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Expert System Design for Early Detection of Tuberculosis Disease (Case Study at Demak District Health Office)

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A B S T R A C T

This research aims to design an expert system for early detection of Tuberculosis (TB) disease. The existence of this system is reduce the number of TB patients in the community. The expert system concept developed is building relationships of TB symptoms based on knowledge obtained from the TB programmer at the Demak District Health Office and the form used for TB screening as a reference for knowledge in this system. Based on the results, the system is designed to be able to diagnose TB disease based on the symptoms felt by the user. It will validate rule matches based on 1 main symptom and 6 additional symptoms to get TB diagnosis results, called suspected tuberculosis or not suspected tuberculosis.

INTRODUCTION

Tuberculosis (TB) is one of the leading causes of health problems and death in the world. The disease is highly contagious and most commonly affects the lungs. The emergence of TB disease is caused by the presence of *Mycrobacterium Tuberculosis* in the body (WHO, 2023a; Ziliwu & Girsang, 2022). It is estimated that about a quarter of the world's population has been infected with *Mycrobacterium Tuberculosis* and 5-10% of them have shown symptoms that lead to TB disease. In Indonesia alone, TB cases are ranked second in the world after India (WHO, 2022). In 2022, WHO estimates that there will be 969,000 TB cases in Indonesia and only 717,941 cases reported (WHO, 2023b). Of these number of cases, there are still many cases that have not been found due to public unawareness of early detection of this disease.

In accordance with Minister of Health Regulation No. 67/2016 on Tuberculosis Control, TB disease must be detected early and treated thoroughly because it is easily transmitted, has a risk of treatment resistance, and can cause various complications and death. The sooner it is detected, the higher the chance of recovery (RI, 2016). Early detection is one of the efforts to break the chain of TB disease development so that it does not become a frightening epidemic for the community. Thus, early detection of TB cases can reduce the number of TB patients in the community.

Along with the development of technology in the health sector, one alternative in conducting system-based early detection is to use an expert system that is able to diagnose TB disease. The knowledge base of this system is built based on an accurate reference in the detection of TB disease. Then the knowledge will be designed in the form of a TB screening information system to facilitate the community in detecting early TB disease automatically (Shih et al., 2019). Case finding efforts through early detection of TB disease can be one of the keys to preventing TB from becoming more widespread in an environment. This research seeks to design an expert system for TB disease. The system designed is limited to disease diagnosis, whether a person is suspected of having TB disease or not.

THEORETICAL REVIEW

Tuberculosis

Tuberculosis is an infectious disease transmitted by the bacteria Mycobacterium tuberculosis. This disease generally attacks the lungs, but it is possible to attack other organs such as the eyes, skin, intestines, and so on. TB is transmitted from the patient to others through droplets of the patient's sputum that are inhaled by others when the patient sneezes, spits, or coughs. A person infected with TB in one cough can produce approximately 3000 sputum splashes (Kemenkes, 2014). After a period of infection, signs and symptoms of the disease will appear. A person infected with the TB bacterium will experience signs and symptoms that can be a signal for someone to immediately see a doctor. Symptoms that arise from someone infected with TB include (Kemenkes, 2014) :

1. *General Symptoms*
   - Cough for 2-3 weeks or with continuous sputum.

- Weight loss and/or loss of appetite.
- Feeling unwell (malaise) and weakness in the body.
- Fever lasts for a long time but the body temperature is not too high, often fever occurs at night with night sweats. In some cases, there is an influenza-like fever, which fluctuates continuously.

2. *Special Symptoms*
   - If there is a partial blockage of the bronchi, the passages leading to the lungs, due to increased pressure on the lymph nodes, this causes a "wheezing" sound with weakened breathing and chest tightness.
   - If there is fluid in the pleural cavity (lung lining), it may be accompanied by chest pain.

