Sudan University Of Science And Technology

College Of Graduate Studies

A Thesis Submitted In Partial Fulfillment For Degree Of M.Sc In
Biomedical Engineering

Design an Expert System for the Diagnosis of Pulmonary Tuberculosis

تصميم نظام خبير لتشخيص مرض السل الرئوى

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FEB.2014

Dedication

For all the people that I love them

For every one stand behind me

And encouraged me to

Produce this work

Acknowledgement

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Abbreviations

AFB	Acid Fast Bacilli
ASP	Active Server Page
CODP	Chronic Obstructive Pulmonary Disease
CT	Computed Tomography
DSS	Decision Support System
EPTP	Extra Pulmonary Tuberculosis
ES	Expert System
GUI	Graphical User Interface
HIV	Human Immunodeficiency Virus
MES	Medical Expert System
MOTT	mycobacterium other than tuberculosis
NTP	National Tuberculosis Program
PTP	Pulmonary Tuberculosis
TB	Tuberculosis

Abstract

Pulmonary tuberculosis (PTB) is a common worldwide infection and a medical and social problem causing high mortality and morbidity, especially in developing countries. An expert system for diagnosis of this disease was designed based on expert's knowledge for providing decision support platform to assist fresh graduator (inexperienced) physicians, and other healthcare practitioners to arrive the final diagnosis of TB more quickly and efficiently especially in rural areas.

Information about pulmonary tuberculosis and its symptoms and treatment from doctor who are specializing in the diagnosis and treatment of tuberculosis were collected.

The system was built using C sharp language and artificial intelligence based expert system in coordinated manner help in the diagnosis of tuberculosis disease and assistance in giving the necessary treatment In addition to giving advice to patients.

المستخلص

الهدف من هذه الدراسة هو تصميم نظام خبير يعمل على تشخيص مرض السل الرئوي وذلك بحسب الاعراض الظاهرية المميزة للمريض وكذلك الاعراض الثانوية وذلك للتفريق بين الامراض التي قد تتشابه في الاعراض مع مرض السل بالاضافة الي استخدام نتائج بعض التحاليل المعملية وذلك لمساعدة الاطباء والتقنيين الجدد في تشخيص المرض بصورة دقيقة .

وقد تم جمع معلومات عن مرض السل و اعراضه و كيفية علاجه من قبل اطباء متخصصين في تشخيص وعلاج السل.

استخدمت في بناء النظام لغة السي شارب و شمل ذلك تطبيق النظام الخبير بشكل منسق يساعد في تشخيص المرض والمعاونة في وصف العلاج اللازم و اعطاء نصائح للمرضى.

Chapter One

Introduction

1.1 General View

Tuberculosis (TB) is a global public health problem of enormous dimension; it is an infectious disease that is caused by a bacterium called *Mycobacterium tuberculosis*. TB primarily affects the lungs, but it can also affect organs in the central nervous system, lymphatic system, and circulatory system among others. TB is a major cause of illness and death worldwide, especially in Africa and Asia. Each year the disease kills almost 2 million people. TB is generally classified as being either latent or active. Latent TB occurs when the bacteria are present in the body, but this state is inactive and presents no symptoms. Latent TB is also not contagious. Active TB is contagious and is the condition that can make you sick with symptoms.

The general symptoms of TB disease include feeling of sickness or weakness, weight loss, fever and night sweats. The symptoms of TB disease of the lung also include coughing chest pain; shortness of breath and the coughing up of blood .symptoms of TB disease in other part of the body depend on the area affected. TB spreads through the air. When people with the disease cough, sneeze, talk or spit, they propel TB germs, known as bacilli, into the air Only a small number of the bacilli need to be inhaled to cause an infection. However, not all people infected with TB bacilli will become sick. The immune system either kills the germs, or "walls off" the TB bacilli where they can lie dormant for years. Failure of the immune system to control infection with TB bacilli leads to active disease, when TB bacilli multiply and cause damage in the body. Left untreated, each person with

infectious TB will spread the germs to about 10 to 15 people every year. . And according to statistics from the World Health Organization, Someone in the world is newly infected with TB bacilli every second.

Overall, one third of the world's population is currently infected with TB and 5% to 10% of people who are infected with TB become actively sick.

Expert systems (ES) are artificial intelligence based system that convert the knowledge of an expert in a specific subject into a software code this code can be merged with other such codes and used for answering questions submitted through a computer, ES designed to provide expert level Solutions in a narrow based problem area. And it must be understandable and flexible enough to accommodate new knowledge. Expert systems typically consist of three parts:

1- A knowledge base which contains the information acquired by interviewing experts, and logic rules that govern how that information is applied.
2- An Inference engine that interprets the submitted problem against the rules and logic of information stored in the knowledge base.
3- Interface that allows the user to express the problem in a human language such as English.

1.2 Problem statement

Diagnosis of tuberculosis is a complex task, takes time, and requires highly qualified expertise. This expertise takes a long time to achieve and usually this happens at an old age when such people are about to retire. Besides, these

knowledge experts are few, many times busy, and expensive to employ especially in the less developed area.

In addition, the late detection of the disease leads to spread rapidly and therefore each person with TB will spread the germs to about 10 to 15 people every year.

An expert system is being used as the problem solving to improve the possibility of early and accurate diagnosis of TB.

1.3 Research Objectives

General objective:

The main objective of this study is to design an expert system for the diagnosing of tuberculosis.

Specific objective:

1- To propose an Analytical system this can easily diagnose TB.
2- To implement the system using (GUI) for easy use of the system.
3- To provide a decision support platform to tuberculosis physicians and other healthcare practitioners.
4- To evaluate the performance of the proposed system.

1.4 Methodology

This system was designed to give medical diagnosis of tuberculosis disease for determining whether a patient suffers from TB or not. And it designed by using C-Sharp programming language.

