ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF COMPUTING

DEVELOPING KNOWLEDGE BASED SYSTEM FOR THE DIAGNOSI OF TUBERCULOSIS DISEASE AND TREATMENT.

BY

YONAS TESFAYE

September 4, 2015

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A Thesis Submitted to the School of Graduate Studies of Adama Science and Technology University for Partial Fulfillment of the Requirements for the Degree of Master of Science In Software Engineering

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ABBREVIATIONS

1.	NTCP	National Tuberculosis Control Programmed
2.	TB	Tuberculosis
3.	WHO	World Health Organization
4.	KBS	Knowledge-Based Systems
5.	MDR-TB	Multi-Drug Resistant Tuberculosis
6.	EDRTB	Extensively Drug-Resistant Tuberculosis
7.	HIV	Human Immunodeficiency Virus
8.	DOT	Directly Observed Treatment
9.	KB	Knowledge Base
10.	AI	Artificial Intelligence
11.	KR	Knowledge Representation
12.	ADS	Automated Decision Support Systems
13.	ES	Expert System
14.	FOL	First Order Logic
15.	INH	Isoniazid
16.	RIF	Rifampin
17.	PZA	Pyrazinamide
18.	EMB	Ethambutol
19.	S	Streptomycin
20.	TST	Tuberculin Skin Test
21.	IGRA	Interferon Gamma Release Assay
22.	LTBI	Latent TB Infection
23.	RPT	Rifapentine
24.	KBSTBDDT	Knowledge-Based Systems For Tuberculosis Disease Diagnosis and Treatment
25.	TBDKBS	TB Diagnosis Knowledge Based System

ABSTRACT

Tuberculosis is major public health problem in Ethiopia more than half a century ago. If the disease is not treated well and on time, it can lead to severe health problems like lungs, but can also affect other organs, including the central nervous system. Therefore, detecting those diseases at early stages enable us to overcome and treat them appropriately. However, among people in the developing countries like Ethiopia, permanent diseases are growing to be causes of death. These problems are becoming worse due to the scarcity of specialists, practitioners and health facilities. In Ethiopia, there has been observed a threat of increased prevalence Tuberculosis and the number of death rates imputed to Tuberculosis reached above 29,000 deaths (35 per 100,000) due to TB, excluding HIV related deaths, during the same period, 2014. In an effort to address such problem, this study attempts to design and develop a prototype knowledge-based system that can provide advice for physicians and patients to facilitate the diagnosis and treatment of Tuberculosis patients. To this end, knowledge is acquired using both structured and unstructured interviews from domain experts which are selected using purposive sampling technique from health agents. Relevant documents analysis method is also followed to capture explicit knowledge. Then, the acquired knowledge is modeled using decision tree that represents concepts and procedures involved in diagnosis and treatment of Tuberculosis and production rules are used to represent the domain knowledge and knowledge-based system is developed using SWI Prolog editor tool. It uses backward chaining which begins with possible solutions or goals and tries to gather information that verifies the solution. The system was evaluated using visual interactive method; it was shown that the system agreed with human expert opinions in 81.25 percent of the decision.

Keywords: Knowledge-Based System, Knowledge representation, knowledge acquisition, Tuberculosis.

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Tuberculosis (TB) is one of those infectious diseases caused by bacteria whose scientific name is mycobacterium. It was first isolated in 1882 by a German physician named Robert Koch. Tuberculosis has been recognized as major public health problem in Ethiopia more than half a century ago. The effort to control tuberculosis began in the early 1960s with the establishment of TB centers and sanatoria in three major urban areas in the country namely Addis Ababa, Asmara, and Harar. The Central Office of the National Tuberculosis Control Programmed (NTCP) was established in 1976. Many years ago, this disease was referred to us consumption because without effective diagnosis and treatment, these patients often would waste away. Today, of course, tuberculosis usually can be treated successfully with antibiotics but there is a problem with diagnosis of the disease. TB is a common and deadly infectious disease that can occur at any age. It mostly affects the lungs, but can also affect other organs, including the central nervous system (Abdi et al, 2010).

Ethiopia's health care system is among the least developed in Sub-Saharan Africa and is not, at present, able to effectively cope with the significant health problems facing the country. Communicable diseases are the primary illnesses. Acute respiratory infections such as tuberculosis, upper respiratory infections, and malaria are the Ministry of Health's priority health problems. These afflictions accounted for 17 percent of deaths and 24 percent of hospital admissions in 1994 and 1995 E.C. Poor sanitation, malnutrition, and a shortage of health facilities are some of the causes of communicable diseases (Asia, 2012).

Ethiopia experiences a heavy burden of disease mainly attributed to communicable infectious diseases and nutritional deficiencies. Shortage and high turnover of human resource, inadequacy of essential drugs and supplies have also contributed to the burden (Abdi A., 2010). Ethiopia is one of the 22 High Burden Countries. According to the WHO global TB report 2011, there were an estimated 220,000 (261 per 100,000) incident cases of TB in Ethiopia in 2010. According to the same report the prevalence of TB was estimated to be 330,000 (394 per 100,000). There were an estimated 29,000 deaths (35 per 100,000) due to TB, excluding HIV related deaths, in Ethiopia during the same period (FDROEMH, 2014)According to the 2002 E.C (2009/10) health and health related indicators of the Federal Ministry of Health, tuberculosis is the second cause of death in Ethiopia. During the year 2010/11 (2003 EC), a total of 159,017 TB cases were notified in Ethiopia. Among these 151,866 (95.5%) were new cases of TB, all forms. According to the 2002 EC (2009/10) report of Federal Ministry of Health, about 79% of HIV positive clients were screened for TB, of these 11% were found to have active TB.

It is estimated that about one billion individuals are infected worldwide with tuberculosis, with 10 million new cases and over 3 million deaths per year(Taura et al, 2008). Tuberculosis is amongst the world's leading cause of death from a single infectious disease. The healthcare industry has experienced a proliferation of innovations aimed at enhancing life expectancy, quality of life, diagnostic and treatment options, as well as the efficiency and cost effectiveness of the healthcare system (Vincent H., 2007).

Particularly in developing countries community health centers usually offer a broad range of services, including prenatal care, immunizations, treatment of childhood illnesses, treatment of malaria, tuberculosis and other common infectious diseases, and other basic medical care. In 2010, an estimated 1.1 million deaths occurred among HIV negative cases of TB including 0.32 million deaths among women (FDROEMH, 2014). In this regard, Ethiopia's main health problems are said to be communicable diseases caused by poor sanitation and malnutrition (Richard, 2009).

These problems are exacerbated by the shortage of trained manpower and health facilities. Hence, the main goal of the country is to have a health care system that gives a comprehensive and integrated primary health care at the community level emphasizing on disease preventive aspects without neglecting the curative aspects of medicine. Naturally, this means building a wide-reaching system that focuses on communicative diseases, such as HIV, Tuberculosis, and Malaria; and maternal and childcare health issues such as immunization and reproductive health. TB is a leading cause of morbidity and mortality in adult's worldwide, killing more than 1.5 million people every year (Elamy A el al., 2010).

Diagnostic delay reflects patient delays in seeking health care, health care providers delay in making prompt and correct diagnosis and initiation of treatment. The incidence of TB has more than doubled in Africa during the last two decades. Ethiopia is ranked 8th among the 22 countries with the highest TB burden in the world (WHO, 2003/2004). This unprecedented increase in TB is attributable to a number of factors, one of the most important being the large number of infectious TB patients who remain undetected and untreated, thereby maintaining the cycle of TB transmission (Abdi A., 2010).

A knowledge based system can be defined as a computerized system that uses knowledge about some domain in order to deliver a solution concerning a problem. The goal of a knowledge base system is to understand and develop computational models of human intelligence. Knowledge based systems are part of artificial intelligence, which is originally designed to solve problems by applying knowledge of domain experts (Thomas et al, 2009).

One of the earliest applications of expert systems in a biological discipline was in the medical area. As they are very rich in domain knowledge, knowledge-based systems (KBS) quickly became an essential tool for diagnostics and treatments in the medical area. Knowledge base systems are widely used in domains where knowledge is more common than data and that require heuristics and reasoning logic to derive new knowledge (Mohamed, 2009).

Knowledge-based intelligent systems can be employed to reduce the number of deaths and the waiting time to see the specialist. The systems developed by imitating human intelligence could be employed to help the medical doctors in making decision without consulting the specialists. The system is not meant to replace the specialist or medical doctor, but it is developed to help general physicians and specialists in diagnosing, predicting condition of patient, and providing treatments from certain grounds or experiences. Thus, using knowledge-based systems can be an encouraging solution to reduce cost, time, human expertise and medical error (W. Wan-Ishak, and F. Siraj, 2011).

1.2. Statement of the Problem

The underlying research problem that needed this research is the existence of high death rate of TB at a national level. TB is a great problem in most low income countries. It is the single most frequent cause of death in individuals aged fifteen to forty-nine years (Temurtas *et al*, 2010). TB continues to be a major public health concern. The devastating impact of TB on vulnerable populations is also driven by its deadly synergy with HIV. HIV infection compounds the problems of accurate diagnosis as well as adequate treatment. TB causes more rapid deterioration of the immune systems of people with HIV or AIDS, and they are 100 times more likely to have active TB during their lifetime than people who are HIV-negative (Elamy A el al., 2010).

People with advanced HIV infection can have active TB that is smear-negative or without typical chest radiography features, which means that co-existent TB infections remain untreated. Although, a good treatment of the patients is periodically carried out in a challenge on the diagnosis of the disease and Serious data quality issues with limited use of TB information for local decision. Reports of varying disease burden across different localities with same-fits-all TB control efforts. Hence, by assuming the patients' disease can be TB, they started the therapy for the disease. After some weeks it may be discovered that it is wrongly diagnosed. This leads to delay the control program of the disease and because of such kind of problems lots of patients die and also in the rural area there is lack of doctor in clinical or lack of proper knowledge by community health workers to be the major challenges of TB controlling program in many developing countries. It has been difficult to health of the people if diagnosis at early stage before the condition get worse. In order to solve this problem, knowledge based system has been identified as a powerful tool with extensive potential in alleviating health problems. TB infections are characterized by low grade fever, coughing, fatigue, and a loss of appetite. Later, coughing with hemoptysis (blood in the sputum), may occur. If the infection in the lung worsens, then further symptoms can include chest pain, and shortness of breath. If the infection spreads beyond the lungs, the symptoms will depend upon the organs involved (Medicine Net, 2011).

The problem in this research emanates from the fact that there is lack of knowledge among primary health care workers which has become obstacle to address the TB diagnosis effectively, especially in developing countries like Ethiopia. If untreated, TB leads to deaths within 5 years in at least half of the patients. (FDROEMH, 2014).

This proposed system is applicable and promising for assisting development agents who are working in rural areas where skilled health experts are unavailable for an early treatment to the infected patient before the condition get worse and also used for urban which is to manage their health problem from TB. In Ethiopia most of in rural area where skilled health experts or doctor are unavailable. Only the health extension in most of in rural area is assigned. However, they are not experts as like a doctor. The tuberculosis diagnosis knowledge based expert system is efficient in solving health problems to make immediate decisions for the outbreak of tuberculosis diseases using the type of diseases and their symptoms stored as rules and facts in the knowledge base.

In this study an attempt will be made to answer the following research questions

- What are the symptoms that indicate tuberculosis?
- What are the appropriate management techniques taken by experts to manage tuberculosis?
- How to design knowledge based system for tuberculosis disease and treatment?
- How to acquire model, represent and implement knowledge based system for tuberculosis disease prototype?
- How to evaluate the performance of knowledge based system prototype developed for knowledge based system tuberculosis disease diagnosis and treatment?

1.3. Objective

1.3.1. General Objective

The general objective of this research was to develop knowledge based system for the diagnosis of tuberculosis disease in order to provide better information for physicians and patients.

1.3.2. Specific Objectives

The specific objectives of the study were:

- To understand the concept that can be helpful in designing knowledge based systems for tuberculosis disease diagnosis of the pre-laboratory screening process.
- To extract knowledge from domain experts and manuals in the area of tuberculosis disease diagnosis.
- To design a system where the user can interact with the system to manage or diagnosis various tuberculosis diseases.
- To model and represent the acquired knowledge using appropriate knowledge representation technique.
- To develop a knowledge base that consist information about tuberculosis disease diagnosis of the pre-laboratory screening process against tuberculosis infection to aid diagnosis and to provide suggestion to control them.
- To test and evaluate the performance and user acceptance of the developed system.

1.4. Methodology of the Study

In order to achieve the objectives of this research the following methods and techniques are employed.

1.4.1. Literature Review

In this study, materials such as journals, related works and manuals, which are helpful for the enhancement of the research, were reviewed. The necessary documents and tools for the development of the prototype were also reviewed.

1.4.2. Requirement Gathering

Both unstructured and structured interview were used to collect tacit knowledge from domain experts. In addition to evaluating the requirements elicitation methods are used to purify the collected knowledge. The acquired knowledge is refined with the consultation of the expert. Moreover, secondary sources of knowledge are gathered from the internet, tuberculosis diseases diagnosis and treatment guide lines, research papers and articles by using document analysis technique.

1.4.3. Requirement Gathering Techniques and Sample Size

Purposive sampling technique would be used to select domain experts for knowledge requirements acquisition. The selection criteria of domain experts for the study are based on the profession, educational qualification level, year of experience and their immediate position in the tuberculosis diseases diagnosis.

1.4.4. Knowledge Requirement Representation Method

After the knowledge would be acquired, it was represented using rule based knowledge requirement representation method. For this research the knowledge requirement representation method, rule based was chosen because it clearly demonstrates the domain knowledge. In rule based system much of the knowledge was represented as a rule that is as conditional sentences (IF THEN) relating statements of facts with one another. As a result rule based representation method is more appropriate to represent and demonstrate the real domain knowledge in diagnosing tuberculosis diseases. Additionally, rule based systems are the most commonly used knowledge representation language in health sector.

1.4.5. Software Requirements Tools

The programming languages and tools would be used to develop knowledge-based systems. In this study, SWI-prolog programming language would be used to build the knowledge base of the system. The reason of the selection of this programming language is the features and abilities of the language that incorporate it. Prolog is a declarative language (we specify what problem we want to solve rather than how to solve it) and has the capacity to describe the real world. It has flexible and fast interface. In addition it is portable to many platforms including almost all UNIX/LINIX platform and window vista.

1.4.6. Requirement Verification and Validation

The developed prototype rule based system would be tested and evaluated to ensure the performance of the system in meeting towards established objectives. Prototyping enables the user to gain a better understanding of the requirements and provides important user feedback. The evaluation process was more concerned with system user acceptance validations of the prototype. User acceptance efforts are concerned with issues impacting how well the system addresses the need of the user. To assess human factors visual interaction together with questionnaires methods are used. Domain expert evaluators interact with the system by using appropriate cases. Then they evaluated the system by using closed ended questionnaires.

1.5. Scope and Limitation

There are many diseases which are affected the patient in Ethiopia. This research focuses on development of a knowledge based system to diagnose tuberculosis disease and treatment in Ethiopia. The reason of developing knowledge based system focusing tuberculosis diseases diagnosis and treatment i.e. TB is a common and deadly infectious disease that can occur at any age and difficult to diagnosis with properly symptom than other disease that affected the patient.

1.6. Significance of the Study

The general, benefits and beneficiaries of the research will be the following:

- The primary beneficiaries of this research output is those experts who are involved tuberculosis diagnosis activities. The knowledge based system can help experts in controlling and managing consistently during tuberculosis diagnosis, to manage wrong tuberculosis diagnosis. Those inconsistencies created by human experts during tuberculosis diagnosis will be solved if this system is applied.
- The secondary beneficiaries of this research output is those subjects who receive tuberculosis diagnosis. Those patients who need a tuberculosis diagnosis can get the correct tuberculosis type for the right patient. An expert can't be any doubts about diagnosis and it is also advantageous for remote and rural areas that have scarcity of medical professionals and medication facilities.
- It can be reduce burden of TB among people living with HIV.
- To serve as temporary assistance to those who are in need of instant help when expert consultant is not readily available due to time and distance.

1.7. Organization of the Thesis

The remaining part of the thesis is organized as follows:

Literature Review (Chapter Two) – In this chapter, the basics of Overview of Tuberculosis in Ethiopia, types of tuberculosis disease, causes of TB and Conceptualizing the basic ideas of knowledge based system is essential to understand sufficiently. Methodology of the study (Chapter Three) - this chapter deals about, the methodology used to carry out the research. The knowledge engineering methodologies, how knowledge for the research is acquired, modeled and verified is provided in detail. The development life cycle used in the research are explained. Knowledge Based System Development (Chapter four) - In this chapter, the knowledge representation procedures followed are explained. Production rule the real representation of this research is represented in this chapter and detailed knowledge representation was presented using IF_THEN representation technique. Chapter five study about summarizes the basic concepts discussed in the entire body of the research and it forwards some future directions on top of this study.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Tuberculosis in Ethiopia

Ethiopia's health care system is among the least developed in Sub-Saharan Africa and is not, at present, able to effectively cope with the significant health problems facing the country. Communicable diseases are the primary illnesses. Acute respiratory infections such as tuberculosis, upper respiratory infections, and malaria are the Ministry of Health's priority health problems. These afflictions accounted for 17 percent of deaths and 24 percent of hospital admissions in 1994 and 1995 E.C. Poor sanitation, malnutrition, and a shortage of health facilities are some of the causes of communicable diseases (Asia Nesredin, 2012).

2.2. Overview of Tuberculosis

Tuberculosis (TB) is a chronic bacterial infection caused by Mycobacterium tuberculosis. It is spread through the air and usually infects the lungs, although other organs and parts of the body can be involved as well. Most people who are infected harbor the tuberculosis bacterium without symptoms. This is known as latent tuberculosis. If the body's resistance is low because of aging, malnutrition, infections such as HIV, or other reasons, the bacteria may break out of hiding and cause active tuberculosis.

According to World Health Organization (WHO, 2008) estimates, each year, eight million people worldwide develop active tuberculosis and nearly two million die. One in 10 people who are infected with tuberculosis may develop active TB at some time in their lives. The risk of developing the active disease is greatest in the first year after infection, but active disease often does not occur until many years later. TB is commonly diagnosed when a person seeks medical attention for symptoms caused by the disease or a concomitant medical condition. Thus, healthcare providers, particularly those providing primary healthcare to populations at high risk, are key contributors to TB case detection. However, the majority of pulmonary TB cases continue to be diagnosed at an advanced stage. Earlier diagnosis would result in less individual morbidity and death, greater success in treatment, less transmission to contacts, and fewer outbreaks of TB(Diagnosis of Tuberculosis Disease,http://codes.ohio.gov/, 2013).

A diagnosis of TB disease is usually based on positive cultures for M. tuberculosis. However, TB may also be diagnosed on the basis of clinical signs and symptoms in the absence of a positive culture. The majority of tuberculosis (TB) cases are detected during the medical evaluation of symptomatic illnesses. Persons experiencing symptoms ultimately attributable to TB usually seek care not at a public health TB clinic but rather from other medical practitioners in other healthcare settings. Professionals in the primary healthcare sector, including hospital and emergency department clinicians, should be trained to recognize patients with symptoms consistent with TB. TB should be suspected in any patient who has a persistent cough for more than two to three weeks, or other compatible signs and symptoms. Note that these symptoms should suggest a diagnosis of TB but are not required. TB should still be considered a diagnosis in asymptomatic patients who have risk factors for TB and chest radiographs compatible with TB.