Expert System

An expert system is a human knowledge system where knowledge is entered into a computer and used to solve problems that normally require human expertise. (Kusrini, 2008). Simply put, an expert system can be defined as a system that can adopt the knowledge of an expert. In addition, this system can be used by lay people in making decisions that can usually only be done by an expert. There are 5 components of expert systems (Bock et al., 2012; Lucas & Van Der Gaag, 1991):

1. *Knowledge Base*
   Contains the relevant knowledge to understand, formulate, and solve problems. It consists of specific facts and rules that guide how knowledge is used to solve specific problems in a particular area.
2. *Inference Engine*
   This component guides the use of the knowledge in the system by developing an agenda for organizing and controlling the steps in solving a task.
3. *Knowledge Acquisition and Learning Module*
   The process of building or extending the knowledge base by collecting, transferring, and transforming problem-solving expertise from expert or documented knowledge sources into a computer program. Knowledge that allows it to be used as a reference such as human experts, books, multimedia documents, databases (both public and private), specialized research reports, and information available on the Internet. An expert system requires a knowledge engineer or knowledge elicitor to interact with one or more human experts to build the knowledge base.
4. *User Interface*
   In order to facilitate communication between the user and the computer, expert systems include a speech processor. In most of the existing systems, a question and answer approach is used to interact with the user.
5. *Explanation Module*
   This module explains the decision-making process by the system (how a decision can be obtained).

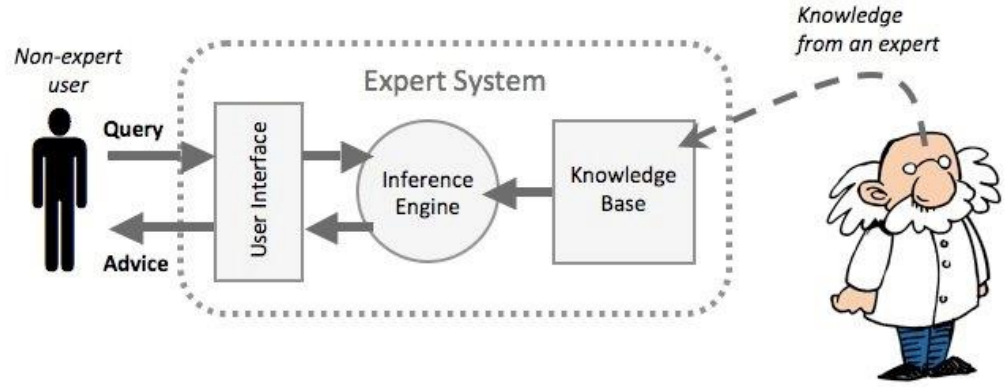


Figure 1. Expert System Model

METHODOLOGY

Collection of information data and rules used as rules in the expert system in this study, obtained based on interviews with the TB Programmer at the Demak District Health Office and supported by the TB screening form which will be used as a reference knowledge in the expert system. The research framework using the expert system design can be seen in the following figure:

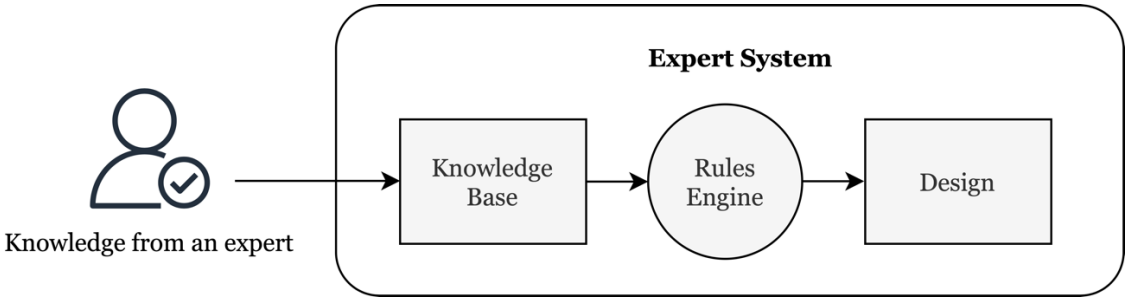


Figure 2. The Research Framework

RESULTS

A. *Knowledge Representation*

Information collection is based on data searches and information obtained from a TB expert. In this study, the relationship of TB symptoms was created based on knowledge obtained from the TB programmer at the Demak District Health Office and the forms used for TB screening in the region. The scientific knowledge gained leads to the recognition of TB disease types through the risk level of the disease based on the corresponding symptoms and is depicted in the following table:

Table 1. Symptoms of Tuberculosis

Symptom Type	Symptoms	Answer	
Main Symptom (MS)	Cough for more than 2 weeks	Yes	No
Additional Symptoms (AS)	Weight loss without apparent cause	Yes	No
	Decreased appetite	Yes	No
	Fever of unknown cause for 2 weeks	Yes	No

	Body weakness or lethargy	Yes	No
	Night sweats without any activity	Yes	No
	Shortness of breath without chest pain	Yes	No

B. Knowledge Inference

In providing the decision results of the expert system, the production rules are written in the form of IF [assumption] THEN [conclusion] statements. The database design of this expert system is based on symptoms and conclusions that affect the type of TB disease, therefore the proposition model is IF (symptom) followed by THEN (suspect/not). In this expert system, a rule can have many symptoms. For each related symptom is combined with the logical operator and (AND). It will be said to be suspected TB if someone has the main symptoms and at least 2 additional symptoms. To make it easier to understand the relationship, it will be explained in the following rule:

Table 2. Tuberculosis Disease Decision Rule

Rules	Condition
Rule 1	IF (MS = 'Yes' AND NumOfAS='Yes' ≥ 2 THEN Suspected Tuberculosis
Rule 2	IF (MS = 'Yes' AND NumOfAS ='Yes' ≤ 2 THEN Not Suspected Tuberculosis
Rule 3	IF (MS = No AND NumOfAS ='Yes' ≥ 2 OR $ NumOfAS ='No' THEN Not Suspected Tuberculosis
Rule 4	IF (MS = No AND NumOfAS ='Yes' ≤ 2 OR $ NumOfAS ='No' THEN Not Suspected Tuberculosis

C. System Design

In order to make it easier to understand the design of this expert system, Use case diagrams are used to describe the function, scope, and interaction of users with the system. In this study, the use case diagram can be described with the following model :

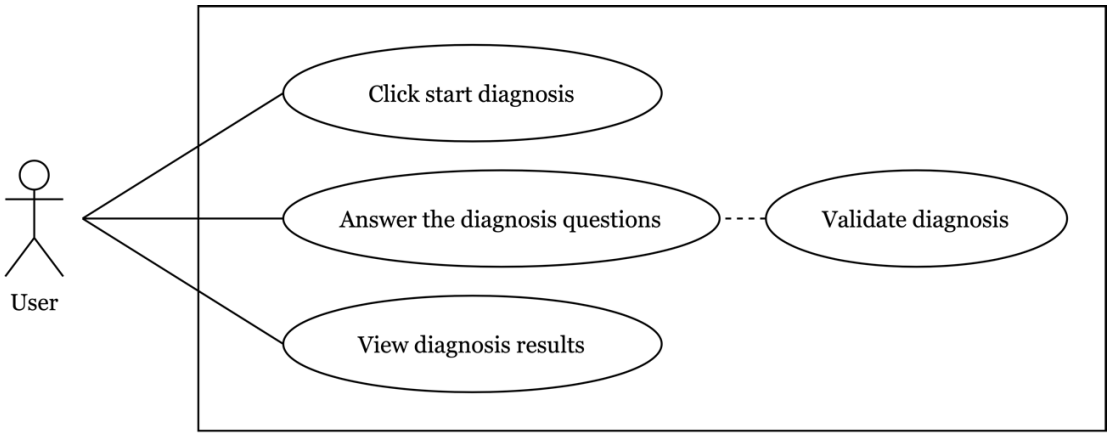


Figure 3. Use Case Diagram

The diagram above is an image that explains how users will use a system or computer program using certain symbols to clarify the flow. The explanation of the user case diagram designed in the TB expert system is as follows:

1. To start using the system, the user clicks "Start Diagnosis"
2. After that the user answers all the questions given by the system for the purpose of validating the diagnosis.
3. From the validation, the system will match the answers to each question given to the user to find the name of the disease experienced by the user.
4. After the system finds an expert system decision that shows the user is suspected of having TB disease or not.