The first step was Knowledge acquisition which was the process of collecting knowledge about tuberculosis. The knowledge acquisition for this work was

obtained through interviews with tuberculosis human experts before implementing the expert system, a lot of tuberculosis basic knowledge was provided including symptoms, complications, and treatment and diagnosis procedures.

In this system the possible symptoms of TB and disease similar to TB will present to the user in a screen where the user can click the specific symptom in order to start a searching process, the system showing the probability of the presence of the disease and the right type of examination, if the search result indicate to the presence of TB such as tuberculin skin test, TB blood test, and sample of sputum to see whether the person has TB disease or not. The system has been designed to help patients provides an efficient way and to assist inexperienced physicians to arrive at the final diagnosis of TB more quickly and efficiently not to replace them. The system was built by using C-Sharp language (Graphical User Interface) to be user friendly and easy to access. Also this expected to reduce the cost because inexperienced doctor can detect the disease and also reduce the time wasted for the doctor and patient.

1.5 Scope

These medical expert systems can be very useful in places where there is lack of doctors who specialize in the diagnosis of tuberculosis. They can assist fresh graduate medical and technician's to diagnose this disease. Therefore these systems can improve the life of rural communities, especially for people living with tuberculosis.

1.6 Thesis Outline

In this work seven chapters are presented. The first four chapters outline the introduction, background knowledge on expert systems, tuberculosis and the previous studies. Chapter five covered the design and explained the tools that used to build an expert system and the mechanism used for knowledge acquisition. Implementation and evaluation of the system are shown in chapter six. The final chapter presented conclusion and recommendations.

Chapter Two

Previous Work

A good number of expert systems have been designed for the diagnosis and treatment of some diseases for example:

A medical expert system for managing tropical diseases was proposed by (Adekoya et al., 2008). The proposed Medical Expert Solution (MES) system was to assist medical doctors to diagnose symptoms related to a given tropical disease, Suggests the likely ailment, and advances possible treatment based on the MES diagnosis. The MES uses a knowledge-base which composes of two knowledge structures; namely symptoms and disease. The MES inference engine uses a forward chaining mechanism to search the knowledge-base for symptoms of a disease and its associate therapy which matches the query supplied by the patient. The MES is useful for people who do not have access to medical facilities and also by those who need first-aid solution before seeing medical consultant.

Fuzzy Cluster Means Expert System for the Diagnosis of Tuberculosis proposed By(Imianvan A.A., Obi J.C., 2011).the proposed was to identification of different types of tuberculosis. The application of Fuzzy Cluster Means (FCM or Fuzzy C-Mean) analysis to the identification of different types of tuberculosis is the focal point of this paper. Application of cluster analysis involves a sequence of methodological and analytical decision steps that enhances the quality and meaning of the clusters produced. The uncertainties often associated with analysis

of tuberculosis test data are eliminated by the proposed system. In this paper, the patients were classified into seven form of TB according to physicians. TB meningitis, gastrointestinal tuberculosis, TB Lymphadenitis, Cutaneous TB, Osteo-articular TB, TB genitourinary, Drug resistant TB. the system was used 20 basic and major parameters, the FCM clustering distribution depicts a total of two symptoms with high degree of membership of TB meningitis, eight symptoms with high degree of membership of Gastrointestinal TB, two symptoms with high degree of membership of TB lymphadenitis, two symptoms with high degree of membership of Cutaneous TB, two symptoms with high degree of membership of Osteo-articular TB, two symptoms with high degree of membership of TB genitourinary and two symptoms with high degree of membership of Drug-resistant TB. This advanced system which uses a set of clustered data set is more precise than the traditional system. 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.

Implementation of XpertMalTyph: An Expert System for Medical Diagnosis of the Complications of Malaria and Typhoid (S.A. Fatumo [1], Emmanuel Adetiba[2], J.O.Onaolapo[3] 2009). In this work designed and implemented XpertMalTyph; a novel medical diagnostic expert system for the various kinds of malaria and typhoid complications. A medical diagnostic expert system uses computer(s) to simulate medical doctor skills in diagnosis of ailments and prescription of treatments, hence can be used to provide the same service in the absence of the experts. XpertMalTyph is based on JESS (Java Expert System Shell) programming because of its robust inference engine and rules for implementing expert systems. There are times that some symptoms that an individual has might be taken for granted, that is, they might just be overlooked and the individual will not see a

need to visit the hospital. This means that instead of a patient consulting the doctor for mild cases of malaria and typhoid complications, the patient can receive treatment even from the house through the Medical Diagnostic Expert system. Work is in progress to enhance this expert system by implementing the system with the hybrid of expert system and artificial neural networks (ANN).

A Decision Support System for Tuberculosis Diagnosis proposed by (X.Y. Djam, MSc. and Y. H. Kimbi, MBBS2, 2011). Fuzzy logic for medical diagnosis provides an efficient way to assist inexperienced physicians to arrive at the final diagnosis of TB more quickly and efficiently. The developed system provides decision support platform to assist TB researchers, physicians and other health practitioners in TB endemic regions. The authors believe that the approach proposed in this study, if used intelligently, could be an effective technique for diagnosing TB. The study evaluated the diagnosis of thirty patients using fuzzy methodology and the results gotten were in the range of the pre-defined limits by the domain experts. The essence of the study was to ascertain the degree to which fuzzy methodology represents the exact diagnosis of the patient as compared with those of medical doctors.

A Medical Multimedia Expert System for Heart Diseases Diagnosis and Training proposed by (M. Ragab Abdul Hamid, Khalid Abdullah and Mohamed Ismail Fakeeh Roushdy 2003).The expert system was developed for diagnosis of heart disease with certainty factor method. Heart disease is classified into 25 types of disease that is left heart failure and right heart failure in the form of semantic networks. Data is divided into patient demographic data (age and sex) and clinical data such as laboratory results and clinical examination. Knowledge Representation is done by using production rules.