2.2.1. Types of Tuberculosis

Different scholars classify tuberculosis in different ways, based on the symptoms and the disease treats. The medical community divides tuberculosis in to two categories called pulmonary and extra-pulmonary, which together causes twelve distinct types of tuberculosis. Pulmonary tuberculosis is responsible for five of these and extra-pulmonary the remaining seven (Stanleyand Swierzewski, 2011).

Pulmonary tuberculosis: this type of TB includes:

a. **Primary Tuberculosis Pneumonia**

This uncommon type of TB presents as pneumonia and is very infectious. Patients have a high fever and productive cough. It occurs most often in extremely young children and the elderly. It is also seen in patients with immune-suppression, such as HIV-infected and AIDS patients.

b. **Tuberculosis Pleurisy**

This usually develops soon after initial infection. A granuloma located at the edge of the lung ruptures into the pleural space, the space between the lungs and the chest wall. Usually, a couple of tablespoons of fluid can be found in the pleural space. Once the bacteria invade the space, the amount of fluid increases dramatically and compress the lung, causing shortness of breath (dyspnea) and sharp chest pain that worsens with a deep breath (pleurisy). A chest x-ray shows significant amounts of fluid. Mild- or low-grade fever commonly is present. Tuberculosis pleurisy generally resolves without treatment; however, two-thirds of patients with tuberculosis pleurisy develop active pulmonary TB within 5 years.

c. Cavitary TB

Cavitary TB involves the upper lobes of the lung. The bacteria cause progressive lung destruction by forming cavities, or enlarged air spaces. This type of TB occurs in reactivation disease. The upper lobes of the lung are affected because they are highly oxygenated (an environment in which M. tuberculosis thrives). Cavitary TB can, rarely, occur soon after primary infection. Symptoms include productive cough, night sweats, fever, weight loss, and weakness. There may be hemoptysis (coughing up blood). Patients with cavitary TB are highly contagious.

d. Miliary TB

Miliary TB is disseminated TB. "Miliary" describes the appearance on chest x-ray of very small nodules throughout the lungs that look like millet seeds. Miliary TB can occur shortly after primary infection. The patient becomes acutely ill with high fever and is in danger of dying. The disease also may lead to chronic illness and slow decline. Symptoms may include fever, night sweats, and weight loss. It can be difficult to use the initial chest x-ray may be normal. Patients who are immunosuppressed and children who have been exposed to the bacteria are at high risk for developing miliary TB.

e. Laryngeal TB:

TB can infect the larynx, or the vocal cord area. It is extremely infectious.

Extra-pulmonary Tuberculosis

There are many form of Extra-pulmonary TB(Imianvan A.A., 2011)**,** such as:

I. Tuberculosis Gastrointestinal

II. Tuberculosis Meningitis

III. Tuberculosis Lymphadenitis (Scrofula)
IV. Cutaneous Tuberculosis (Lupus vulgaris; Tuberculosis verrucae, Miliary tuberculosis
V. Osteon-articular Tuberculosis
VI. Genitourinary Tuberculosis
VII. Drug-resistant Tuberculosis (Multi-drug
VIII. Resistant tuberculosis (MDR-TB) and
IX. Extensively drug-resistant tuberculosis (XDR- TB))

a. Tuberculosis Meningitis

Tuberculosis meningitis is a TB infection of the brain and the spinal cord. The initial symptoms can be irritability and restlessness. Later the patient may develop other symptoms such as a stiff neck, headaches, vomiting, and variations in mental behavior, seizures, or coma.

b. Gastrointestinal Tuberculosis

Gastrointestinal tuberculosis is TB of the gastrointestinal tract, mouth, esophagus, stomach, small and large intestine, and the anus. The symptoms are abdominal pain, fever, weight loss, nausea, vomiting, and change in bowel habits. M. tuberculosis can involve the outer linings of the intestines and the linings inside the abdominal wall, producing increased fluid, as in tuberculosis pleurisy. Increased fluid leads to abdominal distention and pain.

c. Tuberculosis Lymphadenitis (Scrofula)

Tuberculosis lymphadenitis is TB of the lymph nodes, usually along the neck. The symptoms are the formation of masses along the neck, and if the disease is advanced the mass may burst and form a draining sinus. Any lymph node can harbor uncontrolled replication of bacteria, causing the lymph node to become enlarged. The infection can develop a fistula (passageway) from the lymph node to the skin.

d. Cutaneous Tuberculosis

Cutaneous tuberculosis is TB of the skin or mucous membrane from an external source of mycobacteria. There are several types of cutaneous tuberculosis: Lupus vulgaris, tuberculosis verrucae cutis and miliary tuberculosis.

- ✓ Lupus vulgaris is a persistent type of cutaneous TB. The symptoms are small reddish brown lesions that are found on the face, eyelids, around the nose, cheeks, and ears. Tuberculosis verrucae cutis is only contracted through direct skin inoculation when an individual had been previously exposed to mycobacteria. This type of cutaneous TB can last for years. The symptoms are reddish brown wart-like growths on the body, skin lesions on hands, feet, buttocks, elbows and knees. Sometimes pus will seep through the fissures present in the lesions
- ✓ Miliary tuberculosis is a cutaneous TB that starts off as a pulmonary TB infection which then travels through the bloodstream. The symptoms are small red spots on the skin (which are sometimes concentrated to the trunk of the body), necrosis of infected areas, and the development of ulcers or abscesses on the skin.

e. Osteon-articular Tuberculosis

Osteon-articular tuberculosis is TB of the joints: knees, hips, ankles, wrists, shoulders, and elbows. It usually affects one joint. The symptoms are similar to those experienced by individuals with arthritis and pain or stiffness is only felt in the infected area.

f. Genitourinary Tuberculosis

Genitourinary tuberculosis is TB that initially begins as a pulmonary (lungs) TB infection which then travels through the bloodstream to the genitourinary tract. The genitourinary tract includes the urinary tract and the reproductive system. The symptoms are blood present in urine, painful or uncomfortable urination, and experiencing pain on one side of the body between the upper abdomen and back.

g. Drug-resistant Tuberculosis

Drug-resistant tuberculosis is a TB infection that does not respond to drugs used for treatment of TB infection. This type of TB occurs due to the poor management of TB care or the individual was infected by bacteria that were already drug-resistant. There are two types of drug-resistant tuberculosis: multiple drug resistant tuberculosis and extensive drug-resistant tuberculosis.

- ✓ Multi-drug resistant tuberculosis (MDR-TB) is resistant to no less than two of the first-line of drugs used to fight TB infection.

- ✓ Extensively drug-resistant tuberculosis (XDRTB) is resistant to three or more of the second line of drugs used to fight TB infection. This makes it the worst kind of TB infection as treatment for the TB infection is drastically reduced.

The symptoms for MDR-TB and XDR-TB are similar to the symptoms experienced by individuals suffering with pulmonary TB. These symptoms are weight loss, fever, night sweats, coughing and/or coughing up blood, fatigue, and chest pain.

h. Tuberculosis Pericarditis:

The membrane surrounding the heart (the pericardium) is affected in this condition. This causes the space between the pericardium and the heart to fill with fluid, impeding the heart's ability to fill with blood and beat efficiently.

i. Renal Tuberculosis:

This can cause asymptomatic pyuria (white blood cells in the urine) and can spread to the reproductive organs and affect reproduction. In men, inflammation of the epididymis may occur.

j. Adrenal Tuberculosis:

TB of the adrenal glands can lead to adrenal insufficiency. Adrenal insufficiency is the inability to increase steroid production in times of stress, causing weakness and collapse.

2.2.2. Causes for Tuberculosis

All cases of TB are passed from person to person via droplets. When someone with TB infection coughs, sneezes, or talks, tiny droplets of saliva or mucus are expelled into the air, which can be inhaled by another person. Once infectious particles reach the alveoli (small saclike structures in the air spaces in the lungs), another cell, called the macrophage, engulfs the TB bacteria. Then the bacteria are transmitted to the lymphatic system and bloodstream and spread to other organs occurs. The bacteria further multiply in organs that have high oxygen pressures, such as the upper lobes of the lungs, the kidneys, bone marrow, and meninges, the membrane-like coverings of the brain and spinal cord. When the bacteria cause clinically detectable disease, the person can have TB. People who have inhaled the TB bacteria, but in whom the disease is controlled are referred to as infected. Their immune system has walled off the organism in an inflammatory focus known as a granuloma. They have no symptoms, frequently have a positive skin test for TB, yet cannot transmit the disease to others. Tuberculosis is a serious health problem in its own right but it is also the most likely cause of death for HIV positive people. Like HIV, tuberculosis has had an uneven impact around the world (WHO, 2010).

2.2.3. Symptoms of Tuberculosis

Most people who are infected with M. tuberculosis harbor the bacterium without symptoms (known as latent tuberculosis), but some will develop active tuberculosis. In other cases, the bacteria die off. WHO (2010) identified that, a positive TB skin test and old scars on a chest x-ray may provide the only evidence that a person was ever infected with tuberculosis. The primary stage of the tuberculosis may be symptom-free, or the individual may experience a flu-like illness. According to (Asha T., 2011)the main signs and symptoms of Tuberculosis include:

Table 2.1 Symptoms of Tuberculosis (TB)*(Imianvan A.A., 2011)*

1.A cough lasting for more than 2-3 weeks
2. Coma (Seizure)
3. Stiff Neck
4. Headache
5. Abdominal Pain
6. Weight Pain
7. Fever
8. Masses along the neck
9. Draining Sinus
10. Small Reddish brown lesions(face, eyelid, nose, cheek and ear
11. Reddish brown wart-like growth on the body
12. Skin lesions on hand, feet, elbow and knees.
13. Ulcer or abscesses on the Skin
14. Necrosis of infected Skin
15. Stiffness of affected area

16. Blood present in Urine
17. Painful or uncomfortable Urination
18. Hemoptysis (coughing up blood)
19. Fatigue
20. Chest pain
21. Night Sweat

2.2.4. Diagnosis of Tuberculosis Disease

Consideration of tuberculosis (TB) disease as a possible diagnosis is the first step that must be taken before further evaluation, diagnosis, and management can occur. The diagnosis of TB disease is often overlooked because of the failure to consider it among possible diagnoses. While a definitive diagnosis may involve the addition of laboratory and radiographic findings, a high degree of suspicion can be based on epidemiology, medical history, and physical examination. In considering TB disease, it is also important to consider factors that may affect the typical presentation of TB, such as the patient's age, nutritional status, and coexisting diseases. A complete medical diagnosis for TB includes a review of complete medical history, physical examination of patient, a tuberculin skin test, a chest X-ray, and microbiologic smears and cultures. Tuberculosis can be diagnosed by many ways (Asia, 2012).

X-ray: Diagnosis of tuberculosis in the lungs may be made using an X-ray. This is the most common diagnostic test that leads to the suspicion of infection. The main problems with X-ray are poor film quality, low specificity, and difficulties with interpretation.

The Manteaux skin test: also known as a tuberculin skin test (TST). This test helps identify people infected with M. tuberculosis but who have no symptoms. A doctor must read the test. This test can often indicate disease when there is none (false positive). Also, it can show no disease when in fact have TB (false negative).

Quantic FERON-TB Gold test: This is a blood test that is an aid in the diagnosis of TB. This test can help detect active and latent tuberculosis. The body responds to the presence of the tuberculosis bacteria. By special techniques, the patient's blood is incubated with proteins from

TB bacteria. If the bacteria are in the patient, the immune cells in the blood sample respond to these proteins with the production of a substance called interferon gamma (IFN-gamma). This substance is detected by the test. If someone had a prior BCG vaccination and a positive skin test due to this, the Quantic FERON-TB Gold test will not detect any IFN-gamma.

Sputum testing: Sample of sputum is test in laboratory to diagnose the TB. If sputum is available, or can be induced, a lab test may give a positive result in up to 30% of people with active disease.

An individual who additionally is suspected of having TB disease requires a complete medical evaluation, including the following:

- ✓ Medical history, including exposure, symptoms, previous treatment for TB, and risk factors.
- ✓ Human immunodeficiency virus (HIV) screening
- ✓ Physical examination

2.2.5. Treatment of Tuberculosis

Treatment takes that long because the disease organisms grow very slowly and, unfortunately, also die very slowly. Mycobacterium tuberculosis is a very slow-growing organism and may take up to six weeks to grow in a culture media (Asia, 2012).

- Doctors use multiple drugs to reduce the likelihood of resistant organisms emerging.
- Often the drugs will be changed or chosen based on the laboratory results.
- If doctors doubt that the patient is taking the medicine, prescribing doses twice a week helps assure compliance.
- The most common cause of treatment failure is people's failure to comply with the medical regimen. This may lead to the emergence of drug-resistant organisms. The patient must take the medications as directed, even if he/she are feeling better.
- Another important aspect of tuberculosis treatment is public health. This is an area of community health for which mandated treatment can occur. In some cases, the local health department will supervise administration of the medication for the entire course of therapy.
- Active TB disease can almost always be cured with a combination of antibiotics.

- Avoid nutrient deficiencies and imbalances.
- If someone is believed to have been in contact with another person who has TB, preventive antibiotic treatment may have to be given.
- Streptomycin, a drug that is given by injection, may be used as well, particularly when the disease is extensive
- The patient should take his/her pills under the guidance of someone who can supervise the therapy. The approach is called DOTS (Directly Observed Treatment, Short Course).
- Surgery on the lungs may be indicated to help cure TB when medication has failed If the patient develops any side effects from medications such as itching, change in color of skin, tiredness, or excessive fatigue other treatment must be given.

2.2.6. Tuberculosis Preventions

Preventive measures include strict standards for ventilation, air filtration etc.

- A BCG vaccine, is available and has been of some benefit in preventing TB covering of mouth by a mask is helpful in prevention from TB
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep
- Get tested regularly. Experts advise getting a skin test annually
- Keep the immune system healthy.
- The WHO recommends that HIV positive people who have latent TB should be offered isoniazid preventive therapy as needed.

2.3. Knowledge Based Systems

Knowledge based systems are a branch of artificial intelligence, which is a computer program that attempts to replicate the reasoning processes of a human expert and it can make decisions and recommendations and perform tasks based on user input. Artificial Intelligence is all about how to make the system think, or act like human. The expert`s knowledge is available when the human expert might not be and so that the knowledge can be available at all times and in many places, as necessary. Expert systems derive their input for decision making from prompts at the user interface, or from data files stored on the computer (Mahamana et al, 2003; Vinaya, 2006). The main concern of artificial intelligence is to enable computers to behave like human beings and imitate the reasoning power of humans to do tasks that necessitate human being's intelligence by making machines smarter, which is a primary goal, understand what intelligence is all about make machines more intelligent and useful(Connelly, 1987; Spackman) and(Forsythe D., 1993).

Knowledge-based systems are computer-based systems that use information to provide relevant advice and problem solutions within a specific domain. Knowledge based systems enable expert knowledge to be accessed all the time when the system is on, even when an expert is unavailable. KBS gives a privilege to provide a means to preserve information when the expert retires (Schipper, 2008).Knowledge plays a great role in KBS development in that it is a subjective interpretation of information in effort to recognize the applications and approach to act upon in the mind of perceiver. It attaches purpose and competence to information, resulting in the potential to generate action (Rajendra and Priti S , 2010).

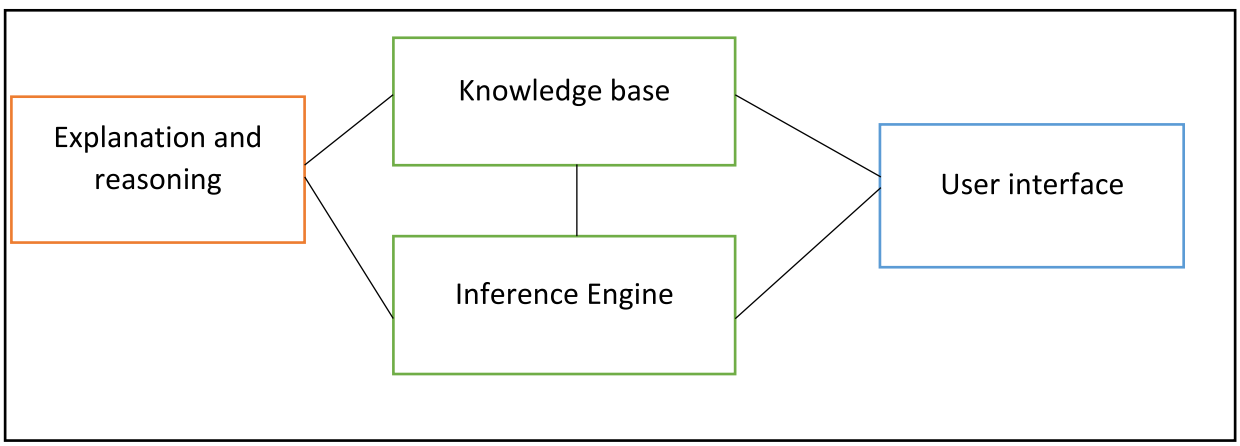
Knowledge-Based System (KBS) is designed to simulate problem solving behavior of an expert in a certain domain or discipline. A knowledge base (KB) is a centralized repository of information. It is used to optimize information collection, organization and retrieval. It is dynamic resources that have the capacity to learn as part of artificial intelligence (Dlodlol et al, 2009).

AI programs that achieve expert level competence in solving problems in task areas by bringing to bear a body of knowledge about specific tasks are called knowledge based systems (Rajendra and Priti S , 2010). Nowadays, the society and industry in general are becoming more of knowledge oriented and relying on different applications of knowledge based systems. According to (Sasikumar M, 2007), Knowledge base systems have the capability to act as an expert on demand, anytime and anywhere.

2.3.1. Component of Knowledge Based System

Knowledge based system consists of at least four components, which are the knowledge base system that contains the experts' knowledge which are the facts, rules and heuristics or experience. The inference engine which contains the reasoning and problem solving strategies, the working memory that holds data about the particular situation the system is evaluating and records the steps of the reasoning sequence. The user interface is used to communicate with the expert system by users (Schipper, 2008).

KBS has the following commonly used components, techniques for acquiring knowledge, ways of representing knowledge internally, because computers are good at representing numbers, words, even maps, but knowledge is potentially much more difficult, search procedures for working with the internally stored knowledge, inference mechanisms for deducing solutions to problems from stored knowledge.



Source: (Rajendra and Priti S, 2010)

Figure 2.1 Component of knowledge based system

2.3.2. Knowledge Base

The knowledge base contains specialized knowledge on a given subject that makes the human a true expert on the subject. This knowledge is obtained from the human expert and encoded in the knowledge base using one of several knowledge representation techniques. One of the most common techniques used today for representing the knowledge in an expert system is rules(Durkin, 1990). A rule is an IF/THEN type structure which relates some known information contained in the IF part to other information. This information can then be concluded to be contained in the THEN part. An example can be given as follows:

Where TB is suspected, the presence of cough with bloody sputum and swollen lymph is probably an indication of Mycobacterium infection, which is captured in the following algorithmic rules.

If < symptom is cough AND (NOT symptom is headache)
AND (symptom is bloody sputum) AND symptom is swollen lymph/neck/joint>
Then<Notify (Patient), “Tuberculosis is very likely, please go and see your doctor”>.

Where TB is not suspected, When cough is not observed and sputum occurrence is none or minimal, and where it occurs, it is not bloody, and then TB is not likely. This is depicted in the following algorithmic rules.

