, carried out in the databases: Center for Disease Control and Prevention, National library of medicine, PubMed and WHO. To make this study concrete, we used a questionnaire empirically and conducted interviews with health professionals from four health institutes namely Hospital of Cabinda, Chinga Health Center, Hospital of 1º of Maio and Catarina Health Center for patients with tuberculosis.

Questionnaire survey is the most suitable technique for collecting requirements for open source software because developers can survey community members and can ask what they need, and users can also add exactly what they want. A questionnaire developed to ensure the consistency of the answers of the experts. Experts will be asked to provide symptoms, signs and pathologies. A series of written questions will be provided to the experts so that they can refer to them as the interview progresses. The interview structured to address multiple levels of detail with an emphasis on distinguishing between important factors. We looked at the form of diagnosis and physician decision making in a non-automated process. It is necessary to take into account the factors involved in decision making. We have prepared a series of questions to use for interviewing experts who are physicians with more than 10 years of experience. The questions were exploratory in nature and resulted in a response other than yes or no. The questions will be general enough to draw the attention of experts to areas of concern, but structured to address multiple levels of detail. The structure of the question will provide sufficient flexibility to be used in interviewing experts from different backgrounds and varying degrees of experience.

Experts or doctors are required to provide common, verifiable, consistent and reliable answers to questions asked by users of this system. They will be queried with a series of questions that will prompt the necessary answers to help the expert system user focus on the correct data for their problem.

Table1: Expert´s opinions of tuberculosis

+++ Highly Probable				
1º Group	2º Group	3º Group	4º Group	5º Group
Chronic fever	Chronic fever	Chronic fever	Chronic fever	Chronic fever
Hemoptisia	Hemoptisia	Hemoptisia	Hemoptisia	Hemoptisia
Transpiration	Transpiration	Transpiration	Transpiration	Transpiration
Dispnea	Dispnea	Weight loss	Dispnea	Dispnea
Weight loss	Weight loss	Anorexy	Weight loss	Weight loss
	Cough>15 days	Astheny	Cough>15 days	Cough>15 days
	Agitation		Anorexy	Agitation
			Astheny	Anorexy
				Astheny
++ Probable				
	Anorexy	Cough>15 days	Tosse>15 dias	Dispnea
	Astheny	Chest pain	Anorexy	Anorexy
	headache	Dispnea	Astheny	Anorexy
	Malaise		headache	Astheny
	Chills		Malaise	headache
			Chills	Malaise
			Chest pain	Chills
			Dispnea	Chest pain
+ Less Probable				
		Chills		Cough<15 days
		Malaise		Astheny
				Chills
				Malaise
- Improbable				
_		Headache	_	

Table 2: Decision table

	1	1	2	2		3	4	3	4	5	5	
Conditions/Rules	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Else
Chronic fever	Y	Y	Y	Y	Y	N	N	N	N	N	N	
Hemoptisia	Y	Y	Y	Y	Y	N	N	N	N	N	N	
Transpiration	Y	Y	Y	Y	Y	N	N	N	N	N	N	
Weight loss	Y	Y	Y	Y	Y	N	N	N	N	N	N	
Dispnea	Y	Y	N	Y	Y	N	Y	Y	Y	N	N	
Cough >15 days	N	Y	N	Y	Y	N	Y	Y	Y	N	N	
Agitation	N	Y	N	N	Y	N	N	N	N	N	N	
Anorexy	N	N	Y	Y	Y	Y	N	Y	Y	N	N	
Chills	N	N	N	N	N	Y	N	Y	Y	Y	Y	
Malaise	N	N	N	N	N	Y	N	Y	Y	Y	Y	
headache	N	N	N	N	N	Y	N	Y	Y	N	N	
Astheny	N	N	Y	Y	Y	Y	N	Y	Y	N	Y	
Chest pain	N	N	N	N	N	N	Y	Y	Y	N	N	
Cough <15 days	N	N	N	N	N	N	N	N	N	N	Y	
Actions												
+++ Highly Probable	X	X	X	X	X							
++ Probable						X	X	X	X			
+ Less Probable										X	X	
- Improbable												X

Table 3: Simplification decision table

Conditions/Rules	R1	R2	R3	R4	R5	R6	Else
Chronic fever	Y	Y	Y	N	N	N	
Hemoptisia	Y	Y	Y	N	N	N	
Transpiration	Y	Y	Y	N	N	N	
Weight loss	Y	Y	Y	N	N	N	
Dispnea	Y	_	Y	_	Y	N	
Cough>15 days	_	_	Y	_	Y	N	
Agitation	_	N	Y	N	N	N	
Anorexy	N	Y	Y	Y	_	N	
Chills	N	N	N	Y	_	Y	
Malaise	N	N	N	Y	_	Y	
headache	N	N	N	Y	_	N	
Astheny	N	Y	Y	Y	_	_	
Chest pain	N	N	N	_	Y	N	
Cough>15 days	N	N	N	N	N	_	
Actions							
+++ Highly Probable	X	X	X				
++ Probable				X	X		
+ Less Probable						X	
- Improbable							X

System Implementation

The Expert system was implemented using Exsys Corvid and Java software hosted on the Windows operating system. Java was chosen because of its cross-platform and simultaneous support. Apache Tomcat is the servlet container used in the official reference implementation for Java Technologies servlets and JSP. Java Servlet and JSP specifications are developed by Sun under the Java Community Process.