While the design of the interface design on the TB early detection system will be described using a user interface. User interface is a visual display that is on the first page of a website or application that contains menus or information with the aim that users feel comfortable when opening a website or application. This system is designed to have several simple pages that are expected to make it easier for people to run the TB early detection system, as follows :

1. *Identity Page*
   The design of the identity page is the design of the system interface that first appears before the user starts the diagnosis by filling in the identity and location data where the user lives.

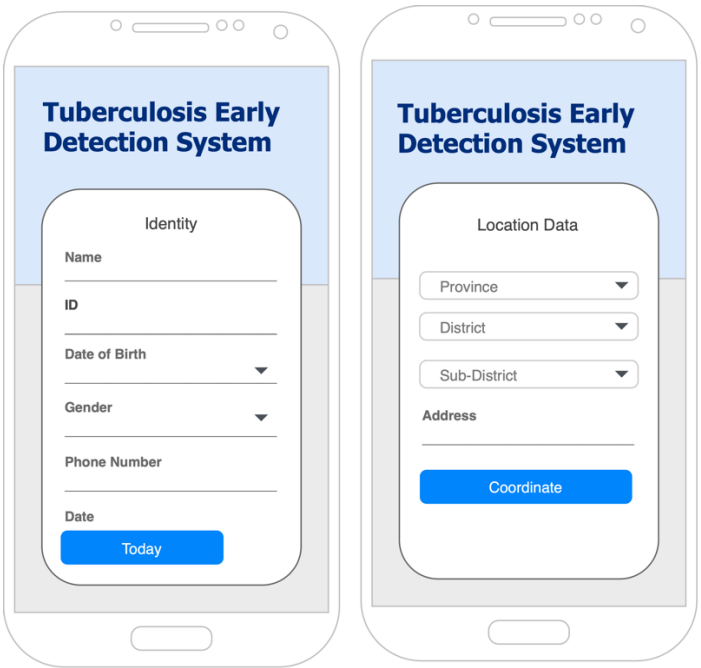


Figure 4. Identity Page

2. *Main Symptom Page*
The main symptom page is one of the core pages in the system because on this page the user inputs the answer choices from 1 question on the system.