An expert system for diagnosis of the heart valve diseases proposed by (Turkoglu, A, et al, 2002). The system is limited in its ability to offer efficient and thorough detection and characterization. All these methods are based on experience and information of physician. Therefore, developing Human–Machine interfaces with the existing methods of studies has become popular in these areas. By using these interfaces, the cardiologist can understand the output of the examination systems more easily and diagnose the problem more accurately.

Chapter Three

Expert System

3.1 Introduction

An expert system is a computer program that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming. The first expert systems were created in the 1970s and then proliferated in the 1980s. [1]. Expert systems were among the first truly successful forms of artificial intelligence software. Expert system can also be defined as are artificial intelligence based system that convert the knowledge of an expert in a specific subject into a software code this code can be merged with other such codes and used for answering questions submitted through a computer, ES designed to provide expert level Solutions in a narrow based problem area. And it must be understandable and flexible enough to accommodate new knowledge. Expert systems typically consist of three parts:

 1- **A knowledge base** which contains the information acquired by interviewing experts, and logic rules that govern how that information is applied.

 2- **An Inference engine** that interprets the submitted problem against the rules and logic of information stored in the knowledge base.

  3- **Interface** that allows the user to express the problem in a human language such as English.

Figure 3.1: Basic component of expert system

3.2 The Architecture of Expert Systems

The process of building expert systems is often called knowledge engineering. The Knowledge engineer is involved with all components of an expert system as shown in figure 3.2.

Building expert systems is generally an iterative process. The components and their interaction will be refined over the course of numerous meetings of the knowledge engineer with the experts and users. Then the inference engine is a program that allows hypotheses to be generated based upon the information in the knowledge base. It is the control structure that manipulates the knowledge in the knowledge base to arrive at various solutions.

Three major methods are incorporated in the inference engine to search a space efficiently for deriving hypotheses from the knowledge base: forward chaining, backward chaining, and forward and backward processing.

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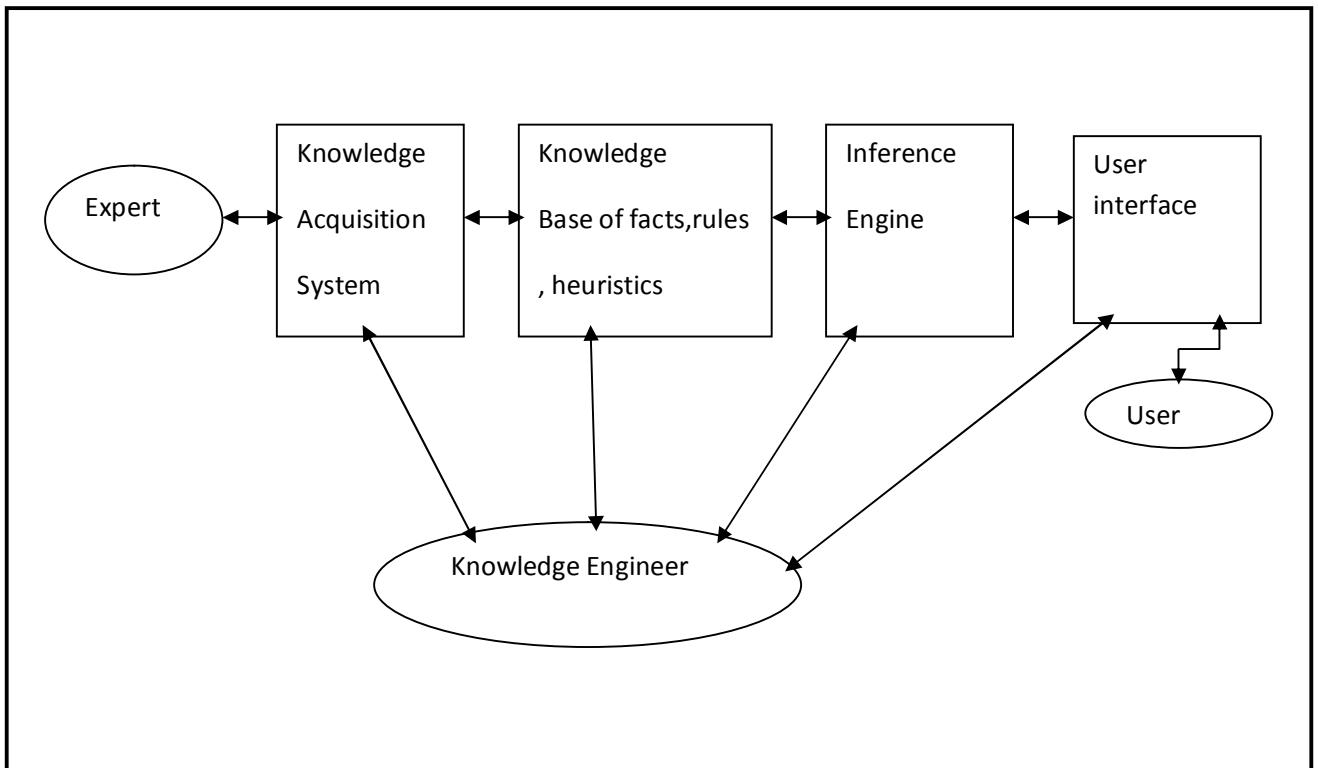
Figure 3.2: The Architecture of expert system

3.3 Building an Expert System

Building an expert system typically involves the rapid prototyping approach. This approach entails "building a little and testing a little" until the knowledge base is refined to meet the expected acceptance rate and users' needs. Expert systems development is an iterative process in which, after testing, knowledge is reacquired, represented, encoded, and tested again until the knowledge base is refined.

The first step in building an expert system is to select the problem, define the expert system's goal(s), and identify the sources of knowledge. The criteria for expert system problem selection can be broken down into three components:

problem criteria, expert criteria, and domain area personnel criteria. The following criteria should be followed when selecting an expert system problem:

i. **Problem Criteria**

1- The task involves mostly symbolic processing.

2- Test cases are available.

3- The problem task is well bounded.