If <symptom is cough AND (not Symptom is bloody sputum)
AND (not symptom is swollen lymph/neck/joint>Then <Notify (Patient), “Tuberculosis is not likely but ordinary cough”>.

This rule contains knowledge which represents for tuberculosis diagnosis. It links the condition of the patient with the type of symptom of tuberculosis the patient has. Using the rule, one can construct a comprehensive knowledge base for diagnosing different domain problems (Akerkar, P.S. Sajja and R., 2010).

2.3.3. Inference Engine

Inference is the process of chaining multiple rules together based on available data in the knowledge base. The inference engines are applicable in answering and solving complex queries in order to infer possible answers. The purpose of the inference engine is to seek information and form relationships from the knowledge base and provide answers. The inference engine matches facts in the working memory against rules in the rule base, and it determines which rules are applicable according to the reasoning method adopted by the engine (Turban E. A. J., 2007).

In an inference mechanism when all the rule's hypotheses or the if parts are satisfied, a rule said to be fired, in a sense inference engine checks every rule in the knowledge base in a forward or backward direction to find rules, which continue until no more rules can fire, or until a goal is achieved (Turban E. S. a., 2010). According to the end-user input and the set of facts from the knowledge base and/or other sources, the inference engine infers facts or makes conclusions from the knowledge base. Three main techniques are known when deducing facts or drawing conclusions from the knowledge base these are: forward chaining, backward chaining and hybrid chaining (E.D. Kock, 2003).

Backward Chaining

Backward chaining is the process of reasoning from conclusions to inputs. Backward chaining systems assume an answer and then attempt to prove or disprove the truth of that assumption. To begin this process, the system selects a rule whose conclusion yields a solution. The system then attempts to satisfy the rule by obtaining values for the variables in the premise of the solution. For each premise, the system first checks the fact base for the value, then searches for a rule that can generate the necessary value to satisfy the premise, and finally asks the user when all else fails(Schipper, 2008). If the fact base contains a value that contradicts the premise, the system disregards the solution as invalid and assumes a new solution by moving on to a different rule.

When examining a rule, if the fact base contains a value matching one of the rules' premises, the system continues to assume that the rule is correct and attempts to prove the next premise until all the premises are satisfied. If no value is found in the fact base for a premise, but a rule is discovered that can derive its value, the system attempts to prove the premises of that rule through the same process. However, no rule capable of satisfying the premise can be found, the system asks the user as a last resort. Then the user can enter a value, which the system adds to the fact base. If the value entered by the user corresponds to the necessary premise value, the system continues trying to prove the rule. If it contradicts the premise, the system moves to a new rule that can generate a solution. This process continues until the system has either found a solution or exhausted all rules capable of yielding a solution.

Forward Chaining

In AI systems, forward chaining refers to a scenario where the AI has been provided with a specific problem which works forward to figure out how to solve the set problem. To do this, the AI would look back through the rule-based system to find the "if" rules and determine which rules to use. Forward chaining is a data-driven search in rule-based KBSs. If the premise clauses match the situation, then the process attempts to assert the conclusion (Turban E. A. J., 2007).

Forward chaining is the process of reasoning from inputs to conclusions. The first step in a forward chaining system is to receive user and sensor inputs by storing them in the fact base. Next, the system searches the rule set and identifies those rules whose premises are satisfied by the facts contained in the fact base. The process of identifying these rules is called pattern matching. If more than one rule is satisfied, the system identifies the rule with the highest priority and executes it, also known as rule firing. The results obtained from the fired rule are added to the fact base. This process of pattern matching, prioritizing, and rule firing continues until a solution is reached or no solution can be reached. If no solution is attained, complex systems may request information from the user that might enable the system to reach a conclusion (Schipper, 2008).

The inference process moves from the facts of the case to a goal (conclusion). The strategy is thus driven by the facts available in the working memory and by the premises that can be satisfied. Forward-chaining systems are commonly used to solve more open-ended problems of a design or planning nature such as, establishing the configuration of a complex product. When there exists a very complex problem domain, the above two techniques can be merged to produce an efficient program called hybrid chaining. Hence, in order to design the strategies used by the expert in the domain area, KBS must implement a complex inference engine that may involve both backward and forward chaining techniques (E.D. Kock, 2003).

The choice from backward chaining and forward chaining depends on how domain experts solve the problems. If the domain experts solves a problem by first collecting data and infer a solution from this data, then it is forward chaining. But if the domain expert starts hypothetical solution and then attempts to find facts to prove the hypothesis, then it is a backward chaining (Turban E. S. a., 2010).

2.3.4. Explanation/Reasoning Facility

This is an important component of a knowledge based systems that can explain and justify the system's reasoning and justify its conclusions. Another unique feature of a knowledge base system is its ability to explain its advice or recommendations and even to justify why a certain action was recommended. In addition to delivering the end outcomes, domain experts together with KBSs can clarify how they reached at outcomes. This ability is usually essential since this kind of problems to which KBSs are carried out need an explanation of the outcome delivered to the end-users. KBSs also have the ability of justifying why a certain problem is being questioned (J. Durkin, 1990).

According to (E. Castillo, J.M. Gutierrez and A.S. Hadi, 1997), in several domains of problems explanations of the actions are essential because of the hazards related with the conclusions to be fired. For instance, in the medical diagnostic field, medical physicians are liable at the end of the day for the diagnoses made, irrespective of the help tools applied to make the actions. In these circumstances, in the absence of an explanation facility, medical physicians may not be capable to justify the reasons for diagnosis to their patients. This explanation session is asked by users why a fact is requested by the system. The system asks the user for an input continuously and the user asks for the system why was the question asked by the system before answering the system's question.

This explanation mainly uses to determine how a certain conclusion or recommendation was reached. Users raised this explanation at the end of certain conclusion or recommendation to know exactly how that specific conclusion was reached. It follows a step-by-step approach to reach the final answer. Such a question is raised if expected results were not reached. Users in this case are interested to know why certain request was unsuccessful.

2.3.5. Knowledge Acquisition

The extraction and formulation of knowledge derived from various sources, especially from experts and other sources of knowledge. Knowledge acquisition in knowledge based systems development involves elicitation and representation of the appropriate knowledge from its sources such as human experts, textbooks, multimedia documents, databases, different research papers, yellow pages and from the web in general. This is a process by which KBS developers use it to determine where in the organization the knowledge exists, how to capture and use it in the prototyping phase. Approaches of capturing knowledge takes many forms and are evolve over time (guesh dagnachew, 2012).

2.3.6. User Interface

As (E. Castillo, J.M. Gutierrez and A.S. Hadi, 1997) noted, user interface is a channel for communication between the KBS and the end-user. Therefore, in order for the KBS to be an interactive tool, it should include a means to show and retrieve information in a simple manner. Examples of information to be shown are the consequences made by the inference engine, the justifications for such consequences, and an explanation for the actions made by the KBS. Conversely, when no consequence can be arrived by the inference engine like because of the absence of information, the user interface offers a mechanism for attaining the desired information from the end-user. Therefore, an insufficient implementation of the user interface that does not assist this process would hinder the importance of the KBS by the end-users. Moreover, the reason for the significance of the user interface component is that end-users usually evaluate KBSs based on the quality of the user interface instead of the KBS itself.

2.4. Application of Knowledge Based Systems

There are several KBS applications, broadly knowledge-based system applications can be divided into two major categories. These are, pure and applied knowledge-based systems application. Pure application includes researches contributing in knowledge-based systems and AI development techniques such as knowledge acquisition, knowledge representation, models of automated knowledge-based systems development such as knowledge engineering approaches, models and CASE tools for KBS, knowledge discovery and knowledge management types of tools(Rajendra and Priti S , 2010).

Knowledge-based systems can be used in a number of applications. The common applications are discussed as follows (R.A. Akerkar and P.S. Sajja, , 2010).

Advisory systems: Knowledge-based systems are preferable than any computer-based information systems for advising purposes. This is because knowledge-based systems are goal-directed, have the ability to adapt to different situations, and have the capacity to justify their decisions.

Health care and medical diagnosis systems: The process of finding out the errors in a certain system or identifying the state of sickness in a living system according to the analysis of noisy or incomplete data is called diagnosis. The interpretation of different medical reports such as dermatology reports and physicians decisions can be verified in a simple manner with the assistance of knowledge-based systems.

Tutoring systems: The tutoring system wants to communicate with the end-user in a friendly style, recognize their status and offer a means to get the teaching modules in a cost-efficient manner. End-users can communicate with the system in their mother tongue language to get the teaching modules based on their desire and request.

Control and monitoring: Monitoring is a continuous interpretation of signals and making important decisions if interference is necessary. For example, such kind of monitoring can be applied to an artificial life support system attached to a person who requires medical care after the surgical process.

Prediction: It is forecasting what will happen in the future according to the models developed on the previous and current status. For example, a knowledge-based system can forecast about the volatile market.

Planning: A plan is a program of activities that can be done to realize objectives. Such kind of a plan assists in using limited resources effectively by preparing a series of activities to be done.

Activities associated with the development of software needs preparing a plan and monitoring stages. However, the knowledge-based system permits a slight change from the plan. The extent of such change without troubling the total goal is identified by the knowledge-based system.

Searching larger databases and data warehouses: It is not a simple task to look for and retrieve relevant information from huge databases. For example, specifically in the Internet the sources of information in the databases are dispersing widely. Therefore, using the knowledge based systems the end-user can retrieve the needed information in an efficient manner.

2.4.1. Related Research Works to Tuberculosis Disease

Fuzzy Cluster Means Expert System for the Diagnosis of Tuberculosis (By Imianvan A.A. and Obi J.C., 2011)**.**

This system was developed by (By Imianvan A.A. and Obi J.C., 2011) to help medical experts in the area of tuberculosis disease. The goal of this system was to support the physician in his or her decision to diagnosis tuberculosis disease. The fuzzy- cluster means model proposed in this paper appears to be a more natural and intelligent way of classification and matching of Symptoms to Tuberculosis groups. This paper is focused only on seven types of tuberculosis disease. As a development tool, rule problem solving method, conditions-actions, fuzzy cluster means is used and a tool is developed to acquire new rules. These rules are automatically integrated in the knowledge base. This paper present a diagnostic fuzzy cluster means system to help in diagnosis of Tuberculosis using a set of symptoms. The paper is only focusing extra pulmonary TB. The classification, verification and matching of symptoms to the seven groups of clusters was necessary especially in some complex scenarios. In this work, knowledge-based system application was used to support the decision of tuberculosis disease.

Mining Patients' Data for Effective Tuberculosis Diagnosis: The Case of Menelik II Hospital (Asia Nesredin, 2012)**.**

This system was developed by (Asia Nesredin, 2012) .The main objective of this system was to determine the class of tuberculosis using two data mining techniques clustering and classification based on symptom. The system mainly concerned how to classify and clustering tuberculosis symptom and determine the value for the symptoms have to be 'yes' especially for the symptoms: Cough, Chest-pain, Bloody-sputum, Weight-loss and Night-sweats. And for a patient to be TB-negative, those attribute values have to be 'no' value. Moreover, in the current practice of the organization, the experts use those symptoms for identifying patients for TB-positive and TB-negative. The model can give an advice for those health care workers to have knowledge of tuberculosis diagnosis and treatment. This paper is not identify types of TB and only determine common TB symptom, so adding knowledge based system with the developed model helps for identifying the type of TB in this study.

In this study, he recommended for further research to make the prototype knowledge based system for diagnosis of tuberculosis and treatment.

2.5. Representing Knowledge

Knowledge representation deals with formalizing and organizing the knowledge. The widely used representation is the production rule. A rule consists of an IF part and a THEN part which is the condition and an action (McClelland D. and Pirie F., 2010).

The IF part lists a set of conditions in some logical combination. Knowledge representation (KR) is the problem of getting knowledge and expertise into the computer in a form that is easy to access and use in solving problems. In the representation of knowledge into knowledge base, the knowledge acquired from knowledge acquisition process is represented into structured form. There are many approaches for representing knowledge into the knowledge base. Knowledge based systems rely on knowledge from specific domains to provide solutions to specific problems.

Although different KR methodologies exist in developing knowledge based system for tuberculosis diseases diagnosis and treatment the rule based KR is used because, the rule based knowledge representation has many advantages compared with other knowledge representation methodologies especially for such problems. This method is widely used because each rule is modular and contains a ''chunk'' of domain knowledge and experts are often able to express their heuristic knowledge in an IF-THEN format. Knowledge bases must represent notions as actions to be taken under circumstances, causality, time, dependencies, goals, and other higher-level concepts (Aronson J., and Turban E, 2007).Several methods of rule based knowledge representation methods are available.

2.5.1. Knowledge Representation in Production Rules

Production Rules: Production rules are the most popular form of knowledge representation for ES and automated decision support (ADS) systems. Production rules follow particular type of reasoning which uses "if-then-else" rule statements. Knowledge is represented in the form of condition/action pairs, IF this condition (or premise or antecedent) occurs, THEN some action (or result or conclusion or consequence) will (or should) occur. Each production rule in a knowledge base implements an autonomous chunk of expertise that can be developed and modified independently of other rules. When combined and fed to the inference engine, the set of rules behaves synergistically, yielding better results than the sum of the results of the individual rules (Sasikumar M, 2007).

If-then rules are one of the most common forms of knowledge representation used in expert systems. Systems employing such rules as the major representation paradigm are called rule based systems. One of the first popular computational uses of rule based systems was the work by Newell and Simon on the General Problem Solver (Newell and Simon, 1972).

2.5.1.1. Advantages of Rule Based Systems

According to (Alty, 1989) , some of the advantages of rule based systems are:

- ✓ **Homogeneity**: Because of the uniform syntax, the meaning and interpretation of each rule can be easily analyzed.
- ✓ **Simplicity**: Since the syntax is simple, it is easy to understand the meaning of rules. Domain experts can often understand the rules without an explicit translation. Rules therefore can be self-documenting to a good extent.

- ✓ **Independence:** While adding new knowledge one need not be worried about where in the rule base the rule is added, or what the interactions with other rules are. In theory, each rule is an independent piece of knowledge about the domain.
- ✓ **Modularity:** The independence of rules leads to modularity in the rule base. You can create a prototype system fairly quickly by creating a few rules. This can be improved by modifying the rules based on performance and adding new rules.
- ✓ **Knowledge is separated from use and control:** The separation of the rule base from the inference engine separates the knowledge from how it is used to solve the problem. This means that the same inference engine can be used with different rule bases and a rule base can be used with different inference engines.

2.5.1.2. Disadvantage of Rule Based System

As rule based reasoning of prototype knowledge based system has many advantages. But, it has the following limitations (Hatzilygeroudis, 2007).

- ✓ **Knowledge acquisition bottleneck:** The standard way of acquiring knowledge through interviews with domain experts is bulky and time-consuming.
- ✓ **Brittleness/fragility of rules:** It is not possible to draw conclusions from rules when there are missing values in the input data.
- ✓ **Inference efficiency problems**: In certain cases the performance of the inference engine is not the desired one especially when the rules are too large.
- ✓ **Difficulty in maintenance of large rules**: The maintenance of rule bases is getting a difficult process as the size of the rules increases.
- ✓ **Interpretation problems:** The general nature of rules may create problems in the interpretation of their scope during reasoning process.

2.5.2. Knowledge Representation in Cased-Based Systems

Case based: Case based reasoning is a process that uses similar problems to solve the current problem. It consists of two steps find those cases in memory that solved problems similar to the current problem, and adapt previous solutions to fit the current problem. The critical step is to find and retrieve a relevant case from the case library. Cases are stored using indexes. The stored case contains a solution, which is then adapted by modifying the parameters of the old problem to suit the new situation resulting in a proposed solution. The solution is tested and if found successful, added to the case library. Knowledge acquisition is easier in case based reasoning because of the granularity of the knowledge. Knowledge is presented in precedent or resultant cases. Beyond the knowledge representation language (rules, semantic nets, frames, cases), the knowledge engineer needs further aids such as tools to edit the knowledge base; inference tracers to assist in error detection; and analytical tools to find update and consistently check the represented knowledge or attributes (Klein & Methlie,1995).

2.5.3. Knowledge Representation in Frame-Based Systems

Frames: If we need to focus on the properties of certain objects, then using frames and objects is a good choice. A frame is a data structure that includes all the knowledge about a particular object. This knowledge is organized in a special hierarchical structure that permits a diagnosis of knowledge independence. Frames are basically an application of object oriented programming for artificial intelligence and ES. They Frames, as in frames of reference, provide a concise structural representation of knowledge in a natural manner. In contrast to other representation methods, with frames, the values that describe one object are grouped together into a single unit called a frame. Thus, a frame encompasses complex objects, entire situations, or a managerial problem as a single entity. The knowledge in a frame is partitioned into slots. A slot can describe declarative knowledge (e.g., the color of a car) or procedural knowledge (e.g. "activate a certain rule if a value exceeds a given level")(Fensel, D., Angele, J. and Struder, R.,. , 1998)and (Jackson, P. , 1999).

2.5.4. Knowledge Representation in Decision Table

Decision tables: Knowledge of relations can be represented in decision tables. In a decision table, knowledge is organized in a spreadsheet format, using columns and rows. The table is divided into two parts. First, a list of attributes is developed, and for each attribute, all possible values are listed. Then a list of conclusions is developed. Finally, the different configurations of attributes are matched against the conclusion. Knowledge for the table is collected in knowledge acquisition sessions. Once the table is constructed, the knowledge in the table can be used as input to other knowledge representation methods (Vadera, 2005).

2.5.5. Knowledge Representation in Decision Tree

Decision tree: Decision trees are related to decision tables and are popular in many places. They are composed of nodes representing goals and links representing decisions. The major advantage of decision trees is that they can simplify the knowledge acquisition process. Knowledge diagramming is often more natural to experts than formal representation methods (Vadera, 2005).

Decision trees can easily be converted to rules. The conversion can be performed automatically by a computer program. In fact, machine learning methods are capable of extracting decision trees automatically from textual sources and converting them to rule bases. It is responsibility of the knowledge engineer to select appropriate knowledge presentation scheme that is natural, efficient, transparent, and developer friendly and the degree of familiarity of the knowledge engineer with a technique. One may think for hybrid knowledge representation strategies (Sajja P. S. and Akerkar, 2010).

2.6. Tools Used in Knowledge-Based System Development

A KBS tool is a collection of software instructions and utilities taken to be a software package designed to support the development of knowledge-based systems. KBS can be built using programming languages namely LISP and Prolog.(John McCarthy, 1960) Published an outstanding paper showing a handful of simple operators and a notation for functions, one can develop a full programming language. Prolog is a logic programming general purpose fifth generation (AI) language (U. Nilsson and J. Maluszynski, , 2000). It has a purely logical subset, called "pure Prolog", in addition to a number of extra logical features. Prolog has its roots in formal logic, and in contrast to numerous other programming languages.

Prolog is declarative. The program logic is expressed in terms of relations, and execution is activated by running queries over these relations. The language was first believed by a group around Alain Colmerauer in Marseille in the early 1970s. According to (R.A. Kowalski, 1988), the first Prolog system was developed in 1972 by Alain Colmerauer and Phillipe Roussel.

2.7. Testing and Evaluation of the KBS

Evaluating a knowledge base system requires more elaborate methodology than a simple iterative test and refines cycle. At the design stage an adequate knowledge base structure is required to allow focused modification of the knowledge base when errors are discovered. Evaluation of a system by domain experts is helpful to determine the quality and interactive feature of the knowledge based system. Moreover, verification of a knowledge base system is to demonstrate the consistency, completeness and correctness of the knowledge base system so as to make users confident enough in using it. According to(Berry D. and Hart E, 1993), the success of a system is not only about the system matching user needs and supporting users in their tasks, but also deals with the match between the system and the social and political factors within the host organization. This is performed by give emphasis to the usability, through interviews, questionnaires, formal observation while users interact with the system, system logging, simple testing and experiments.