Figure 1: The user selects an option and then moves to the next page

Figure 2: The results

Results and Discussion

The discussion about the results will based on ISO/TR 16982 [8].

Table 4: Descriptive statistical analysis of questionnaire data

Summary of study variable				
Usability Measures	Responses from doctors	Responses from pacientes	Total numbers of respondents	Total mean rating
Effectiveness	4	4	8	5,6
Efficiency	4	4	8	5,5
User satisfaction	4	4	8	5,7

Table 5: User survey results N = 8

Survey questions Background information	**Average**
Would you be in favor of using the computerized system to diagnose tuberculosis in	
your Hospital Yes/No ?	***5/3
Do you need additional computer training/time to be able to use the computerized	
system(Yes/No) ?	**7/1
Effectiveness	
	Average
Q1 I was able to complete my task successfully and correctly using the application	5,5
Q2 I could easily recognize my mistakes	5,6
Q3 I feel comfortable with the application	5,6
Average	5,6
Efficiency	
Q1 Using the system saves me time	5,5
Q2 I was able to complete my task on time	5,4
Q3 I did not have to perform too many steps or difficulties before completing my task	5,6
Average	5,5
User satisfaction	
Q1 The system is very easy to learn	5,9
Q2 The system was easy to use and user friendly	5,5
Q3 I am satisfied using the system	5,6
Average	5,7
Average	5,6

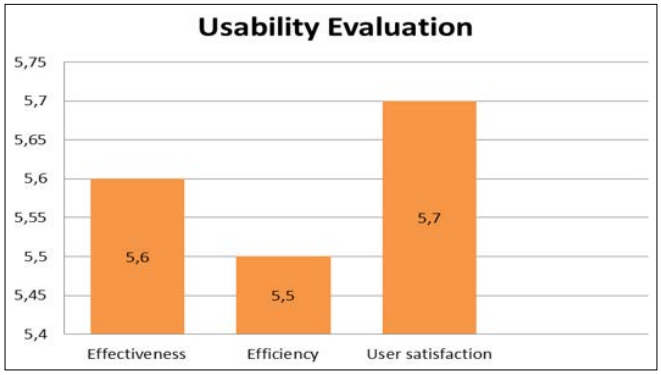

Figure 3: Usability analysis.The effectiveness, efficiency and user satisfaction with the system

A usability study was carried out using the specification in ISO 9241-11 [6].

After collecting the knowledge of the doctors and creating the expert system to help the doctors to diagnose tuberculosis from the symptoms and signs, and to carry out the study on the results, a questionnaire was designed and administered to the doctors and the patients. The questionnaire survey was divided into five sections, namely, General Information, Expert System Effectiveness, Expert System Effectiveness, and User Satisfaction. Each section on effectiveness, efficiency and user satisfaction contains four questions represented by Q1, Q2 and Q3. A total of 9 questionnaires were administered, but only 8 responses were received, analyzed and reported (see Table 4).

Questions were designed using a limited 5-point scale, where 1=strongly disagree, 2=disagree, 3=undecided, 4=agree, and 5=strongly agree.

The mean scores, standard deviation (SD) and variance (VAR) are shown in Table 4. In terms of questions such as "Would you support the use of expert system diagnosis for the diagnosis of tuberculosis in your hospital?", 5 users answered "yes" and 3 said no."

Responses to Q4 on effectiveness - "I feel comfortable with the application" - were lower compared to the other questions. Nevertheless, the results of the user survey were encouraging, especially the responses to questions about user satisfaction. It has been proposed by Sauro and Kindlund that "good usability" should mean a rating of 4 on a scale of 1 to 5 and 5.6 on a scale of 1 to 7 [7].

Therefore, it can be concluded that the application has "Good usability" based on the average total rating of 4.08. The usability analysis chart for each survey variable tested is shown in Figure 6 and Kindlund that "good usability" should have an average rating of 4 on a scale of 1 to 5 and 5.6 on a scale from 1 to 7 [7]. Therefore, it can be concluded that the developed expert system has "good usability" based on an average total score of 5.6. The usability analysis plot for each survey variable tested is shown in Figure 6.

Conclusion

After performing extensive information collected from the clinical biology of Mycobacterium, we used a questionnaire, a decision table based on facts and rules for the development of the prediction system. Our knowledge base draws heavily on the depth of information gathered on the clinical biology of Mycobacterium. A rules-based approach was applied and the knowledge stored in the form of rules and facts to help medical practitioners reduce the patient-doctor ration in hospitals and ultimately the long-term consultation time. The result of the usability evaluation reveals that the prototype application developed has obtained a "good usability" rating of 5.6 out of 7. This shows that the application will not only complement the manual diagnostic systems of the existing tuberculosis, but will also benefit doctors and patients.

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