4- The task must be performed frequently.

5- Written materials exist explaining the task.

6- The task requires only cognitive skills.

7- The experts agree on the solutions.

ii. **Expert Criteria**

1- An expert exists.

2- The expert is cooperative.

3- The expert is articulate.

4- The expert's knowledge is based on experience facts and judgment

5- Other experts in the task area exist.

iii. **Domain Area Personnel Criteria**

1- A need exists to develop an expert system for that task.

2- The task would be provided with the necessary financial support.

3- Top management supports the project.

4- The domain area personnel have realistic expectations for the use of an expert system.

5- Users would welcome the expert system.

6- The knowledge is not politically sensitive or controversial.

3.4 Knowledge Acquisition

Knowledge acquisition is the most difficult part of expert systems development**.**
The knowledge acquisition component allows the expert to enter their knowledge or expertise into the expert system, and to refine it later as and when required. Historically, the knowledge engineer played a major role in this process, but automated systems that allow the expert to interact directly with the system are becoming increasingly common.

The knowledge acquisition process is usually comprised of three principal stages**:**

1. **Knowledge elicitation** is the interaction between the expert and the knowledge Engineer/program to elicit the expert knowledge in some systematic way.
2. The knowledge thus obtained is usually stored in some form of human friendly **Intermediate representation**.
3. The intermediate representation of the knowledge is then compiled into an **Executable form** (e.g. production rules) that the inference engine can process. In practice, much iteration through these three stages is usually required.

Knowledge Base

The knowledge base is the last and most important component of an expert system. It is composed of domain facts and heuristics based upon experience. According to Duda and Gaschnig, the most powerful expert systems are those containing the most knowledge.

3.5 Benefits of using expert systems

Like many other traditional forms of software, an expert system offers benefits over human experts such as:

1. *Accessibility*- the knowledge of multiple human experts can be combined to give a more knowledgeable system than what a single person is likely to achieve. Expert systems are always available for use when human experts are not readily available.

2. *Consistency*- expert systems are less likely to contain inaccuracies provided the expert system has good knowledge representation. Inaccuracies or errors can be easily prevented.

3. *Time constraints*- many copies of an expert system can be made, but training new human experts is time-consuming and expensive.

4. *Stability*- it can assist a human expert in problem solving and is more likely to consider all possibilities.

5. An expert system can review all the transactions whereas a human expert can only review a sample.

3.6 Limitations of human experts

1. Human experts have more limitations over expert systems.

2. Human experts are unable to retain large amounts of data in memory.

3. Humans are unable to comprehend large amounts of data quickly.

4. Humans are slow in recalling information stored in memory.

5. Humans get tired from physical or mental workload.

6. Humans are subject to deliberate or unintentional bias in their actions.

Despite the aforementioned limitations, human expert also have benefits over expert systems. Human experts have common sense but expert systems do not have common sense yet. Human experts can respond creatively to unusual situations, expert systems cannot. Human experts automatically adapt to changing environments but expert systems must be explicitly updated. Expert systems are not good at recognizing when no answer exists or when the problem is outside their area of expertise. For this reason any output or advice from an expert system must be concluded and tested by a human expert.

3.7 Limitations of expert systems

Despite the aforementioned benefits, expert systems have certain limitations that impair their effectiveness in applying human-like decision making methods. Expert systems are knowledge dependent therefore they are only as good as the knowledge stored into them. Therefore, the expertise of an expert system is limited to the knowledge domain that the system contains. A practical limitation of many expert systems today is lack of fundamental knowledge. That is, the expert systems do not really have an understanding of the underlying causes and effects in a system. Typical expert systems cannot generalize their knowledge by using analogy to reason about new situations the way people can.

The gathering of human expert knowledge can be time consuming and the output depends mostly on the knowledge engineering. Transferring the knowledge of experts into rules and facts is not simple, especially when the expert's knowledge has never been systematically explored. There may be inconsistencies, ambiguities, duplications or other problems with the expert's knowledge.

Hence the problem of transferring human knowledge into an expert system is a major task.

3.8 C-sharp Language

C-sharp language is a simple, modern, general-purpose, object-oriented programming language developed by Microsoft within its .NET initiative led by Anders Hejlsberg.

C# is a powerful and flexible programming language. Like all programming languages, it can be used to create a variety of applications. The C# language does not place constraints on what you can do; therefore, your potential with it is limited only by your imagination [16].it is used to create both Web-Based and GUI-Based applications on Windows. Also C# is a great language simply because you can use it for so many different tasks. And you can accomplish very sophisticated tasks in a reasonably small number of lines of code.

C# has its roots in the C family of languages and will be immediately familiar to C, C++, and Java programmers.

When creating a program in C# (or in any language), you should follow a similar Sequence of steps:

1. Determine the objective(s) of the program.

2. Determine the methods you want to use in writing the program.

3. Create the program to solve the problem.

4. Run the program to see the results.

If you don't have an objective, you won't be able to write an effective program. The second step is to determine the method want to use to write the program. For example if there is need for a computer program to solve the problem? What information must be tracked? What formulas will be used? During this step, try to determine what you need and in what order the solution should be implemented. Steps 3 and 4, which are called the program development cycle. In those steps, use an editor to create a file that contains the source code. Next compile the source

code to create an intermediate file called either an executable file or a library file. Then run the program to see whether it works as originally planned.

Source code is a series of statements or commands used to instruct the computer to perform the desired tasks. These statements and commands are a set of keywords that have special meaning along with other text. As a whole, this text is readable and understandable.