Furthermore, determine a system whether the implemented KBS completely satisfies its specifications specified in the scope of the study area. According to (Hope T and Meseguer P, 1993), and (Clarke K., 1994), checking a system against the well-defined objectives of a KBS with respect to its specification in particular KBS components such as; knowledge base content, inference engine and the user interface is taken into consideration for evaluation. Analysis of KBS evaluation and assessment helps to identify the main points in the evaluation and assessment of the knowledge base system. The important features of knowledge base system evaluation is the absence of a well-defined and well-structured set of requirements at the beginning of the development process, continuous changes in the requirements during the whole development phase is required to make the system full-fledged KBS.

CHAPTER THREE

3. DESIGN AND METHODOLOGY OF THE STUDY

3.1. Knowledge Acquisition

Knowledge acquisition is a general term used to represent the process of acquiring expert expertise. Also Knowledge acquisition is the general term used for the process of developing a computational problem-solving model, specifically a program to be used in some consultative or advisory role. Programs built based on knowledge acquisition from experts is called Expert Systems (Dr. Adel Hamdan Mohammad and Dr. Nedhal Abdul Majied Al Saiyd, 2010).

No doubt that Knowledge acquisition plays a significant function in building knowledge based system. Knowledge engineering is all about build maintain and development of knowledge based systems in the field of artificial intelligence. Knowledge-engineering process includes five major activities:

Knowledge acquisition: This is acquisition of knowledge from its different resources such as experts, books, and documents.

Knowledge representation: This means organizing the knowledge.
Knowledge validation: this means verifying the knowledge quality.
Inference: design suitable software which allows inference.
Explanation and justification: this means design an explanation facility to answer questions (Dr. Adel Hamdan Mohammad and Dr. Nedhal Abdul Majied Al Saiyd, 2010). There are several methods and steps of knowledge acquisition which will be discussed later in this paper. Knowledge acquisition is a process of acquiring, organizing and studying knowledge (W. Wiriyasuttiwong and W. Narkbuakaew, 2009). In this research, the knowledge is acquired from a physician and medical books for testing system. The knowledge acquisition process starts with Elicitation. Methods such as structured interviews are used for acquiring informal descriptions of the knowledge about the specific domain and the problem solving process itself. The resulting

knowledge expressed in natural language is stored in knowledge protocols (Rudi S, Richard B. and Dieter F, 1998).

Knowledge engineering has phases such as elicitation, representation, design, and implementation (Ferruccio M., Nicola P.and Paolo C., 2010). Each of these activities deals with different aspects of the system development. It is the result of the knowledge acquisition which contains all the functional requirements of the intended knowledge base system.

According to (A. Anand and M.D. Singh, 2011), there are usually two types of knowledge sources. These are documented (tacit) knowledge and undocumented (explicit) knowledge. Tacit knowledge is commonly deeply ingrained in human mind and organizations through experience. Explicit knowledge is relatively simple to express and capture in the form of books, tables, diagrams, and so on. Knowledge can be discovered and collected by using either the human senses or machines (e.g., scanners, cameras, pattern matchers, intelligent agents)(Education Pearson, 2012).

Transferring expert knowledge to a computer system is done by conducting several steps, each of which has its own characteristics and merits. The following figure shows the process of knowledge acquisition.

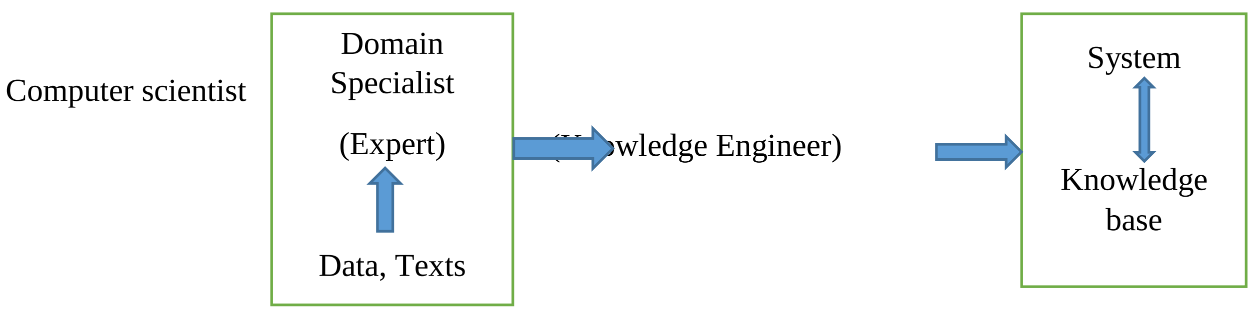


Figure 3.2 Knowledge Acquisition process

3.1.1. Knowledge Elicitation Methods

Many knowledge elicitation methods have been used to obtain the knowledge required to solve problems. These methods can be classified in many ways. One common knowledge elicitation method is how to directly obtain knowledge from the domain expert. Direct methods involve directly questioning a domain expert on how they do their job. In order for these methods to be successful, the domain expert has to be reasonably articulate and willing to share their knowledge. The knowledge extracted has to be easily expressed by the knowledge engineer, which is often difficult task. Indirect methods are used in order to obtain knowledge that cannot be easily expressed directly such as observation. Many methods of knowledge elicitation can fit into more than one category of knowledge such as tacit and explicit and are applicable in collecting knowledge. However, for the sake of this study, direct methods such as interview and document analysis and indirect methods such as observation are employed.

Acquiring knowledge from experts is not a simple task. It involves knowledge identification, knowledge representation in an appropriate format, organizing the knowledge, and transferring the knowledge to a computer machine. Some of the reasons that increase to the difficulty of knowledge acquisition from experts and its transfer to a computer machine are stated below (Education Pearson, 2012).

- Experts possibly will not recognize to express or state clearly their knowledge.
- Experts possibly have shortage of time to be able to work together with knowledge engineers.
- Examining and filtering knowledge is very difficult. Ways for knowledge elicitation possibly are ill-defined.
- It is hard to identify a particular knowledge when it is mingled with unrelated data and information.
- Knowledge engineers possibly will vary their behavior when they are conducting an interview, and bad communication factors that occur among people may affect the knowledge collection task.

The process of acquiring knowledge from experts could be significantly acted upon by the roles of the three main actors: the knowledge engineer, the expert, and the end-user. The knowledge engineer must act as a trainer of knowledge structuring, a tool designer, and a catalyst at the interface between the expert and the end-users.

3.1.1.1. Tacit Knowledge Elicitation

There are contextual complexities in the area of knowledge management and knowledge based systems as a result of the nature of knowledge based resources which are dominantly becoming the basis for competitive advantage in organizations (Garcia-Perez A. and Mitra A, 2007). Procedures are also methods that can be used to determine the steps followed to complete a task during Tuberculosis diagnosis.

According to(Garcia-Perez A. and Mitra A, 2007), many research works have been proved that measuring and managing of explicit knowledge is more appropriate than tacit knowledge resources. The knowledge management research and practice communities agree on the importance of identifying and measuring tacit knowledge-based resources, while absence of suitable instruments designed to apply to it continues to be a problem. Most dominantly interviewing and observation are found to be the most appropriate methods to collect a tacit knowledge from domain experts (Forsythe.D, 1993).

In observation methods of knowledge acquisition will be applied to determine how experts of Tuberculosis diagnosis performing their job. This prevents the knowledge engineer from inadvertently interfering in the process.

3.1.1.2 Explicit Knowledge Elicitation

Such knowledge is the one that can be made explicit and shared through written language, often embedded in documents (Garcia-Perez A. and Mitra A, 2007). Knowledge about tuberculosis diagnosis was collected by referring from manuals and procedures which are designed in particular use for tuberculosis diagnosis. In a document analysis the knowledge engineer involves in gathering information from existing documentation regarding tuberculosis diagnosis with a human expert interaction to confirm or add to this information.

3.2 Knowledge Acquisition Methods

Knowledge acquisition methods can be classified into manual and computer-based. Computer can support to acquire knowledge using semi-automatic or fully-automatic means (A.H. Mohammed and N.A.M. Al Saiyd, 2010).

3.2.1. Manual Knowledge Acquisition Methods

Interviews: The most frequently used form of knowledge acquisition is interviewing. This is an unambiguous technique that comes out in numerous inconsistencies. It encompasses a direct exchange of ideas between the human expert and the knowledge engineer. Information is gathered with the help of instruments such as tape recorders, questionnaires, and so on and is consequently transliterated, analyzed, and coded. During the interview, the expert is presented with an imitated case or preferably, with a real problem that the KBS will be anticipated to find the solution. The expert is inquired to talk the knowledge engineer via the solution of the problem.

At the beginning of any study, numerous knowledge acquisition interview sessions are frequently conducted informally. Beginning informally avoids wastage of time and aids to proceed rapidly to the main structure of the domain. Normally, it is followed by a formal technique. Contrary to what numerous people think, unstructured interviews are not easy. Actually, they may present the knowledge engineer with a number of very problematic consequences.

Unstructured interviewing rarely offers comprehensive or well-ordered descriptions of cognitive processes. There are several reasons for this, the domains are complex, the experts frequently find it very hard to express some of the most significant elements of their knowledge, domain experts may interpret the lack of structure as implying that they need not prepare for the interview, data acquired from an unstructured interview are often unrelated, exist at varying levels of complexity, and are hard for the knowledge engineer to review, interpret, and integrate, and few knowledge engineers have the training and experience to efficiently conduct an unstructured interview. Hence, it should be supplemented by structured interviews.

Structured interview is a systematic and goal-driven process. It coerces organized communication between the knowledge engineer and the expert. The structure decreases the interpretation problems inbuilt in unstructured interviews and permits the knowledge engineer to avoid the bias caused by the subjectivity of the domain expert. Structuring interview need to care many procedural issues, which are listed as follows (Education Pearson, 2012).

- The knowledge engineer studies obtainable material on the domain to identify main demarcations of the relevant knowledge.
- The knowledge engineer reviews the planned KBS capabilities. He/she identifies targets for the questions to be inquired during the knowledge acquisition session.
- Using a form, the knowledge engineer properly schedules and plans the structured interviews.
- The knowledge engineer may write sample questions, concentrating on question type, level, and questioning methods.
- The knowledge engineer makes sure that the domain expert understands the purpose and goals of the session and motivates the expert to prepare before the interview.
- During the interview, the knowledge engineer follows guidelines for conducting interviews.
- During the interview, the knowledge engineer uses directional control to keep the interview's structure.

Tracking methods: It is a collection of techniques that try to track the reasoning process of an expert. It is a widely held approach among cognitive psychologists who are interested in discovering the expert's train of thought in reaching a conclusion. The knowledge engineer can use the tracking process to find what information is being used and how it is being used. Tracking methods can be formal or informal (Education Pearson, 2012).

The common formal method is protocol analysis. Protocol analysis (also called verbal protocol analysis) is a method by which the knowledge engineer gets in depth knowledge from the expert. A protocol is a record or documentation of the expert's stepwise information-processing and decision-making behavior. In this method, the expert is inquired to accomplish an actual task and to articulate his/her thought processes.

Observations: Occasionally, it is possible to observe an expert at work. In many ways, this is the most obvious and direct approach to knowledge acquisition. However, the difficulties involved should not be underestimated. For example, most experts advise several people and may work in several domains at the same time. In this case, the knowledge engineers observations will also cover all the other activities. Therefore, large quantities of knowledge are being gathered, of which only a little is useful. In particular, if recordings or videotapes are made, the cost of transliterating large amounts of knowledge must be carefully considered.

3.2.2. Computer-Based Knowledge Acquisition Methods

Acquiring knowledge from experts can be supported using computer-based tools. These tools offer surroundings for knowledge engineers to identify knowledge via an interactive process (A.H. Mohammed and N.A.M. Al Saiyd,, 2010). Besides, semiautomatic methods that use computer-based tools for helping the knowledge acquisition process are also possible to extract knowledge automatically from the set of data. The process of finding useful information and patterns from the set of data using computers is known as knowledge discovery. In early 1990s, the process was also known as machine learning. But, currently knowledge discovery and data mining are becoming widely used terms (Education Pearson, 2012).

3.3. Conceptual Knowledge Modeling

There are numbers of knowledge modeling techniques, such as rules in the form of First Order Logic (FOL), scripts and frame based neural networks (Rajendra and Priti S , 2010). Once knowledge is acquired, it must be documented hence knowledge base developer and/or knowledge engineer can better understand and modeled it easily. Before knowledge modeling is done, it is very critical to ask the valid questions for experts and understand the appropriate flow, breakdown and consolidate the embedded knowledge in a structure so that implementing this knowledge results in appropriate solution for a specific problem in certain knowledge area. It is the responsibility of knowledge engineer to select appropriate knowledge presentation scheme that is more natural, efficient, transparent, and developer friendly. In this case the acquired knowledge during knowledge acquisition is represented so that it is ready for use which involves preparation of a knowledge map and before proceeding to encoding of the knowledge in the knowledge base. In this study, production rule is used for knowledge representation due to the reason that the researcher founds it easy in converting production rules into code in a rule based knowledge base development.

3.3.1. Knowledge Modeling For Tuberculosis Disease

Knowledge modeling is a cross disciplinary approach to capture and model knowledge into a reusable format for the purpose of preserving, improving, sharing, aggregating and processing knowledge to simulate intelligence (Aronson J., and Turban E, 2007).Knowledge is modeled after it is captured form its sources, Knowledge modeling for tuberculosis diagnosis has been done after the core concepts are extracted from domain experts and secondary source of data (document) analysis. Interpersonal communication and analytic skills are important to come up with quality knowledge base. The knowledge of the various infestations was obtained from specific literature and symptom descriptions and the rules from domain experts.

Two stages were iteratively done to implement this prototype. The first stage was the ‘Domain Acquaintance’, during which, the Knowledge Engineer, aiming to characterize the key problems, became familiar with the domain by studying books and papers related to TB diseases and identify appropriate, domain experts to be consulted. The second stage was the ‘‘Meeting with the Experts’’, during which, the expert system builder had meetings with the domain experts. The interviews with domain experts provided a lot of help in getting the idea of the extent of knowledge required to solve the problems. The experts were asked mainly the following questions, “What are the common signs and symptoms of tuberculosis?”, “What are the most common types of tuberculosis?”, “What are the laboratories testing methods used for diagnosis of tuberculosis?’’ and “Which one is the most common laboratory testing method used for diagnosis of tuberculosis?” Initially disease, symptoms and treatments were identified. This interview questioner is attached at appendix I. The following experts are interviewed.

Table 3.1 Profile of experts who participated in the knowledge acquisition

No	Name of expert	Specialization	Area interviewed
1	Dr. Alemayehuw Tesema	Medicine	Medical category
2	DR. Tamirate Mulugeta	Medicine	Medical category
3	Mr. abay Anbase	Health officer	Medical category
4	Mr. Habtamu Asrat	Health officer	Medical category

As indicated in the Table 3.1 the health professionals are devoted to providing health care services in the institution. According to the domain experts, the investigation of patient health problem starts by collecting some relevant information such as sex, age and family history of the patient. History of patient is important attribute to determine the types of health problem, because tuberculosis is communicable diseases.

After the interviews with the experts and thorough review of the literature, the researcher summarized the information in the following Table 3.2. The table gives information about the details of types of extra pulmonary TB disease, their symptom and area of the body that affected by TB disease.

Table 3.2 Symptom of extra pulmonary TB

Types of TB	**Affected area**	**Symptoms**
Tuberculosis Meningitis	brain and spinal cord	Irritability and restlessness. Stiff neck, headaches, Vomiting, mental confusion of insidious onset, seizures, or coma.
Gastrointestinal Tuberculosis	mouth, esophagus, stomach, small and large intestine, and the anus	Abdominal pain, fever, loss appetite and weight, nausea, vomiting, and change in bowel habits, producing increased fluid.
Tuberculosis Lymphadenitis (Scrofula)	usually along the neck	The formation of masses along the neck, and if the disease is advanced the mass may burst and form a draining sinus.

Cutaneous Tuberculosis (Lupusvulgaris, tuberculosis, verrucae cutis and miliary tuberculosis.)	the skin or mucous membrane	(Lupus vulgaris) small reddish brown lesions that are found on the face, eyelids, Around the nose, cheeks, and ears. (TB verrucae cutis) Reddish brown wart-like growths on the body, skin lesions on hands, feet, buttocks, elbows and knees. (TB Miliary) Small red spots on the skin (which are sometimes concentrated to the trunk of the body), necrosis of infected areas, and the development of ulcers or abscesses on the skin.
Osteon-articular Tuberculosis	TB of the joints: knees, hips, ankles, wrists, shoulders, and elbows	arthritis and pain or stiffness is only felt in the infected area, muscle weakness ,paralysis
Genitourinary Tuberculosis	the urinary tract and the reproductive system	blood present in urine, painful or uncomfortable urination, and Experiencing pain on one side of the body between the upper abdomen and back.
Drug-resistant Tuberculosis (MDR-TB and XDR-TB)		Weight loss, fever, night sweats, coughing and/or coughing up blood, fatigue, and chest pain.
Tuberculosis Pericarditis	the heart	the heart to fill with fluid, Impeding the heart's ability to fill with blood and beat efficiently.
Adrenal Tuberculosis	adrenal insufficiency	Increase steroid production in times of stress, causing weakness and collapse.

The details of type’s Pulmonary TB disease, their symptom and area of affected are identified in the Table 3.3.

Table 3.3 Symptom of pulmonary TB

Types of pulmonary TB	Affected area	Symptom
Primary TB Pneumonia	HIV-infected and AIDS patients	a high fever and productive cough more than 2 weeks duration
Pleurisy TB	the lungs and the chest wall	amount of fluid increases dramatically and compress the lung, causing shortness of breath sharp chest pain
Cavitary TB	upper lobes of the lung	Productive cough, night sweats, fever, weight loss, and weakness. hemoptysis (coughing up blood)
Military TB	Lungs	High fever, night sweats, and weight loss.

3.3.2. Concept of Treatment of TB

The goal of tuberculosis treatment is to interrupt tuberculosis transmission, prevent acquisition of drug resistance and cure the patient. The domain expert said to achieve the aim of TB treatment, the patient should receive adequate chemotherapy .the requirement for adequate chemotherapy are:

- An appropriate combination of drugs
- Prescribe in the correct dosage
- Take regularly by the patient
- For sufficient period of time

Directly observed therapy (DOT) is the standard of care for treatment of active TB.

The domain expert is recommending following the DOT. It is the direct observation by a trained health-care worker of every anti tuberculosis medication dose administered. DOT should be used with both pulmonary and extra pulmonary TB patients.

Drugs used for the chemotherapy of TB

The drugs used for TB treatment are safe and effective if properly used. Standard initial treatment consists of isoniazid (INH), rifampin (RIF), pyrazinamide (PZA) and Ethambutol (EMB). First line drugs for the treatment of TB in Ethiopia include:

- Rifampicin(R)
- Ethambutol (E)
- Isoniazid (I)
- Pyrazinamide (P)
- Streptomycin(S)

Before you put patient on anti TB drugs:

- Determine the type of TB whether pulmonary TB or Extra pulmonary TB.
- Determine previous treatment history whether new patient or previously treated.