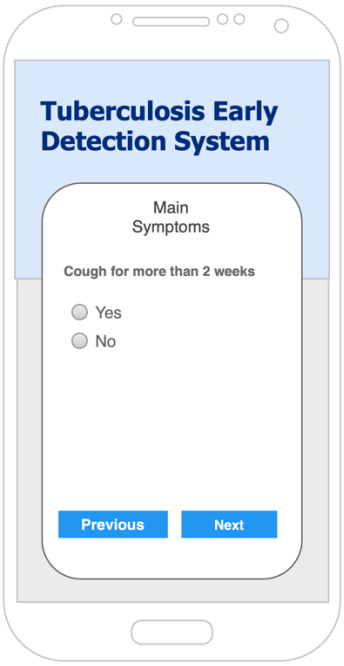
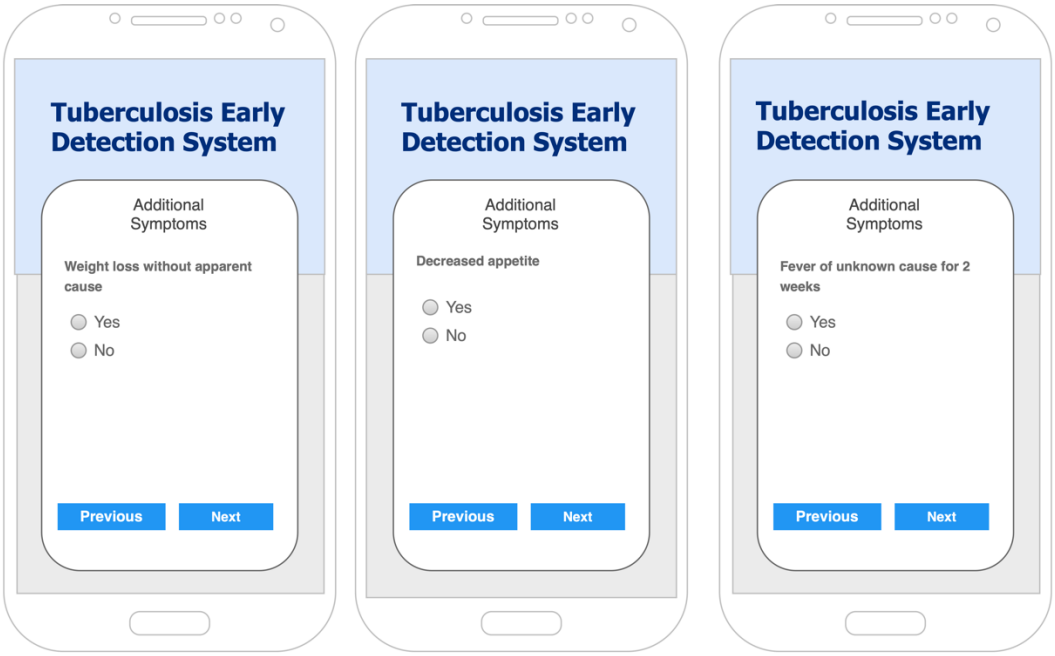


Figure 5. Main Symptom Page

3. *Additional Symptoms Page*
The design of the symptom page displays the questions asked by the system with 6 questions and two answer options "yes" and "no" are provided. The user must answer all the questions of the symptom statement that is felt.