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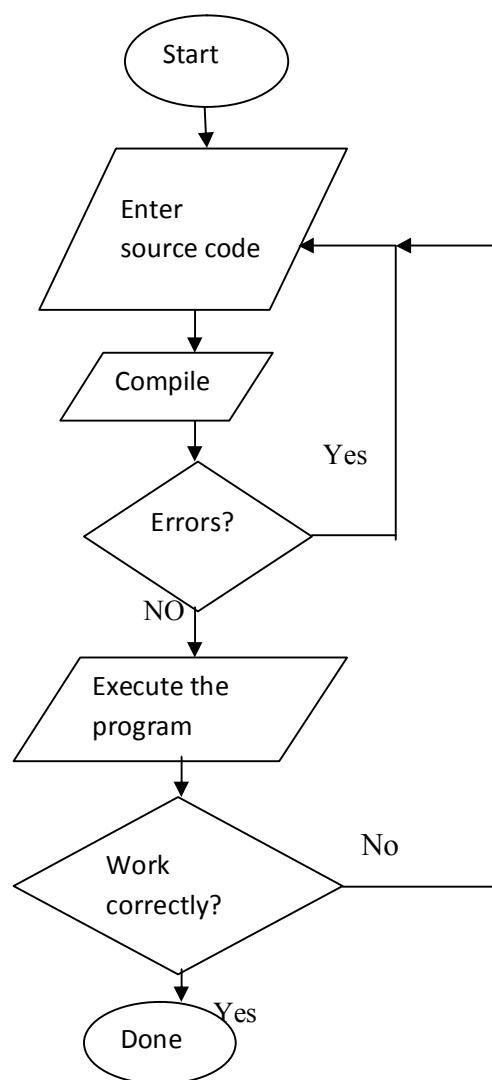
Figure 3.3: The steps involved in C# program development.

3.8.1 Types of C# Programs

Before continuing with another program, it is worth reviewing the types of applications you can create with C#. You can build a number of types:

1. **Console applications**—Console applications run from the command line.

2. **Window forms applications**—can also create Windows applications that take advantage of the graphical user interface (GUI) provided by Microsoft Windows.

3. **Web Services**—Web Services are routines that can be called across the Web.

4. **Web form/ASP.NET applications**—ASP.NET applications are executed on a Web server and generate dynamic Web pages.

In addition to these types of applications, C# can be used to do a lot of other things, including create libraries, create controls, and more.

3.8.2 Advantages of using C#

C# is a language derived from C and C++, but it was created from the ground up. Microsoft started with what worked in C and C++, and added new features that would make this language easier to use.

Other reasons exist for using C#, beyond Microsoft's reasons. C# removes some of the complexities and pitfalls of languages such as Java and C++, including macros, multiple inheritance, and virtual base classes. These are all areas that cause either confusion or potential problems for C++ developers. Statements, expressions, operators, and other functions are taken directly from C and C++, but improvements make the language simpler. Some of the improvements include eliminating redundancies. Other areas of improvement include additional syntax changes. Changes like these make learning C# easier.

Chapter Four

Tuberculosis

4.1 Tuberculosis disease

TB is a bacterial disease caused by Mycobacterium tuberculosis (an occasionally by Mycobacterium bovis and Mycobacterium africanum).These organisms are also known as tubercle bacilli (because they cause lesions called tubercles) or as acid-fast bacilli (AFB). [8]. TB primarily affects the lungs, but it can also affect organs in the central nervous system, lymphatic system, and circulatory system among others. The disease was called "consumption" in the past because of the way it would consume from within anyone who became infected.

4.2 Classification based on anatomical site of disease

TB disease can occur in pulmonary and extra pulmonary sites.

4.2.1 Pulmonary tuberculosis (PTB)

Refers to any bacteriological confirmed or clinically diagnosed case of TB involving the lung parenchyma or the tracheobronchial tree. Miliary TB is classified as PTB because there are lesions in the lungs. Tuberculous intra-thoracic lymphadenopathy (mediastinal and/or hilar) or tuberculous pleural effusion, without radiographic abnormalities in the lungs, constitutes a case of extra pulmonary TB. A patient with both pulmonary and extra pulmonary TB should be classified as a case of PTB.

4.2.2 Extra pulmonary tuberculosis (EPTB)

Refers to any bacteriological confirmed or clinically diagnosed case of TB involving organs other than the lungs, e.g. pleura, lymph nodes, abdomen, genitourinary tract, skin, joints and bones, meninges. In HIV-infected persons, extra pulmonary TB disease is often accompanied by pulmonary TB. Persons with extra pulmonary TB disease usually are **not** infectious unless they have 1) pulmonary disease in addition to extra pulmonary disease; 2) extra pulmonary disease located in the oral cavity or the larynx; or 3) extra pulmonary disease that includes an open abscess or lesion in which the concentration of organisms is high, especially if drainage from the abscess or lesion is extensive, or if drainage fluid is aerosolized. Persons with TB pleural effusions may have underlying pulmonary TB that is masked on chest radiograph because the effusion fluid compresses the lung. These patients should be considered infectious until pulmonary TB disease is excluded.

4.2.3 Miliary TB

Miliary TB occurs when tubercle bacilli enter the bloodstream and disseminate to all parts of the body, where they grow and cause disease in multiple sites. This condition is rare but serious. "Miliary" refers to the radiograph appearance of millet seeds scattered throughout the lung. It is most common in infants and children younger than 5 years of age, and in severely immunocompromised persons. Miliary TB may be detected in an individual organ, including the brain; in several organs; or throughout the whole body. The condition is characterized by a large amount of TB bacilli, although it may easily be missed, and is fatal if untreated. Up to 25% of patients with miliary TB may have meningeal involvement.