Anti TB drug dosages

The dose and type of anti TB drugs are age and weight dependent. There is no sex difference in TB treatment unless the patient is pregnant and breeds breasting who should not give streptomycin.

Table 3.4 Recommended Doses of First Line Ant-TB Drugs for Adult

Drugs	Recommended dose	
	Dose and range(mg/kg Bwt)	Maximum(mg)
Isoniazid	5(4-6)	300
Rifampicin	10(8-12)	600
Pyrazinamide	25(20-30)	2,000
Ethambutol	15(15-20)	1600
Streptomycin	15(12-18)	1000

Anti-TB Dosage for New TB Cases

The domain expert said new TB cases means the patient is not affected before or previously by TB diseases. Treatment regimen and dose is based on the weighting of the patient is given. All medication doses should be calculated based upon weight for both children and adults. In general, utilize the lowest possible dose for weight. Adjust doses as the individual's weight changes. For obese patients, dosing should be based on ideal body weight to avoid toxicity.

Table 3.5 Anti-TB Dosage for New TB Cases

Patient's weight in Kgs	Treatment regimen and dose	
	Intensive phase 2SRHZE/1RHZE	Continuation phase 5(RH)E
20-29	$1^{1/2}$	$1^{1/2}$
30-39	2	2
40-54	3	3
>55	4	4

Anti -TB Drugs Dosage for Previously Treated Cases

The domain expert said that Previously Treated Cases means the patient is affected before or previously by TB diseases .Treatment regimen and dose is based on the weighting of the patient is given.

Table 3.6 Anti -TB Drugs Dosage for Previously Treated Cases

Patient's weight in Kgs	Treatment regimen and dose			
	Intensive phase 2RHZE		Continuation phase 4RH	
	S	RHZE	RH	E
20-29	½(0.5 g)	$1^{1/2}$	$1^{1/2}$	$1^{1/2}$
30-39	½(0.5 g)	2	2	$1^{1/2}$
40-54	¾(0.75 g)	3	3	2
>55	1 g	4	4	3

Dosage of INH for Children According To Their Weights

Because of the high risk of disseminated tuberculosis in infants and children younger than 4 years of age, treatment should be started as soon as the diagnosis of tuberculosis is suspected. In general, the regimens recommended for adults are also the regimens of choice for infants, children, and adolescents with tuberculosis; with the exception that ethambutol is not used routinely in children. Because there is a lower bacillary burden in childhood-type tuberculosis there is less concern with the development of acquired drug resistance. The Table 3.7 is indicating the children can take dosage of INH for children according to their weights.

Table 3.7 Dosage of INH for Children According To Their Weights

Weight	Number of 100 mg tablets of INH per dose	Dose given(mg)
<5	½ tablet	50
5.1-9.9	1 tablet	100
10-13.9	$1^{1/2}$ tabletor1\2adult tablet	150
14-19.9	2 tablet	200
20-24.9	$2^{1/2}$ tablet	250
>25	3 tablet or one adult tablet	300

The fixed dose combination (FDC) drugs available for adult and adolescent are the following

- RHZE 150/75/400/275 mg
- RHZ 150/75 mg
- EH /400/150 mg

All the drugs should be taken together as a single, daily dose, preferably on an empty stomach.

Phase of chemotherapy

Treatment of TB has two phases

Initial phase

This phase consists of treatment with combination of four drugs for the first 8 weeks for new cases and with combination of five drugs for the first 8 weeks followed by four drugs for the next 4 weeks for re-treatment cases.it renders the patient non-infectious by rapidly reducing the load of bacilli in the sputum, usually within 2-3 weeks except in case of drug resistance.

Continuation phase

This phase immediately follows the intensive phase and is important to ensure cure or completion of treatment. It is necessary in order to prevent relapse after completion of treatment. This phase requires treatment with combination of two drugs, to be taken for 4 month for new cases and treatment with the combination of three drugs for re-treatment case for 5 month.

Table 3.8 TB treatment phase

phase	Purpose	treatment
Initial phase	Kills most of the tubercle bacilli during the first 8 weeks of treatment, but some bacilli can survive longer ➢ Prevents the emergence of drug resistance ➢ Determines the ultimate outcome of the regimen	Initial 2-month treatment regimen ➢ Includes four drugs in the treatment(usually NH, RIF, PZA, and EMB) ➢ Each of the drugs plays an important role for short-course regimens with high curates ➢ Multiple drugs are needed to prevent the development of drug-resistant TB disease
Continuation phase	Kills remaining tubercle bacilli (after initial phase) ➢ If treatment is not continued long enough, the surviving bacilli may cause TB disease in the patient at a later time	An addition of either 4 or 7 months of treatment ➢ 4 months is used for majority of patients ➢ 7 months is recommended only for persons » Who have drug-susceptible cavitary or extensive pulmonary TB disease and whose sputum culture obtained at the time of completion of 2 months of treatment is positive

		» Whose initial phase of treatment did not include PZA » Who are treated with once-weekly INH and RPT and whose sputum culture at the time of completion of the initial phase is positive
Treatment completion	Defines the number of doses ingested within a specified time frame duration depends on ➢ Drugs used ➢ Drug susceptibility test results of the isolate ➢ Patient's response to therapy	Most patients with previously untreated pulmonary TB disease can be treated with either ➢ 6-month regimen (preferred) containing INH, RIF, and initially PZA or ➢ 9-month regimen containing INH and RIF

3.3.3. Concepts of Laboratory Test Result

Since considering only the symptoms of TB are not enough to conclude that whether the patients have TB or not, laboratory test result is the key part and the most important concept for the decision. Because of this the domain expert sends the patient for a laboratory test. As the domain experts said most of diagnosis is done during physical examination conversation between the domain expert and the patient, the rest of diagnosis is a phase of decision. The following is one of the most common types of laboratory tests that the domain experts should know that will help them in order to make decisions:

- **Tuberculin Skin Test (TST)**

The Manteaux tuberculin skin test is a test to check if a person has been infected with TB bacteria. Using a small needle, a health care provider injects appliqued (called tuberculin) into the skin of the lower part of the arm. When injected, a small, pale bump will appear. The person given the TST must return within 2 or 3 days to have a trained health care worker look for a reaction on the arm where the liquid was injected. The health care worker will look for a raised, hard area or swelling, and if present, measure its size using a ruler. Redness by itself is not considered part of the reaction.

A positive TST result mean

The TST result depends on the size of the raised, hard area or swelling. It also depends on the person's risk of being infected with TB bacteria and the progression to TB disease if infected.

Positive TST: This means the person's body was infected with TB bacteria. Additional tests are needed to determine if the person has latent TB infection or TB disease. A health care worker will then provide treatment as needed.

Negative TST: This means the person's body did not react to the test, and that latent TB infection or TB disease is not likely.

- **TB Blood Tests**

An Interferon Gamma Release Assay (IGRA): is a blood test that can determine if a person has been infected with TB bacteria. An IGRA measures how strong a person's immune system reacts to TB bacteria by testing the person's blood in a laboratory. Blood is collected into special tubes using a needle. The blood is delivered to a laboratory as directed by the IGRA test instructions. The laboratory runs the test and reports the results to the health care provider.

A positive IGRA result mean

Positive IGRA: In this test the domain experts know the person has been infected with TB bacteria. Additional tests are needed to determine if the person has latent TB infection or TB disease. A health care worker will then provide treatment as needed.

Negative IGRA: In this test the domain experts know the person's blood did not react to the test and that latent TB infection or TB disease is not likely.

- **Sputum testing**: Sample of sputum is test in laboratory to diagnose the TB. If sputum is available, or can be induced, a lab test may give a positive result in up to 30% of people with active disease. In this test the domain experts know if in the sputum TB bacteria occur during laboratory test the result indicate TB disease.
- **Chest radiograph**: The chest radiograph is essential to detect and describe chest abnormalities suggestive of active pulmonary TB disease or inactive TB. This standard defines the minimum

frequency of chest radiographs required to diagnose active TB disease, inactive TB and latent TB infection (LTBI) and medically manage uncomplicated TB disease.

3.3.4. Concepts of Family History of TB disease

The domain experts have a concept of family history of TB. The family history of TB may cause the patient to be TB affected. By considering this the domain expert asks the patient for his/her family history of TB, then the domain expert can decide the patient has TB disease, especially for patients with TB can easily transmitted to other by contacting and sneezing on the air.

3.4.5. Concept of Pregnancy and Breastfeeding Women

The domain expert have a concept of pregnant and breastfeeding women. By considering this the domain expert asks the patient whether the women pregnant or breastfeeding, then the domain expert can decide pregnant women should start treatment as soon as TB is suspected. The preferred initial treatment regimen is INH, rifampin (RIF), and ethambutol (EMB) daily for 2 months, followed by INH and RIF daily, or twice weekly for 7 months (for a total of 9 months of treatment). Streptomycin should not be used because it has been shown to have harmful effects on the fetus. In most cases, pyrazinamide (PZA) is not recommended to be used because its effect on the fetus is unknown. And also the domain expert ask the patient whether the patient is breastfeeding, then the domain expert can decide Breastfeeding should not be discouraged for women being treated with the first line anti tuberculosis drugs because the concentrations of these drugs in breast milk are too small to produce toxicity in the nursing newborn. For the same reason, drugs in breast milk are not an effective treatment for TB disease or LTBI in a nursing infant. Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation.

Table 3.9 Recommendation Drugs for Women pregnancy and breastfeeding

Women Patient affected by TB	Recommendation drugs
Pregnancy	Ionized INH, rifampin (RIF), and ethambutol (EMB)
Breastfeeding	INH + pyridoxine (vitamin B6)

3.4.6. Concept of HIV Patients

Concept of HIV testing is the standard of care for all tuberculosis cases and suspects, and is recommended for all contacts to cases. Knowledge of HIV status is critical both because the presentation of tuberculosis in HIV-infected persons can differ from that in immune competent persons and the TB treatment regimen is adjusted based upon the CD4+ cells/µl count.

3.4.7. Anti-TB Drugs Currently Used in the Ethiopia

After the interviews with the experts and thorough review of the literature, the researcher summarized the information in the following Table 3.2. The table gives information about the details of types of Anti-TB Drugs and their Comments and the Drug classes that the patient affected by TB can take the drug through two regimes are identified in the Table 3.2.

Table 3.10 Anti-TB Drugs Currently Used in Ethiopia

Drug Classes	Anti-TB Drugs	recommendation
First-line drugs	Isoniazid (INH)	Isoniazid (INH) INH, RIF, PZA, and EMB form the core of initial treatment regimen.
	Rifampin (RIF)	
	Pyrazinamide (PZA)	
	Ethambutol (EMB)	
	Rifabutin* (RBT)	May be used as a substitute for RIF in the treatment ofall forms of TB caused by organisms that are known or presumed to be susceptible to this agent.
	Rifapentine (RPT)	May be used once weekly with INH in the continuation phase of treatment for HIV-negative patients with non cavitary, drug-susceptible pulmonary TB who have negative sputum smears at completion of the initial phase of treatment.
Second line drugs	Streptomycin (SM)	• SM was formerly considered to be a first-line drug and in some instances, is still used in initial treatment. • Increasing prevalence of resistance to SM in many parts of the world has decreased its overall usefulness.
	Cycloserine Capreomycin ρ-Aminosalicylic acid Levofloxacin Moxifloxacin Amikacin/Kanamycin	These drugs are reserved for special situations such as drug intolerance or resistance.

3.3.8. Decision Tree for Modeling TB diagnosis

Decision trees are one of a modeling tool that used in variety of settings to organize and break down cluster of data. It is a graphical representation of the information in the factor table to determine a course of actions and models the possible consequences of a series of decisions in some situations (Bethune et al, 2007). Decision analysis is explicit because it forces the decision maker to separate the problem into its component parts without losing the context of the big picture. It is an analytic approach forces the decision maker to consider explicitly the timing of choices that must be made, the data that must be acquired to make informed decisions. Thus, decision tree takes as input an object or situation described by a set of properties, and outputs a yes/no decision. They are able to produce human readable descriptions of trends in the underlying relationships of a data set and can be used for classification and prediction tasks. A decision tree is formalism for expressing and mappings attributes linked to two or more sub-trees and leafs or decision nodes (Podgorelec et al, 2002).

Moreover, in this research decision tree has been used as knowledge modeling tool. The reason of choosing this modeling tool is that decision trees depict a strong sense of cause and effect relationships of types of TB diseases and the associative symptoms that lead to the identification of those diseases. Purposefully, decision trees can easily be converted to the form of if-then rules that are suitable and understandable by computer programs. So, the conversion can be executed by a computer program.

Knowledge representation in decision tree for pulmonary TB

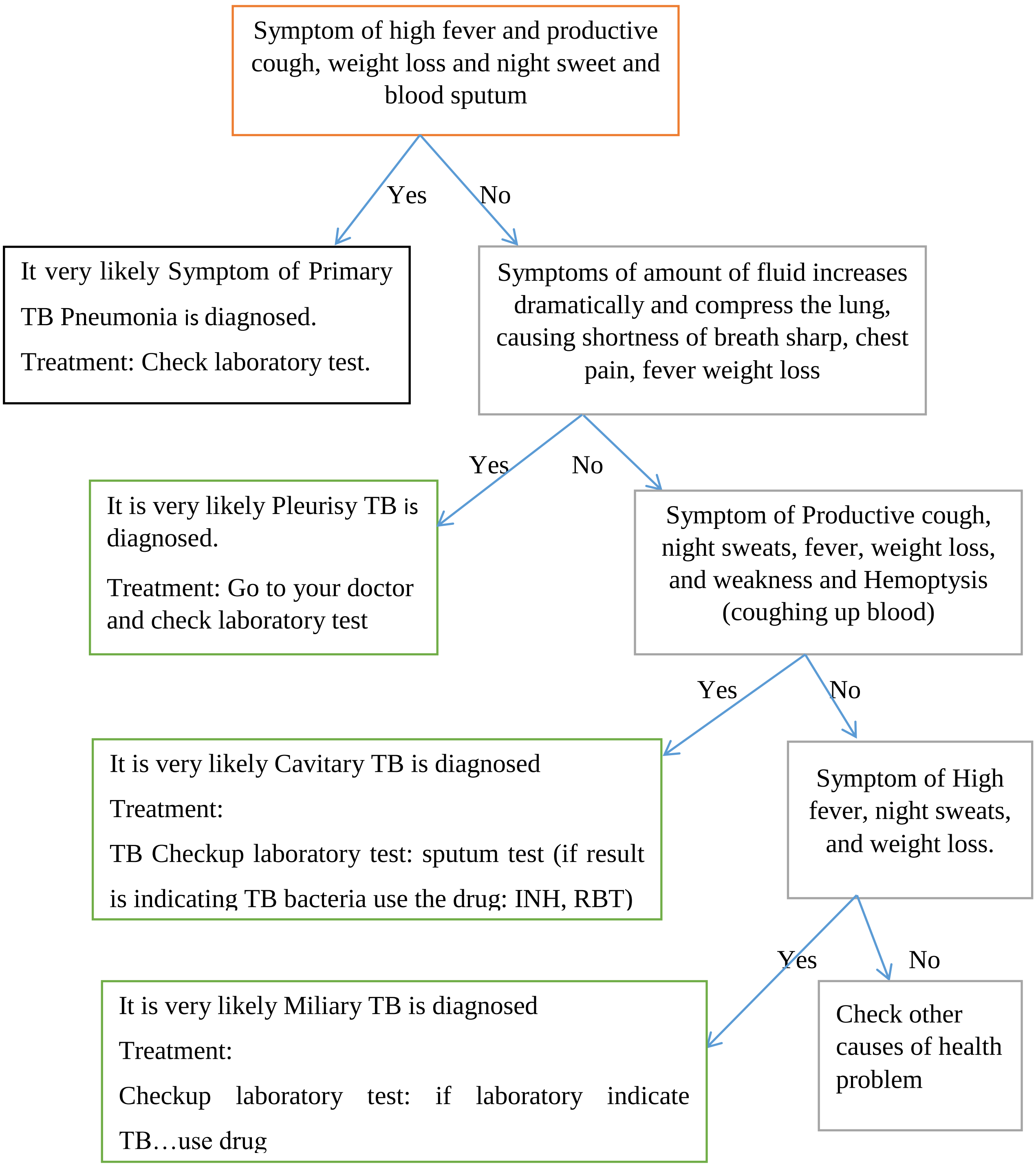
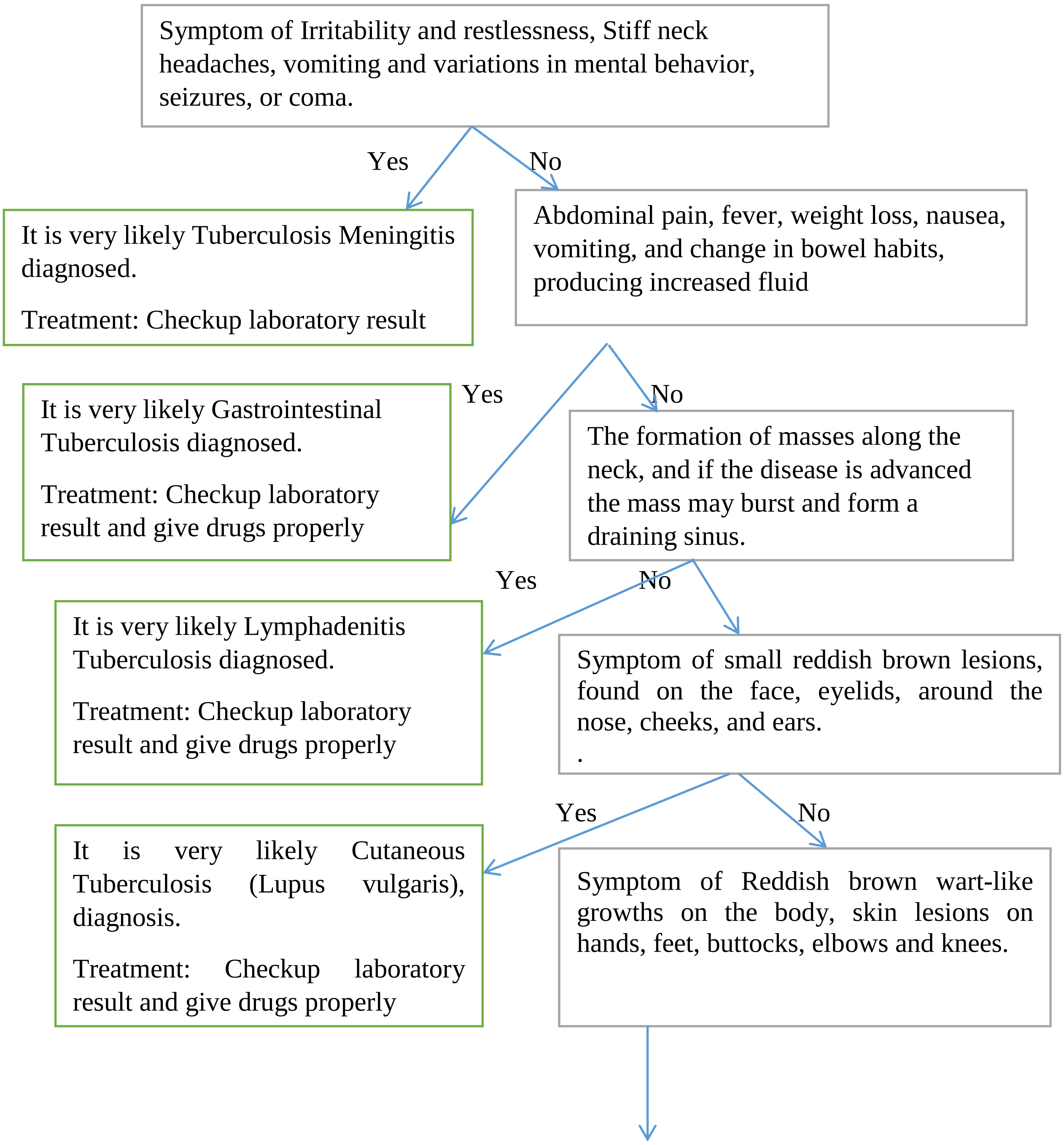