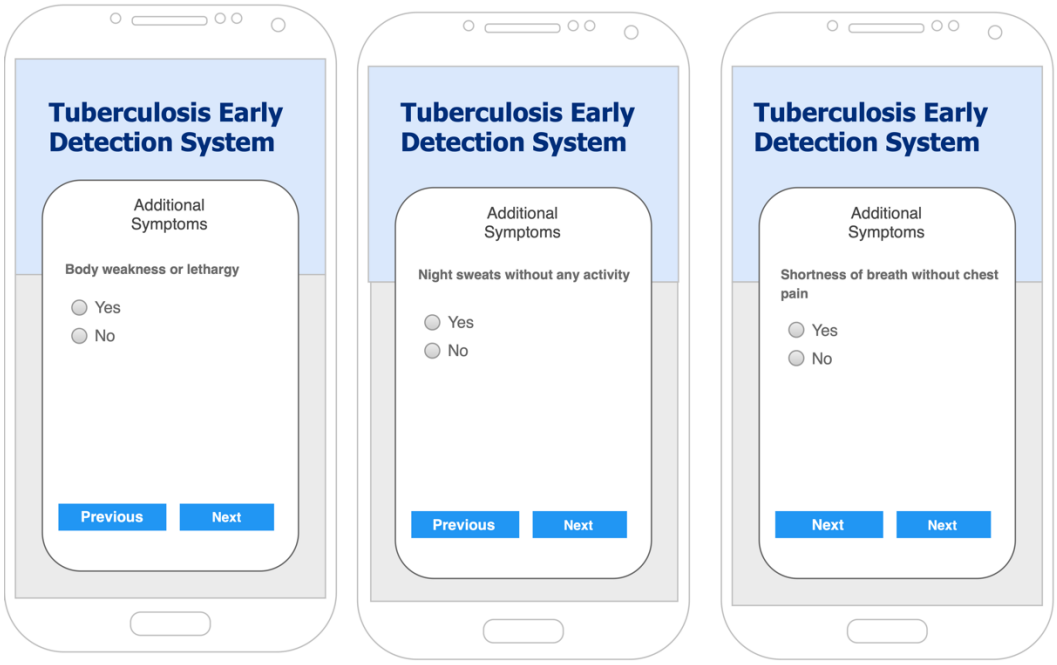


Figure 6. Additional Symptomps Page

4. The TB Diagnosis Results Page of the Expert System
   The design of the diagnosis results page displays the results of the diagnosis according to the symptoms filled in on the previous page in the application according to the answers inputted by each user. Then the system will validate the match of rules to get the results of TB diagnosis, called Suspected TB or not.

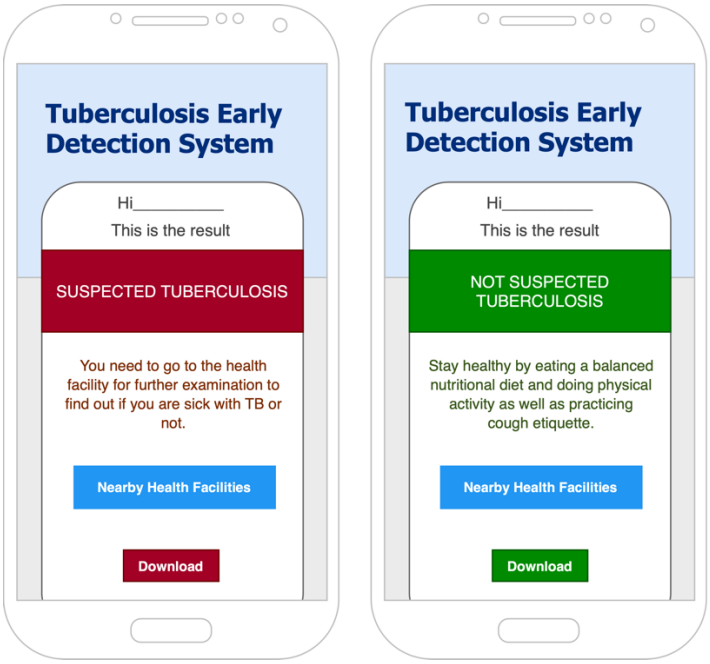


Figure 7. TB Diagnosis Results Page of the Expert System

DISCUSSION

TB early detection system is a system that involves the use of information technology using medical knowledge and predefined rules to help identify the possibility of tuberculosis in a person. These systems typically utilize user-inputted symptom data, such as disease history and symptoms to provide an initial diagnosis or recommendation. The system will analyze and interpret the symptom data and health-related information of the individual to determine the likelihood of tuberculosis.

The importance of early detection of disease using expert systems has proven to be very helpful for the community and health workers in reducing the number of TB patients in an area. TB expert systems have higher reliability in detecting TB disease (Nabila, 2023; Zendrato et al., 2023). The system is able to provide a more accurate and reliable diagnosis that allows early detection to be more effective (Idensia et al., 2024; Ruliah et al., 2020). The existence of this system can be a tool that helps and facilitates health care facilities to increase TB case finding in the community. This system also contributes to increasing the discovery of cases at risk of TB as an early prevention effort for the community related to TB disease so as to improve public health status (Madona et al., 2023).

CONCLUSIONS

Based on the results of designing an expert system for early detection of TB disease, it is found that the system is designed to be able to diagnose TB disease based on the symptoms felt by the user. The system will validate rule matches based on 1 main symptom and 6 additional symptoms to get TB diagnosis results, namely TB suppression or not. In addition, the design of the expert system display produces several main pages in the TB expert system, namely the identity page, the diagnosis page based on the main symptoms and additional symptoms, and the TB diagnosis results page. The design of each page is designed simply so that users are easy and understand in operating the developed system. Early detection of TB cases is expected to reduce the number of TB patients in the community.

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