4.2.4 Central Nervous System

When TB occurs in the tissue surrounding the brain or spinal cord, it is called tuberculous meningitis. Tuberculous meningitis is often seen at the base of the brain on imaging studies. Symptoms include headache, decreased level of consciousness, and neck stiffness. The duration of illness before diagnosis is variable and relates in part to the presence or absence of other sites of involvement. In many cases, patients with meningitis have abnormalities on a chest radiograph consistent with old or current TB, and often have miliary TB.
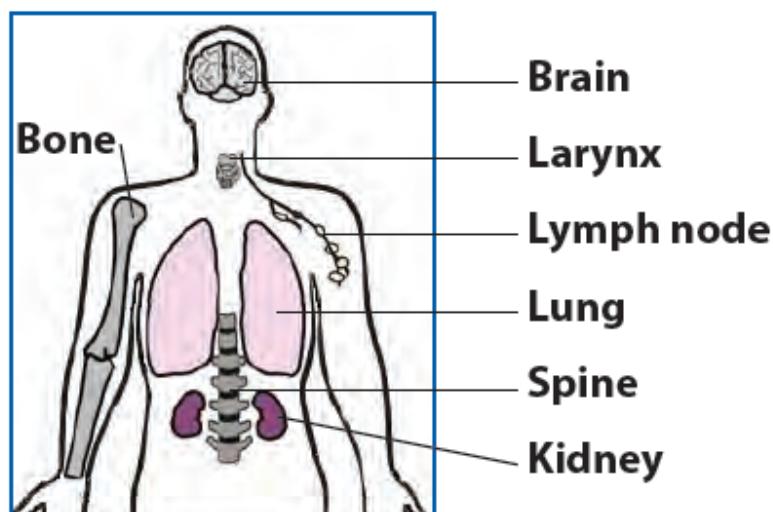

Figure 4.1: figure show where TB disease is more likely to develop

4.3 Tuberculous infection and tuberculosis

Tuberculous infection occurs when a person carries the tubercle bacilli inside the body, but the bacteria are in small numbers and are dormant. These dormant bacteria are kept under control by the body's defenses and do not cause disease. Many people have tuberculous infection and are well.

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Tuberculosis is a state in which one or more organs of the body become diseased as shown by clinical symptoms and signs. This is because the tubercle bacilli in the body have started to multiply and become numerous enough to overcome the body's defenses.

4.4 Transmission of TB

Tuberculosis (TB) is a serious disease caused by bacteria. It's spread from person to person through the air and usually affects the lungs. When a person who is sick with TB coughs, sneezes, or speaks, they put TB germs in the air. Other people may breathe in the TB germs, and some may become sick.

Brief contact with people who are sick with TB (such as on trains or buses) is Unlikely to give a person TB. TB is not spread by shaking hands, sharing food, or having sex.

People usually get TB germs in their bodies only when they spend a long time around someone who is sick with TB for example, if they live or work with someone with TB every day. Most people don't know they have TB until they become sick. That's why it's a Good idea for people at high risk for TB *to* get tested. With proper care and treatment, TB can be prevented and cured.

Figure 3.2 shown how tuberculosis bacteria transmitted from one person to another.

The infectiousness of a person with TB disease is directly related to the number of tubercle bacilli that he or she expels into the air. Persons who expel many tubercle bacilli are more infectious than patients who expel few or no bacilli. Table 3.1 shown the factors that determine the probability of transmission of M.tuberculosis.
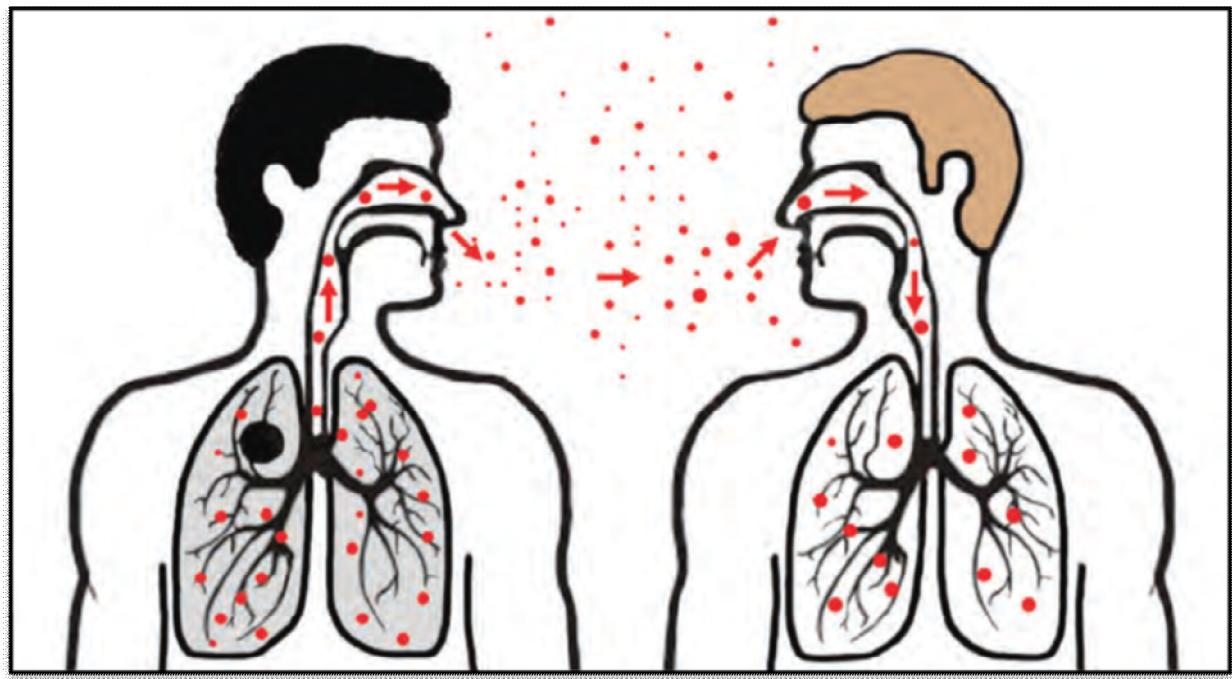
Figure 4.2: how TB is spread from person to person

4.5 The immune system role

People usually get TB germs in their bodies only when they spend a long time around someone who is sick with TB. Even then, the body can usually fight off the germs.