Figure 3.1 Decision trees for diagnosis and treatment for pulmonary TB

Knowledge representation in decision tree for extra pulmonary TB



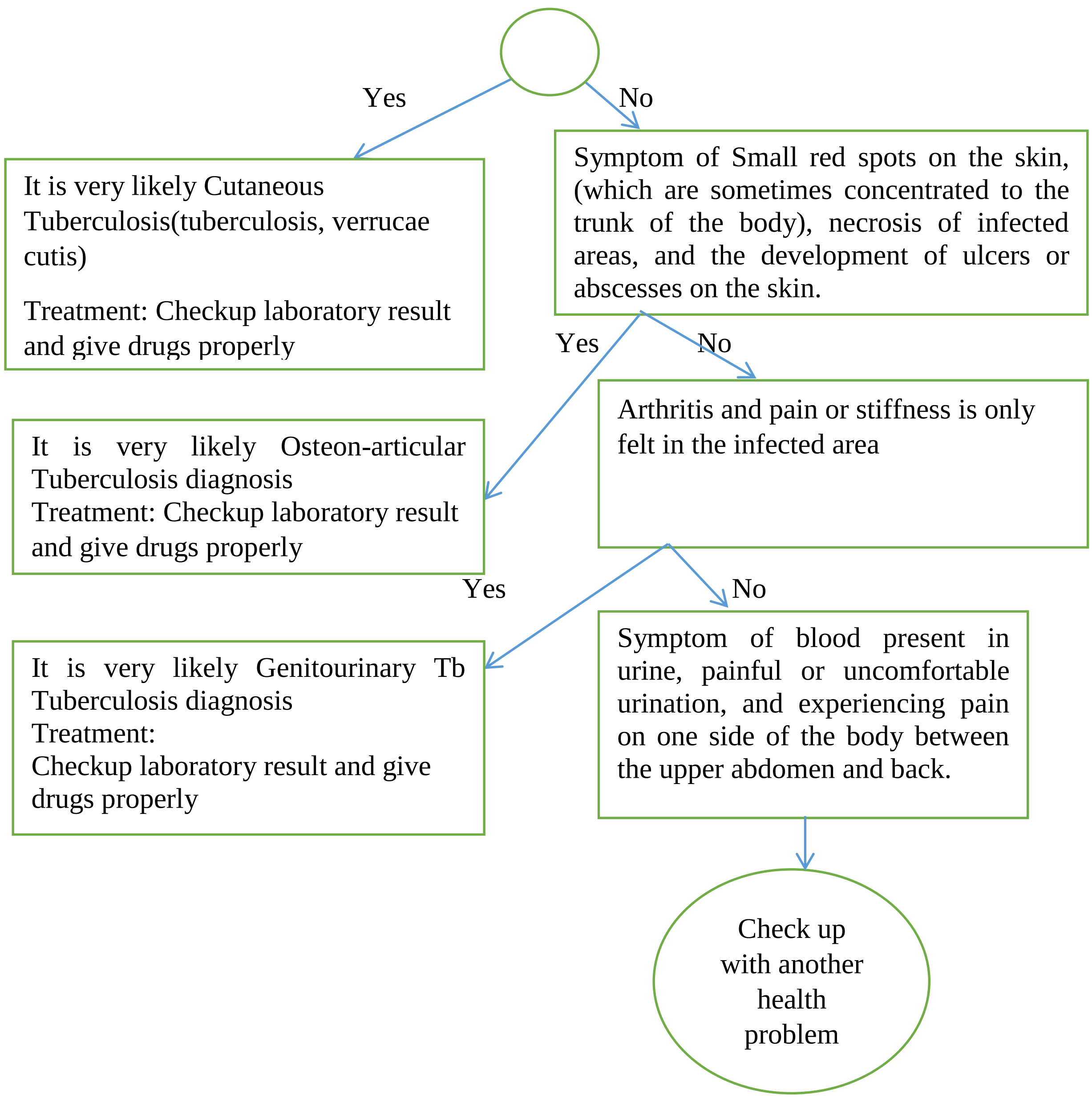


Figure 3.2 Decision trees for diagnosis and treatment for extra pulmonary TB

3.4. System architecture

This system was designed with the progression of conceptual design that refined the systems' architecture. Of course, the conceptual design was essential to stabilize the architecture of knowledge based system for tuberculosis diagnosis and treatment. Throughout design iterations, the design of knowledge based system for tuberculosis diagnosis and treatment was expended into system architecture to ensure that it supported the disease and treatments. The system architecture and the functional follow of the system are presented below.

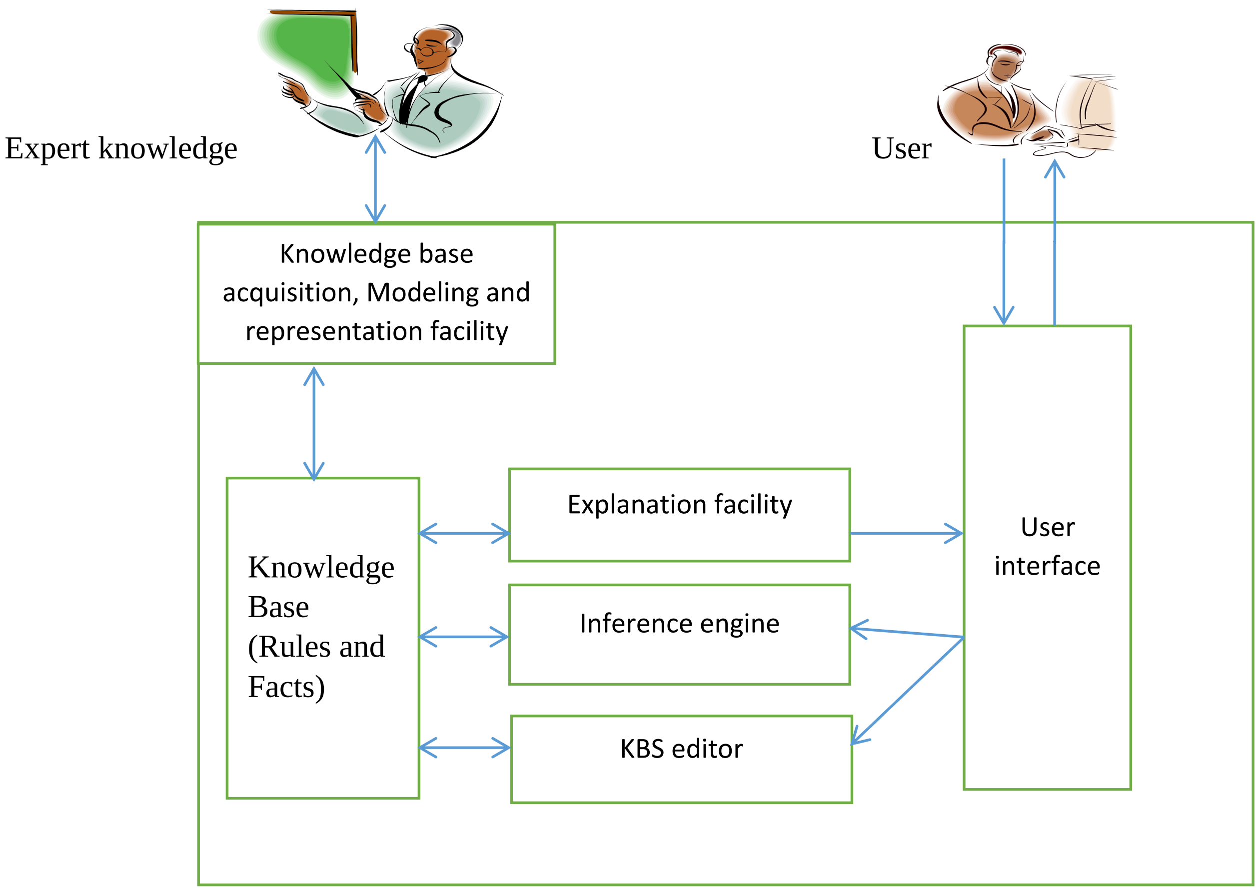


Figure 3.3 Architecture of the System

CHAPTER FOUR

4. KNOWLEDGE BASED SYSTEM DEVELOPMENT

4.1. Introduction

The knowledge base system infers solution by running the knowledge base through inference engine, which is a software program that interacts with the user and processes the result from the rules and facts in the knowledge base. In the previous chapter (chapter three) the domain knowledge has been extracted from the experts and modeled using tree structure of decision tree knowledge modeling techniques. The rule representation in this study involves selection of the types of TB diseases as goals (hypothesis) to be checked and the symptoms of each TB diseases as conditions to make conclusions for the rule to be fired or executed.

The Knowledge representation which was presented using IF_THEN representation technique, inference mechanism, development of the user interface and evaluation of the prototype knowledge base system for TB diseases diagnosis and treatment (KBSTBDDT) are discussed in this chapter. Based on this representation formalism, the acquired knowledge is expressed in a manner that compatible with a computer representation which is implemented using backward chaining inference mechanism. This represented knowledge is encoded and implemented using appropriate programming tool. To implement TB diagnosis knowledge based system (TBDKBS) in this study, SWI prolog programming language has been used.

4.2. Representation of Knowledge

Knowledge representation (KR) is the problem of getting knowledge and expertise into the computer in a form that is easy to access and use in solving problems. In the representation of knowledge into knowledge base, the knowledge acquired from knowledge acquisition process is represented into structured form. There are many approaches for representing knowledge into the knowledge base. Knowledge based systems rely on knowledge from specific domains to provide solutions to specific problems. Although different KR methodologies exist in developing knowledge based system for TB diagnosis and treatment. The rule based KR is used because, the rule based knowledge representation has many advantages compared with other knowledge representation methodologies especially for such problems. This method is widely used because each rule is modular and contains a chunk of domain knowledge and experts are often able to express their heuristic knowledge in an IF-THEN format.

Rule based expert systems are easy to understand and seem to effectively reflect the way our utility experts represent and diagnose problems. Another major advantage of this scheme is the visibility of the knowledge, because the designer of the expert system will not be the maintainer, which is the case in most software development projects. For such and the like advantages of production rule the real representation of this research is represented in the following tables using production rule.

Production Rule for Pulmonary TB

Table 4.1 Disease diagnosis form for Primary TB Pneumonia disease

IF : symptom appears on patient lung And Symptom of high fever And productive cough more than two weeks, And weight loss And night sweet And blood sputum
THEN :Possible Disease Primary TB Pneumonia**.**
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage Take drugs For sufficient period of time

Please identify the age of patient (adult, children or old). please identify the patient whether pregnancy or breastfeeding **Recommendations for adult use the following drugs:** 1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly. 2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly. 3. Ethambutol (EMB) 15_20 mg/kg per day. 4. Pyrazinamide (PZA) 20_25 mg/kg per day. **Recommendations for Children use the following drugs:** 1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3). 2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly. 3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g). Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution

Table 4.2 Disease diagnosis form of Pleurisy TB

IF : symptom appears on patient lung And Symptoms of amount of fluid increases dramatically And compress the lung, causing shortness of breath sharp, And chest pain and fever, weight loss
THEN :Possible Disease Pleurisy TB
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage Take drugs For sufficient period of time Please identify the age of patient (adult, children or old). please identify the patient whether pregnancy or breastfeeding **Recommendations for adult use the following drugs:**

1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly.
2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly.
3. Ethambutol (EMB) 15_20 mg/kg per day.
4. Pyrazinamide (PZA) 20_25 mg/kg per day.

Recommendations for Children use the following drugs:

1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily; 20–30 mg/kg (900 mg) twice weekly (3).
2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly.
3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g).

   Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection.

Recommendations for pregnant women use the following drugs:

1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day).
2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus.
3. Pyrazinamide (PZA) is not recommended.

Recommendation for Breastfeeding women

'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation.

Preventions :

- Strict standards for ventilation, air filtration etc.
- covering of mouth by a mask
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep
- Get tested regularly
- Keep the immune system healthy.

Table 4.3 Disease diagnosis form of Miliary TB

IF : symptom appears on patient lung

And Symptom of High fever,

And night sweats and weight loss.

THEN: possible disease Miliary TB
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage Take drugs For sufficient period of time Please identify the age of patient (adult, children or old). please identify the patient whether pregnancy or breastfeeding **If the patient is adult use the following drugs:** 1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly. 2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly. 3. Ethambutol (EMB) 15_20 mg/kg per day. 4. Pyrazinamide (PZA) 20_25 mg/kg per day. **Recommendations for Children use the following drugs.** 1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3). 2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly. 3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g). Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection. **Recommendations for pregnant women use the following drugs.** 1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day). 2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus. 3. Pyrazinamide (PZA) is not recommended. **Recommendation for Breastfeeding women** 'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation. **Preventions :** ➢ Strict standards for ventilation, air filtration etc.

- covering of mouth by a mask
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep
- Get tested regularly
- Keep the immune system healthy.

Table 4.4 Disease diagnosis form of Cavitary TB

IF : symptom appears on patient lung

And Symptom of Productive cough,

And night sweats, fever, weight loss,

And weakness and Hemoptysis (coughing up blood)

THEN: possible disease Cavitary TB

Treatment:

Please check additional laboratory testing

An appropriate combination of drugs

Prescribe in the correct dosage

Take drugs For sufficient period of time

Please identify the age of patient (adult, children or old).

please identify the patient whether pregnancy or breastfeeding

Recommendations for adult use the following drugs.

1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly.
2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly.
3. Ethambutol (EMB) 15_20 mg/kg per day.
4. Pyrazinamide (PZA) 20_25 mg/kg per day.

Recommendations for Children use the following drugs.

1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3).
2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly.
3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g).

Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection. **Recommendations for pregnant women use the following drugs.** 1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day). 2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus. 3. Pyrazinamide (PZA) is not recommended. **Recommendation for Breastfeeding women** 'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation. **Preventions :** ➢ Strict standards for ventilation, air filtration etc. ➢ covering of mouth by a mask ➢ Exercise regularly to keep the immune system ➢ Get adequate amounts of sleep ➢ Get tested regularly ➢ Keep the immune system healthy.

Production Rule for Extra Pulmonary TB

Table 4.5 Disease diagnosis form of TB Meningitis

IF : symptom appears on patient neck And Symptom of Irritability and restlessness. , And Stiff neck headaches and vomiting And variations in mental behavior and seizures, or coma.
THEN: possible disease TB Meningitis
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage

Take drugs For sufficient period of time

Please identify the age of patient (adult, children or old).

please identify the patient whether pregnancy or breastfeeding

Recommendations for adult use the following drugs:

1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly.
2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly.
3. Ethambutol (EMB) 15_20 mg/kg per day.
4. Pyrazinamide (PZA) 20_25 mg/kg per day.

Recommendations for Children use the following drugs:

1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3).
2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly.
3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g).

Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection.

Recommendations for pregnant women use the following drugs:

1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day).
2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus.
3. Pyrazinamide (PZA) is not recommended.

Recommendation for Breastfeeding Women

'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation.

Preventions :

- Strict standards for ventilation, air filtration etc.
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep
- Get tested regularly
- Keep the immune system healthy.

Table 4.6 Disease diagnosis form of Gastrointestinal Tuberculosis

IF : symptom appears on patient And Abdominal pain and fever and weight loss, And nausea and vomiting, and change in bowel habits, And producing increased fluid.
THEN: possible disease Gastrointestinal Tuberculosis
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage Take drugs For sufficient period of time Please identify the age of patient (adult, children or old). please identify the patient whether pregnancy or breastfeeding **Recommendations for adult use the following drugs:** 1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly. 2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly. 3. Ethambutol (EMB) 15_20 mg/kg per day. 4. Pyrazinamide (PZA) 20_25 mg/kg per day. **Recommendations for Children use the following drugs.** 1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3). 2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly. 3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g). Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection. **Recommendations for pregnant women use the following drugs:** 1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day). 2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus.

3. Pyrazinamide (PZA) is not recommended.

Recommendation for Breastfeeding Women

'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation.

Preventions :

- Strict standards for ventilation, air filtration etc.
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep
- Get tested regularly
- Keep the immune system healthy.

Table 4.7 Disease diagnosis form of Lymphadenitis Tuberculosis

IF : symptom appears on patient neck

And The formation of masses along the neck,

And if the disease is advanced the mass may burst

And form a draining sinus.

THEN: possible disease

Lymphadenitis Tuberculosis

Treatment:

Please check additional laboratory testing

An appropriate combination of drugs

Prescribe in the correct dosage

Take drugs For sufficient period of time

Please identify the age of patient (adult, children or old).

please identify the patient whether pregnancy or breastfeeding

Recommendations for adult use the following drugs:

1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly.
2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly.
3. Ethambutol (EMB) 15_20 mg/kg per day.

4. Pyrazinamide (PZA) 20_25 mg/kg per day.

Recommendations for Children use the following drugs:

1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3).
2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly.
3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g).

Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection.

Recommendations for pregnant women use the following drugs:

1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day).
2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus.
3. Pyrazinamide (PZA) is not recommended.

Recommendation for Breastfeeding Women

'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation.

Preventions :

- Strict standards for ventilation, air filtration etc.
- covering of mouth by a mask
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep
- Get tested regularly
- Keep the immune system healthy.

Table 4.8 Disease diagnosis form of Lupus vulgaris

IF: symptom appears on patient face, ears and nose. And Symptom of small reddish brown lesions, And found on the face and eyelids and around the nose, And cheeks and ears.
THEN: possible disease Cutaneous Tuberculosis (Lupus vulgaris).
Treatment:

Please check additional laboratory testing

An appropriate combination of drugs

Prescribe in the correct dosage

Take drugs For sufficient period of time

Please identify the age of patient (adult, children or old).

Please identify the patient whether pregnancy or breastfeeding.

Recommendations for adult use the following drugs:

1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly.
2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly.
3. Ethambutol (EMB) 15_20 mg/kg per day.
4. Pyrazinamide (PZA) 20_25 mg/kg per day.

Recommendations for Children use the following drugs:

1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3).
2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly.
3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g).

Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection.

Recommendations for pregnant women use the following drugs:

1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day).
2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus.
3. Pyrazinamide (PZA) is not recommended.

Recommendation for Breastfeeding women

Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation.

Preventions :

- Strict standards for ventilation, air filtration etc.
- covering of mouth by a mask
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep

- Get tested regularly
- Keep the immune system healthy.

Table 4.9 Disease diagnosis form of tuberculosis verrucae cutis

IF : symptom appears on patient hands, feet, knees And Symptom of Reddish brown wart-like growths on the body, And skin lesions on hands, feet, buttocks, elbows and knees.
THEN: possible disease Cutaneous Tuberculosis (tuberculosis, verrucae cutis)
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage Take drugs For sufficient period of time Please identify the age of patient (adult, children or old). please identify the patient whether pregnancy or breastfeeding **Recommendations for adult use the following drugs:** 1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly. 2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly. 3. Ethambutol (EMB) 15_20 mg/kg per day. 4. Pyrazinamide (PZA) 20_25 mg/kg per day. **Recommendations for Children use the following drugs:** 1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3). 2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly. 3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g). Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection. **Recommendations for pregnant women use the following drugs:** 1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day).

2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus. 3. Pyrazinamide (PZA) is not recommended. **Recommendation for Breastfeeding Women** 'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation. **Preventions :** ➢ Strict standards for ventilation, air filtration etc. ➢ covering of mouth by a mask ➢ Exercise regularly to keep the immune system ➢ Get adequate amounts of sleep ➢ Get tested regularly ➢ Keep the immune system healthy.

Table 4.10 Disease diagnosis form of Osteon-articular Tuberculosis

IF : symptom appears on patient skin And Symptom of Small red spots on the skin, (which are sometimes concentrated to the trunk of the body) and necrosis of infected
THEN: possible disease Osteon-articular Tuberculosis
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage Take drugs For sufficient period of time Please identify the age of patient (adult, children or old). please identify the patient whether pregnancy or breastfeeding **Recommendations for adult use the following drugs:** 1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times

weekly. 2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly. 3. Ethambutol (EMB) 15_20 mg/kg per day. 4. Pyrazinamide (PZA) 20_25 mg/kg per day. **Recommendations for Children use the following drugs:** 1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3). 2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly. 3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g). Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml); aqueous solution (100 mg/ml) for intravenous or intramuscular injection. **Recommendations for pregnant women use the following drugs:** 1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day). 2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus. 3. Pyrazinamide (PZA) is not recommended. **Recommendation for Breastfeeding Women:** 'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation. **Preventions :** ➢ Strict standards for ventilation, air filtration etc. ➢ Exercise regularly to keep the immune system ➢ Get adequate amounts of sleep ➢ Get tested regularly ➢ Keep the immune system healthy.

Table 4.11 Disease diagnosis form of Genitourinary TB

IF : symptom appears on patient And Symptom of blood present in urine, painful or uncomfortable urination, And experiencing pain on one side of the body between the upper abdomen and back.
THEN: possible disease

Genitourinary TB
Treatment: Please check additional laboratory testing An appropriate combination of drugs Prescribe in the correct dosage Take drugs For sufficient period of time Please identify the age of patient (adult, children or old). please identify the patient whether pregnancy or breastfeeding **Recommendations for adult use the following drugs:** 1. Isoniazid (INH) 5 mg/kg (300 mg) daily, 15 mg/kg (900 mg) once, twice, or three times weekly. 2. Rifampin (RIF) 10 mg/kg (600 mg) once daily, twice weekly, or three times weekly. 3. Ethambutol (EMB) 15_20 mg/kg per day. 4. Pyrazinamide (PZA) 20_25 mg/kg per day. **Recommendations for Children use the following drugs:** 1. Isoniazid (INH) 10_15 mg/kg (300 mg) daily, 20–30 mg/kg (900 mg) twice weekly (3). 2. Rifampin (RIF) 10_20 mg/kg (600 mg) once daily or twice weekly. 3. Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily, 50 mg/kg twice weekly (2.0 g). Preparations. Tablets (50 mg, 100 mg, 300 mg), syrup (50 mg/5 ml), aqueous solution (100 mg/ml) for intravenous or intramuscular injection. **Recommendations for pregnant women use the following drugs:** 1. Isoniazid (INH) +. RIF + EMB + Pyridoxine supplementation (25 mg/day). 2. Streptomycin should not be used because it has been shown to have harmful effects on the fetus. 3. Pyrazinamide (PZA) is not recommended. **Recommendation for Breastfeeding women:** 'Breastfeeding women taking INH should also take pyridoxine (vitamin B6) supplementation. **Preventions :** ➢ Strict standards for ventilation, air filtration etc.

- covering of mouth by a mask
- Exercise regularly to keep the immune system
- Get adequate amounts of sleep
- Get tested regularly
- Keep the immune system healthy.

4.3. Implementation Software

There are many different tools to implement knowledge based systems. A KBS tool is a set of software instructions and utilities taken to be a software package designed to assist the development of knowledge-based systems. Personal computers, typical programming languages like java and framework like .NET can also be used in KBS development. These programming languages are general purpose and also being used to develop other application than AI applications. KBS shell with the convenient utilities of rule based, explanation and inference like Java Expert System Shell (JESS) are more specific and can also be useful to develop KBS. Tailor made KBS can be developed using programming languages like LISP and Prolog (Abraham, 2002)

In this paper the programming language Prolog (Programming in Logic) language is chosen to implement the designed KBS. This programming language represents knowledge in rules of the form "IF THEN...ELSE". It is a suitable language as it is more to English and it is easy to understand rather than using other programming languages such as C or C++ or Visual Basic. It provides a good inference engine mechanism that automatically matches facts against patterns in the rules then determines which rules are applicable. (Akerkar, P.S. Sajja and R., 2010).

The knowledge represented using IF_THEN rules was used to construct the knowledge base of the system. The IF_THEN rules were converted to prolog code so that they can be easily inferred by the expert system shell. The implementation of the expert system shell uses backward chaining logic in its inference. Preliminary symptoms of diseases were recognized. Subsequently, particular disease corresponding to the symptoms and actions that need to be taken were identified. This process, proceeding from the end result through a logical of causal chain back to symptoms, was well suited to developing a backward chaining system. A user interacts with the system through dialogue. The system forwards successive questions to identify the diseases occurrence and to recommend treatment. Based on the symptoms observed and fed to the system, the system displays disease associated to the symptoms and appropriate actions that need to be taken. When asked for consultation the system will ask the existence of several symptoms associated with a particular disease.

4.4. User Interface

KBSTBDDT used a simple user interface to display the information. When KBSTBDDT identified a possible type of TB disease, the system would present descriptions, treatments and preventions of the disease on the screen. The user could view different type of disease problems, descriptions, and treatments for the TB disease. The first page of the user interface welcomes users and describes what the system does as shown in the figure 4.1.

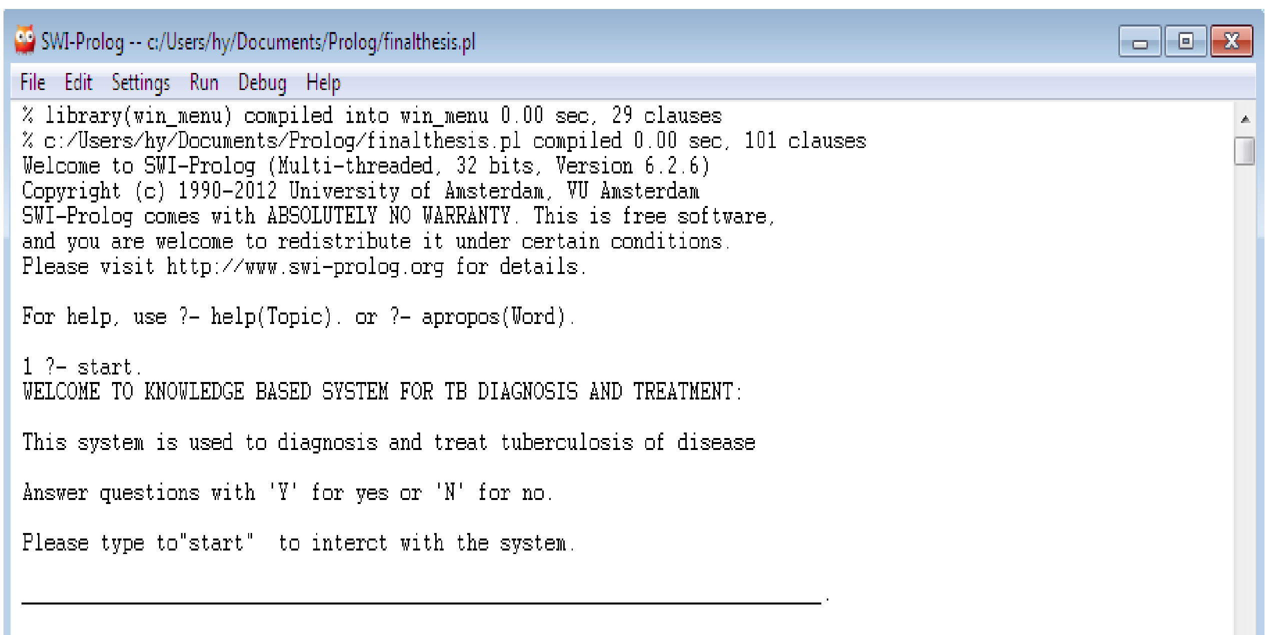


Figure 4.1 Welcoming windows of KBSTBDDT user interface above

After the prototype displays the greeting page a user can interact directly with the system by answering the question "yes or no" followed by dot. The following figure shows the sample dialogue windows between the user and the system to identify the infections on Tuberculosis disease.

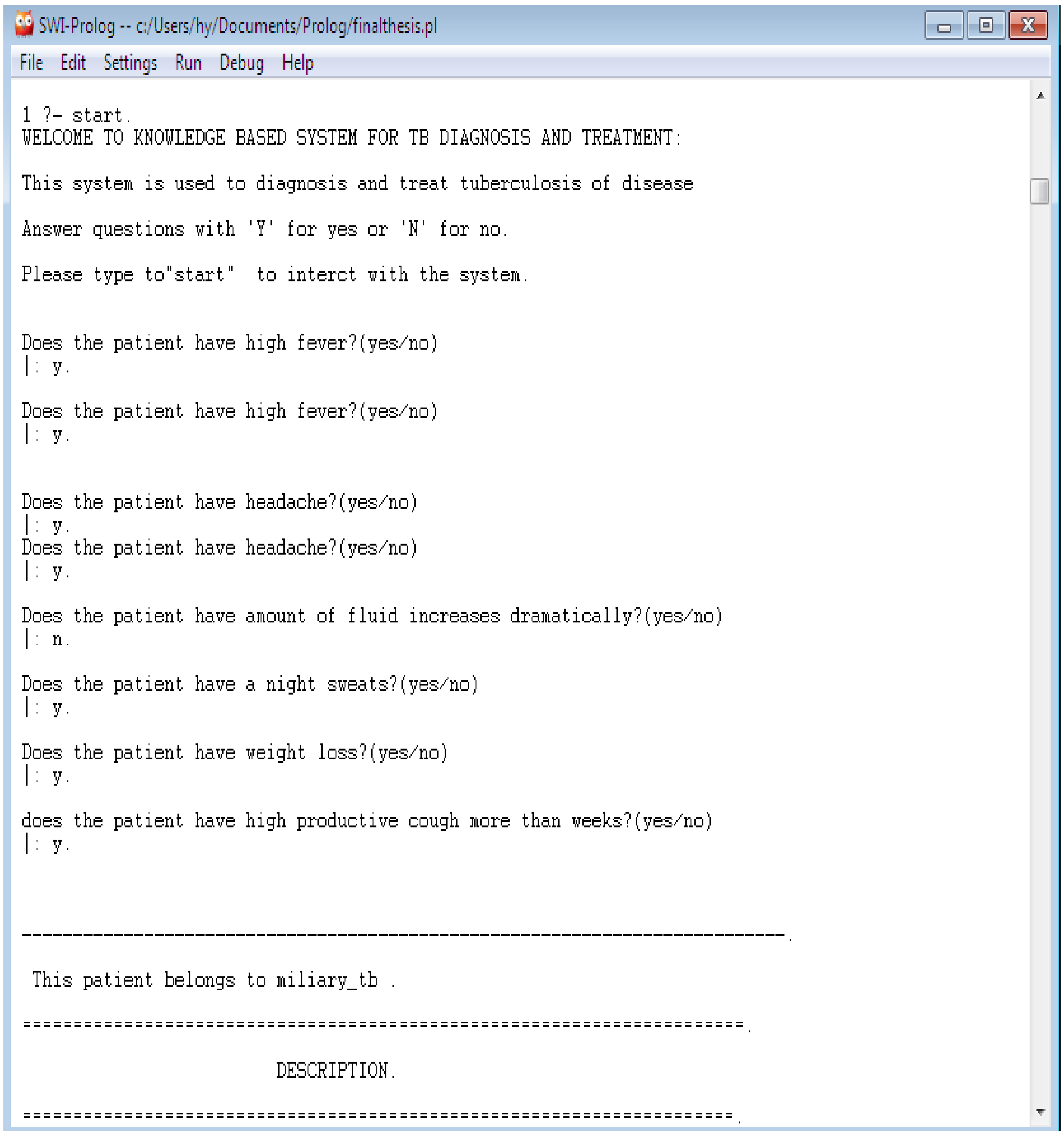


Figure 4.2. Sample dialogue windows between the user and the system to identify TB infections.

After the system identifies the type of infection on TB disease it provides the concerning description and treatment for the identified disease. As indicated in the following window identified miliary TB based on user input from the dialogue is described in detail to better inform the user about the infection.

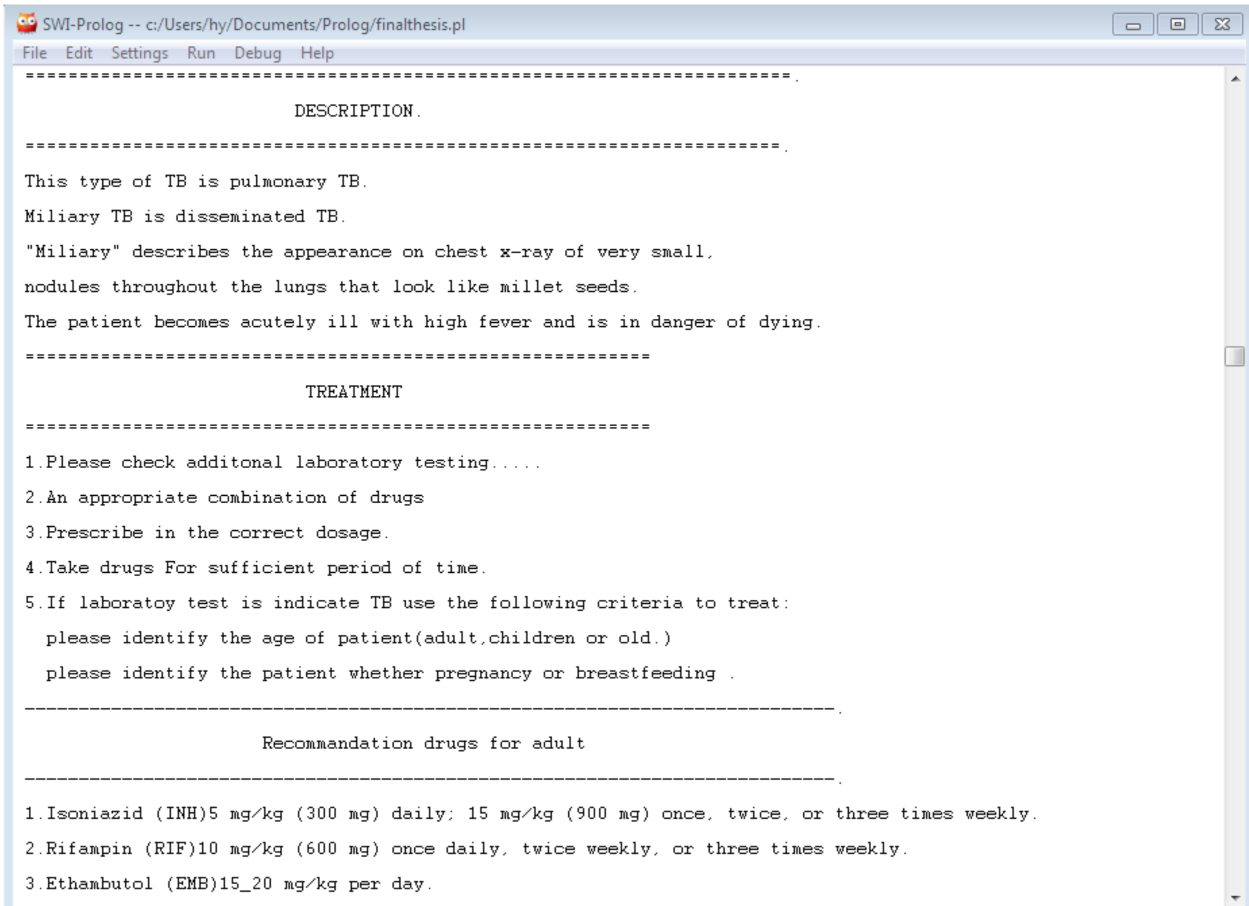
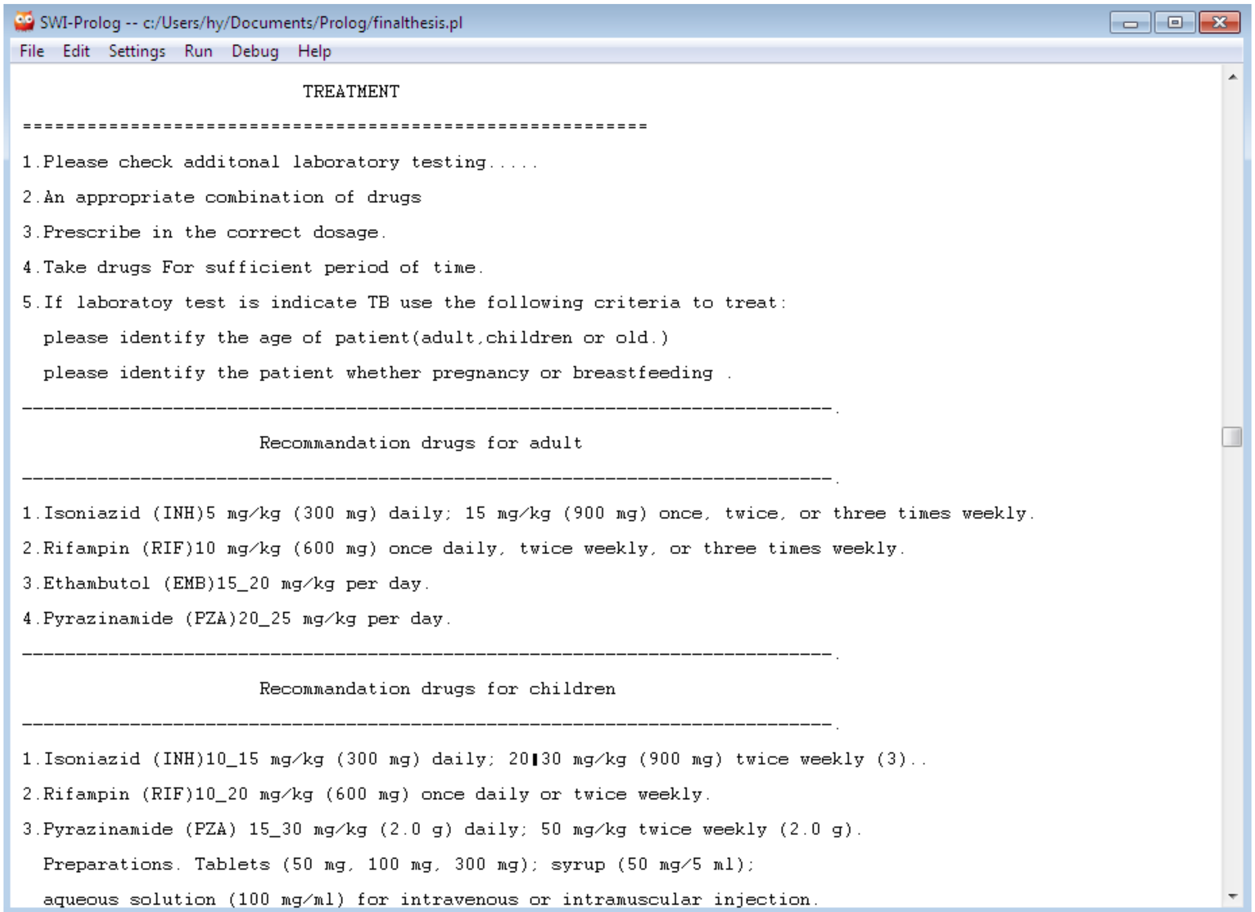


Figure 4.3 Sample dialogue windows of the system's description and treatment for the identified disease.