When a person becomes infected with tuberculosis, the bacteria in the lungs multiply and cause pneumonia along with chest pain, coughing up blood, and a prolonged cough. In addition, lymph nodes near the heart and lungs become enlarged. As the TB tries to spread to other parts of the body, it is often interrupted by the body's immune system. The immune system forms scar tissue or fibrosis around the TB bacteria and this helps fight the infection and prevents the disease from spreading throughout the body and to other people. If the body's immune system is unable to fight TB or if the bacterium breaks through the scar tissue, the

disease returns to an active state with pneumonia and damage to kidneys, bones, and the menings that line the spinal cord and brain.

Table 4.1: factors that determine the probability of transmission of M.tuberculosis

Factor	Description
Susceptibility	Susceptibility (immune status) of the exposed individual
Infectiousness	Infectiousness of the person with TB disease is directly related to the number of tubercle bacilli that he or she expels into the air. Persons who expel many tubercle bacilli are more infectious than patients who expel few or no bacilli
Environment	Environmental factors that affect the concentration of *M. tuberculosis* organisms
Exposure	Proximity, frequency, and duration of exposure

4.6 TB types

TB is generally classified as being either latent or active.

4.6.1 Latent TB

Most people who breathe in TB germs do *not* get sick. When a person's immune system is strong, it builds a wall around the germs so they can't spread and hurt the

body. These walls are called tubercles — that's how tuberculosis gets its name. Once the germs are trapped inside the tubercles, they slow down and stop activity, as if they went to sleep. This is called latent (sleeping) TB.

4.6.2 Active TB

When a person can't fight TB germs, they become sick. The TB germs multiply and do a lot of damage to the body. This is called active TB. People with active TB usually have symptoms:

1. Coughing for more than 3 weeks.
2. Weight loss.
3. Loss of appetite.
4. Heavy sweating at night.
5. Fever.
6. Feeling tired all the time.
7. Chills.

People with active TB must take medicine to kill the germs and prevent damage to the lungs and other parts of the body, including the brain, spine, and kidneys. Until they take medicine, people with active TB in their lungs are contagious. They can spread the disease to others when they speak, cough, or sneeze.

4.7 The Difference between Latent TB and Active TB

Several differences can be found between latent TB and active TB as shown in table 4.2.

Table 4.2: the differences between latent TB and Active TB

Latent TB	Active TB
TB germs in the body are walled off (sleeping).	TB germs in the body are active and spreading.
Person can't spread TB germs to others.	Person can spread TB germs to others.
Person does not feel sick.	Person usually feels sick.
TB test result usually positive.	TB test result usually positive.
Chest X-ray usually normal.	Chest X-ray usually shows damage to lungs.
Some times has to be treated with medicine to prevent active TB.	Always has to be treated with medicine to cure the disease and prevent spread to others.
Should consider treatment for latent TB to prevent TB disease. Usually treated with 1 medicine, for 4-9 months	Need treatment for TB disease. Usually treated with 3 or 4 medicines, for 4-9 months.
Does not require respiratory isolation	May require respiratory isolation
Not a TB case	A TB case

4.8 The symptoms of tuberculosis

Most people who become infected with the bacteria that cause tuberculosis actually do not present symptoms of the disease. However, when symptoms are present, they include:

1- Unexplained weight loss.

2- Tiredness.

3- Fatigue

4- Shortness of breath

5- Fever

6- Night sweats

7- Chills

8- Loss of appetite.

Symptoms specific to the lungs include:

1. Coughing that lasts for 3 or more weeks.

2. Coughing up blood.

3. Chest pain.

4. Pain with breathing or coughing.

4.9 Explanation

Fever: this can be of any type .there may be only slight rise of temperature in the evening. The temperature may be high or irregular. Often there is no fever.

Chest pain: is not uncommon in tuberculosis. Sometimes it is just a dull ache. Sometimes it is worse on breathing in (due to pleurisy). Sometimes it is due to muscle strain from coughing. Sometimes the cough has been so severe that the patient has cracked a rib (cough fracture).

Breathlessness: in tuberculosis Is due to extensive disease in the lungs , or the pleural effusion complicating the lung tuberculosis .The breathless patient frequently appears ill and has lost weight .he will often have fever. Occasionally the patient has a localized wheeze. This is to due to local tuberculous bronchitis or to pressure of a lymph node on a bronchus.

Sometimes the patient seems to have developed an acute pneumonia. But the pneumonia may not get better with routine antibiotics. The cough and fever may persist. The patient remains ill. If you question him closely you may find that he

has had cough and loss of weight for weeks or months before the pneumonia came on. If there is any doubt examine his sputum for TB.

Sometimes the patient says that for months he has had one cold after another. Question him carefully .the colds may be just that a chronic cough has got repeatedly worse: examine the sputum for TB.

Remember that, in an older smoker, cough and loss of weight which come on gradually, may be due to lung cancer but you must check for tuberculosis by examining the sputum.

Cough: of course is a common symptom after acute respiratory infections. It is also common in smokers. It is common in some areas where the houses or huts have no chimneys and the houses are often full of smoke-especially in cold climates or cold weather when fires may be used for heating as well as cooking. Both tobacco and domestic smoke lead to chronic bronchitis.

Cough may come on gradually in a patient with lung cancer, which is becoming commoner in counties with increasing cigarette; smoking .Bronchiectasis is common in some countries: the patent may have had a chronic cough with purulent sputum since childhood. But if a patient has had a cough for more than three weeks you must get his sputum examined for TB to make sure the cough is suggests tuberculosis.

Blood in the sputum: may vary from a few spots to a sudden coughing of a large amount of blood. Occasionally this blood loss is so great that the patient quickly does, usually from asphyxia due to aspirated blood .If you see blood in the sputum you must always examine the sputum for TB.

4.10 Distinguishing tuberculosis from other conditions

The main conditions which have to be distinguished are:

1- Pneumonia

In acute pneumonia the symptoms usually come on suddenly. In the x-ray the soft shadows may look like tuberculosis. This is especially so if they are in the upper part of the lung .if the sputum is negative, give a non-tuberculous antibiotic for 7 days and x-ray again. A raised white blood count is in favour of pneumonia .if you have no x-ray, a rapid fall of temperature when you give the antibiotic makes the diagnosis likely to be pneumonia.