After the type of TB infection is identified and described well its recommended treatments are provided as it is presented in the following sample window. Next window with recommendation drugs for adult and children in addition to the above information is presented, it is shown as follow.



```
SWI-Prolog -- c:/Users/hy/Documents/Prolog/finalthesis.pl
File  Edit  Settings  Run  Debug  Help
                          TREATMENT
==========================================================
1.Please check additonal laboratory testing.....
2.An appropriate combination of drugs
3.Prescribe in the correct dosage.
4.Take drugs For sufficient period of time.
5.If laboratoy test is indicate TB use the following criteria to treat:
  please identify the age of patient(adult,children or old.)
  please identify the patient whether pregnancy or breastfeeding .
---------------------------------------------------------------------------.
                      Recommandation drugs for adult
---------------------------------------------------------------------------.
1.Isoniazid (INH)5 mg/kg (300 mg) daily; 15 mg/kg (900 mg) once, twice, or three times weekly.
2.Rifampin (RIF)10 mg/kg (600 mg) once daily, twice weekly, or three times weekly.
3.Ethambutol (EMB)15_20 mg/kg per day.
4.Pyrazinamide (PZA)20_25 mg/kg per day.
---------------------------------------------------------------------------.
                      Recommandation drugs for children
---------------------------------------------------------------------------.
1.Isoniazid (INH)10_15 mg/kg (300 mg) daily; 20▮30 mg/kg (900 mg) twice weekly (3)..
2.Rifampin (RIF)10_20 mg/kg (600 mg) once daily or twice weekly.
3.Pyrazinamide (PZA) 15_30 mg/kg (2.0 g) daily; 50 mg/kg twice weekly (2.0 g).
  Preparations. Tablets (50 mg, 100 mg, 300 mg); syrup (50 mg/5 ml);
  aqueous solution (100 mg/ml) for intravenous or intramuscular injection.
```

Figure 4.4 Sample window shows how it identified recommendation and treatment.

After the type of TB infection is identified and described well its recommended treatments are provided as it is presented in the following sample window. Next window with preventive mechanism information in addition to the pregnant and breast feeding women information is presented, it is shown as follow.

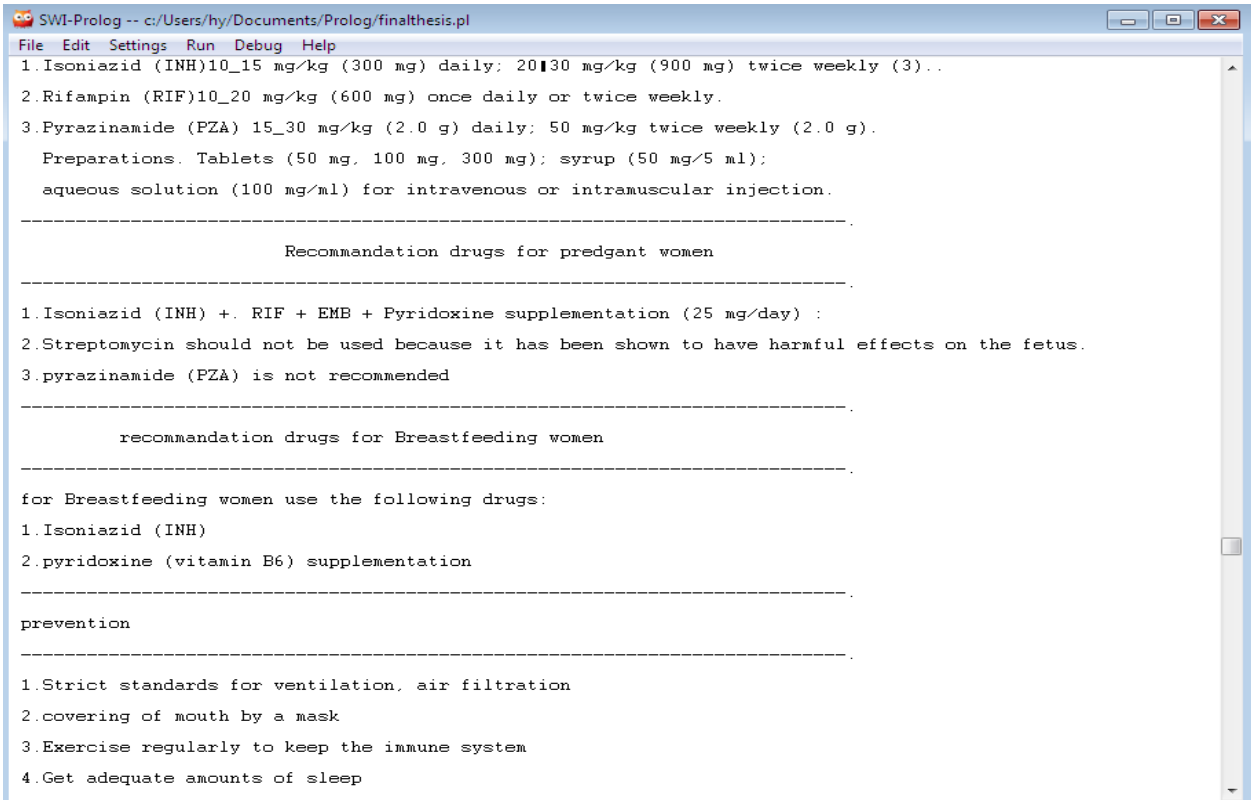


Figure 4.5 Sample dialogue windows of the system's recommended treatments for the identified disease.

4.5. System Evaluation

Evaluation of the prototype knowledge based system is an important phase that helps to measure the performance of the developed system. In this study, TBDKBS is evaluated to recognize accuracy and efficiency of description and treatments provided by the system in diagnosing TB. It also helps to check whether the objective of this research work is achieved.

Knowledge based System evaluation using visual interaction is used to ascertain how domain experts interact with developed system. Direct interaction intend system user to evaluate the performance of the knowledge based system from the users' point of view. In addition, this method helps to ensure the performance of the prototype by assessing the feedback acquired from the domain expert towards the developed system. Semi-Structure questions are developed to assess and evaluate the appropriateness and applicability of KBSTB in the domain area. This evaluation method allows expert to make comments while interacting the system (Anumba and Scott, 2001).

It also helps to ensure the performance of the prototype by assessing the feedback of the experts towards the developed system and altering the parameter as desired. To evaluate TB diagnosing knowledge based system in this study, five domains were selected as system evaluators. Before starting the evaluation, the researcher explained the objective of the developed system and how the system interacts with the users. This explanation helps the evaluator get full understanding how they consult the system in getting advice.

Then, the domain experts were allowed to interact with the system by running number of cases having similar parameter with the facts incorporated in the knowledge base. After the consultation of the system, to assess the user acceptance of the prototype knowledge based system, questionnaires were distributed. Using these questionnaires, domain expert's feedback towards this developed system was gathered for analysis.

The type of questionnaires distributed for feedback collection from the evaluators were closed ended and open ended questionnaires focusing on easiness, attractiveness, time efficiency, accuracy of TB Diagnosis Knowledge Based System . The questionnaires also focused on the applicability of the system in diagnosing TB disease, problem solving ability and the significance of the system in the domain area.

The format of the questionnaire was adapted from Tagel Aboneh (2013), which used to evaluate to pre-medical triage diagnosis prototype knowledge based system and Anumbam and Scott (2001) performance evaluation of knowledge based System for subsidence management. The adapted questionnaires were modified in the context of TB diagnosing knowledge based system.

All seven closed ended questions answered as excellent, very good, good, fair and poor. Therefore, for the ease of analyzing the relative performance of the system based on users evaluation the researcher assigned numbers for each criteria as excellent=5, very good= 4, good=3, fair=2, poor=1. The system evaluators give the value for each closed ended questions. The following table indicates the results obtained.

Table 4.12 KBSTBDDT user performance evaluation results

		Criterions					
No	Questions	Poor(1)	Fair(2)	Good(3)	V. good(4)	Excellent(5)	Average
1	The easiness of the system to use and interact with it is	0	0	1	2	1	4.0
2	Attractiveness of the system is	0	0	2	2	0	3.5
3	The efficiency of the system in time is	0	0	1	2	2	4.2
4	The accuracy of the system to reach the decision about TB disease identification.	0	0	1	2	2	4.2
5	The sufficiency of the knowledge does the system incorporate to diagnosis TB disease in its scope is	0	0	2	2	1	3.8
6	The accuracy of the system in providing the right treatment and recommendation for the identified disease is			1	1	2	4.25
7	How do you rate the significance of the system in the domain area?	0	0	0	3	2	4.4
		Total average					4.06

As shown in table above (Table 4.12) 25% of the respondents rated easiness to use and interact with it as good,50% of the respondents rated easiness to use and interact with it as very good, while the remaining 25% respond the same question as excellent. In the same way, for question 'attractiveness of the prototype' 50% of the respondents evaluated as very good 50% of them as excellent and none of them rate it as good. Similarly, 20% of the respondent rated the efficiency of time as good, 40% of respondent as very good and the remaining 40% of them as excellent. Additionally 20% of them responded as good, 40% of them as very good and the rest 40% as excellent for the criteria "system's ability to identify type of infections". Likewise for the criterion 'adequacy of knowledge it contain ' 40% of them respond as good, 40% of them rated as very good and the rest 20% as excellent. As well for the criterion 'does it provide the right treatment and recommendation for the identified infection' 25% of the respondents respond as good, 25% of them as very good and 50% of them rated as excellent. Lastly, concerning to the question related to the significance of the prototype 60% of the respondent evaluated as very good and the rest 40% as excellent. Based on the results obtained the overall average performance of the prototype with user's point of view is 4.06 on a scale of 5. This result indicates that the overall average performance of the prototype knowledge based system is about 81.25%. This implies that the modeled prototype was performs well in making right decisions on the diagnosis of TB affected

4.6. Discussion.

The evaluation and testing procedures help to address the question of user acceptance and accuracy of the prototype. Visual interaction and questionnaire methods are used to assess user's acceptance issues and applicability of the prototype. Based on the evaluation results obtained from visual interaction with closed ended questions none of the evaluators respond as poor or fair. On the other hand evaluators reply good eight times (15%), very good fourteen times (35%) excellent ten times (31.25%) the following table summarizes the results obtained on close ended questions.

Table 4.13 Users evaluation result summary on closed ended questions

Respondents who respond as	Poor(1)	Fair(2)	Good(3)	Very good(4)	Excellent(5)	average
Total number	0	0	8	14	10	4.06
%age of 100%	0	0	15	35	31.25	81.25

As shown in the above Table 4.13 the overall average user acceptance evaluation of the prototype Knowledge based system is about 81.25%, this means the prototype is accepted by 81.25% of respondents. Therefore, above 81.25% of users are satisfied with the easiness, attractiveness, speed, accuracy, adequacy problem solving ability and the significance of the prototype knowledge based system in the domain area. This implies that the prototype modeled relevance and satisfactory domain knowledge in useful way and it performs well in making right decisions on the diagnosis of TB.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Tuberculosis is major public health problem in Ethiopia more than half a century ago. If the disease is not treated well and on time, it can lead to severe health problems like lung disease and any extra body can be easily affected. TB in the developing countries like Ethiopia, permanent diseases are growing to be causes of death.

Hence, in this study an effort has been made to design and develop a prototype of acknowledge-based system that can provide advice for physicians and patients to facilitate the diagnosis and treatment of patients affected by TB.

In developing the prototype system, knowledge is acquired using both structured and unstructured interviews with domain experts and from relevant documents by using documents analysis method to find the solution of the problem. The acquired knowledge is modeled using decision tree that represents concepts and procedures involved in diagnosis and treatment of TB. Then, the validated knowledge is represented using rule-based representation technique and codified using SWI-Prolog editor tool for building the knowledge-based system to provide advice for patients and experts.

This paper has presented the architecture, design and development of an expert system for diagnosis of diseases TB. The knowledge base contains the knowledge about the different diseases of TB represented. Such system is especially useful for those in rural, lack of expert who are not getting the specialists. The system is an operational automatic identification tool that helps experts to identify the major disease of TB and provides the appropriate description, treatments and prevention. To implement the system prolog programming language was used and the knowledge is represented in the linguistic form of IF_THEN rules.

The inference engine analyzes specific information entered by the user to determine potential risks of occurrence for TB diseases. These potential occurrence risks are presented as identification, description and treatment and prevention. The system was evaluated using user interaction technique. By preparing questions for the experts in the domain to answer it about the overall performance of the system after they appropriately interact with the system, it was shown that the expert system agreed with human expert opinions in 81.25 percent of the decisions made. It also reviews about the ruled based expert system, modules and architecture, also state the advantages of rule based expert system.

5.2. Recommendations

The following recommendations are given based on the observed opportunities and uncover areas by this research.

- This rule based system is not self-learning, in the future learning component should be integrated that reasons and remembers when new circumstances and unknown facts are asked by users to suggest solutions.
- To enhance the performance of the prototype knowledge based system, the hybrid strategy approaches should be investigated which combines case based reasoning. The inclusion of case based reasoning helps the system to learn from documented experiences.
- In its present version, this system is a standalone one. For the future, it will be more attractive and effective if a Web-based version of it is developed that would make the diagnostic system accessible to anyone with a computer and an Internet connection.

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Appendixes

Appendix I

Interview Questions

The importance of this interview questions is to extract tacit knowledge from specialists in internal medicine that will support for the development of a knowledge based system for diagnosis and treatment of tuberculosis. The interviewer stores the answerers" reply using pen, paper, and I would like to thank for your cooperation and valuable information.

1. What is tuberculosis?
2. What are the risk factors of tuberculosis?
3. What are the complications of tuberculosis?
4. What are the common signs and symptoms of tuberculosis?
5. What are the most fundamental symptoms that you consider when making diagnosis of tuberculosis?
6. In diagnosis using only signs and symptoms of tuberculosis, can we say the new patient is tuberculosis or not?
7. What are the most common types of tuberculosis?
8. What are the laboratories testing methods used for diagnosis of tuberculosis? Which one is the most common laboratory testing method used for diagnosis of tuberculosis?
9. How can we differentiate extra pulmonary and pulmonary tuberculosis during diagnosis?
10. How can we manage extra pulmonary and pulmonary tuberculosis disease?
11. What are the treatments recommended for extra pulmonary tuberculosis?
12. What are the treatments recommended for pulmonary tuberculosis?
13. What are the main challenges encountered during diagnosis of tuberculosis?

Appendix II

Sample prolog rules from the knowledge base

```
Start:-
write('WELCOME TO KNOWLEDGE BASED SYSTEM FOR TB DIAGNOSIS AND TREATMENT:'),nl,nl,
write('This system is used to diagnosis and treat tuberculosis of disease'),nl,nl,
write('Answer questions with "Y" for yes or "N" for no.'),nl,nl,
write('Please type to"start"  to interact with the system.'),nl,nl,
clearFacts,
try_questions.
% try_questions
% Asks questions until an answer is found
try_questions :-
tb_is(TB),!,
describe(TB),
treatment(TB),
fail.
try_questions.
% Defines the Knowldege base rules
tb_is(tb_pneumonia):-
symptom(high_fever,yes),
symptom(headach,yes),
symptom(cough,yes),
symptom(weight_loss,yes),
symptom(high_productive_cough_more_than_weeks, yes).
tb_is(tb_negetive):-
symptom(headache,yes),
symptom(cough,no ),
symptom(high_fever,no),
```

```
symptom(blood_sputum,no).
tb_is(pleurisy_tb):-
symptom(have_amount_of_fluid_increases_dramatically,yes),
symptom(compress_lung,yes),
symptom(shortness_of_breath_sharp,yes),
symptom(chest_pain,yes),
symptom(have_fever,yes),
symptom(weight_loss,no).
tb_is(miliary_tb):-
symptom(high_fever,no),
symptom(night_sweats,yes),
symptom(weight_loss,yes).
tb_is(tuberculosis_meningitis):-
symptom(irritability_and_restlessness,yes),
symptom(stiff_neck,yes),
symptom(vomiting,yes),
symptom(variations_in_mental_behavior,yes),
symptom(seizures_or_coma,yes).
tb_is(gastrointestinal):-
symptom(abdominal_pain,yes),
symptom(weight_loss,yes),
symptom(nausea,yes),
symptom(vomiting,yes),
symptom(change_in_bowel_habits,yes),
symptom(producing_increased_fluid,no).
tb_is(lymphadenitis):-
symptom(the_formation_of_masses_along_the_neck,yes),
symptom(mass_may_burst,yes),
symptom(form_a_draining_sinus,yes).
tb_is(lupusvulgaris):-
```

```
symptom( small_reddish_brown_lesions_on_face,yes),
symptom( small_reddish_brown_lesions_on_eyelids,yes),
symptom(small_reddish_brown_lesions_around_nose,yes),
symptom(small_reddish_brown_lesions_around_neck,yes).
tb_is(verrucosacutis):-
symptom(reddish_brown_wart_like_growths_on_the_body,yes),
symptom(skin_lesions_on_hands,yes),
symptom(skin_lesions_on_feet,yes),
symptom(skin_lesions_on_buttocks,yes),
symptom(skin_lesions_on_knees,yes).
tb_is(osteo_articular_tuberculosis ):-
symptom(small_red_spots_on_the_skin,yes),
symptom(necrosis_of_infected,no ),
symptom(skin_lesions_on_buttocks,yes).
tb_is(genitourinary_Tb ):-
symptom(blood_present_in_urine,yes),
symptom(painful_or_uncomfortable_urination,yes),
symptom(pain_on_one_side_of_the_body_between_the_upper_abdomen_and_back,yes).
```

Appendix III

Questionnaires for Prototype Evaluation. These questionnaires are prepared to TB diagnosis prototype knowledge based system based on the domain experts‟ opinion and feedback.

Please circle the options for each of the following questions given below.

1.Is the prototype easy to use and interact with it?

1. Poor 2.Fair 3. Good 4.Very good 5. Excellent

2. How do you rate the attractiveness of TBDKBS?

1. Poor 2.Fair 3. Good 4.Very good 5. Excellent

3. Is TBDKBS more efficient in time?

1. Poor 2.Fair 3.Good 4.Very good 5. Excellent

4. How accurately does the TBDKBS reach a decision to diagnose TB?

1. Poor 2.Fair 3. Good 4.Very good 5.Excellent

5. Does the system incorporate sufficient and practical knowledge to diagnose TB diseases?

1. Poor 2.Fair 3. Good 4.Very good 5. Excellent

6. Can the system give right description and treatment for identified TB disease?

1. Poor 2.Fair 3. Good 4.Very good 5. Excellent

7. How do you rate the significance of the system in the domain area?

1. Poor 2.Fair 3. Good 4. Very good 5.Excellent