Pneumonia due to pneumocystic carinii is a common complication of AIDS. There is often a low –grade fever for several weeks and cough without sputum.

2- Lung cancer

In the x-ray a tumor may sometimes break down into a cavity .or infection beyond a bronchus blocked by a tumor may cause a lung

Abscess with a cavity. If the sputum is negative diagnosis may have to be made by bronchoscopy. A solid rounded tumor may be difficult to distinguish on the x-ray from a rounded tuberculous lesion. A patient with lung cancer is almost always a smoker. Feel also for enlarged lymph node behind the inner end of the clavicle, a common place for secondary tumor.

3- Lung abscess (empyema)

There is usually a lot of purulent sputum .the patient is usually feverish and ill. If the purulent sputum is repeatedly negative for TB lung abscess is more likely. The blood count is usually high.

4- Bronchiectasis

There is usually a lot of purulent sputum. It has often been produced since childhood .persistent moist coarse 'crackles' may be repeatedly heard over the same area of the lung. Sputum is negative for TB.

5- Asthma

Wheeze is not common in tuberculosis. But it may occasionally occur:

1- From enlarged lymph nodes, which may obstruct a bronchus or even the trachea.

2- from tuberculous bronchitis.

Either of these may cause a localized wheeze. Remember also that a few patients with severe asthma may be on long-term corticosteroid drugs (such as prednisolone). This can weaken the patient's defense against TB. He can the develop tuberculosis as well as asthma. If an asthma patient develops a cough while under treatment or if he begins to run a fever or loses weight, test his sputum for TB.

6- Chronic Obstructive Pulmonary Disease (COPD).
7- Human Immunodeficiency Virus (HIV).
8- Infection with fungus such as in histoplasmosis.

But if a patient has any of the following consider him a tuberculosis suspects

i. Cough for more than three weeks.
ii. Coughing blood.
iii. Pain in the chest for more than three weeks.
iv. Fever for more than three weeks.

All these can be due to other disease but sputum must be tested if any are present.

Table 4.3: The table shows possible alternative diagnoses.

Diagnosis	Pointers to the correct diagnosis
Bronchiectasis	coughing large amounts of purulent Sputum.
bronchial carcinoma (lung cancer)	risk factor (smoking, older age, previous mine-work)
bacterial pneumonia	Usually shorter history, febrile, response to antibiotic
lung abscess	cough with large amounts of purulent sputum abscess with fluid level on CXR
Pneumocystis carinii	often dry, non-productive cough with prominent dyspnoea
Asthma	intermittent symptoms, generalized expiratory wheeze; symptoms wake the patient at night
chronic obstructive airways disease	risk factor (smoking), chronic symptoms, prominent dyspnoea, generalized wheeze, signs of right heart failure (e.g. ankle oedema)

4.11 The diagnosis of tuberculosis

People suspected of having TB disease should be referred for a medical evaluation, which will include:

a. Medical history.
b. Physical examination.
c. Test for TB infection (TB skin test or TB blood test).
d. Chest radiograph (X-ray).
e. Appropriate laboratory tests.

4.11.1 Choosing a TB test

The person's health care provider should choose which TB test to use. Factors in selecting which test to use include the reason for testing, test availability, and cost. TB tests are:

1- Skin test

The most common diagnostic test is a simple skin test called the Mantoux test. The doctor or other health care provider will use a small needle to put a few drops of test solution under skin and ask patient to return after 2-3 days then a doctor or nurse looks for a reaction at the injection site; a hard, raised red bump usually indicates a positive test for TB.

Skin test is the preferred method for testing for children under the age of 5 years and pregnancy women.

2- Blood test

The doctor or health care provider will collect a small sample of blood from the patient .the blood sample will be sent to a laboratory and tested for TB. The provider gives the results in 2-3 days.

Blood tests may also be used to determine whether TB is active or latent (inactive), and microscopic sputum analyses or cultures can find TB bacteria in the sputum.

Blood tests are the preferred method of testing for Groups of people who have poor rates of return for skin test reading and interpretation (e.g., homeless persons).

3- Sputum test

The large majority of specimens received for diagnosis are sputum samples. If good specimens are to be obtained, patients must be instructed in how to produce

sputum. Specimens should be collected in a separate, ventilated room or preferably outdoors. Keeping both hands on hips, cough forcibly and collect sputum in the mouth; spit the sputum carefully into a wide-mouthed, unbreakable, leak proof container and close the lid tightly.

i.   Ideally, a sputum specimen should be 3-5 ml in volume, although smaller quantities are acceptable if the quality is satisfactory.

ii. If specimens are to be cultured using a centrifugation method, sputum should preferably collected directly into a 50 ml centrifuge tubes to avoid the need for their transfer from one container to another.

iii. Label each specimen with the identification number from the laboratory request form.

iv. Collect two specimens from each patient according to the NTP policy.

4- Chest x-rays and computer tomography (CT) scans

Chest x-ray and computer tomography (CT) scans are also used to diagnose TB. If the immune system traps the TB bacteria and creates scar tissue, this tissue and the lymph nodes may harden like stone in a calcification process.

This results in granulomas (rounded marble-like scars) that often appear on x-rays and CT scans. However, if these scars do not show any evidence of calcium on an x-ray, they can be difficult to distinguish from cancer.

5- Other test

In addition to above tests there are other tests suitable for some cases such as:

i. Laryngeal swab

Laryngeal may be useful in children and patients who cannot produce sputum or may swallow it. Laryngeal swabs collected in the early morning before patients eat or drink anything.

ii. Gastric lavage

Gastric lavages often contain MOTT and are therefore rarely used for adults; they are indicated for children, however, who produce almost no sputum.Gastric lavage collected early in the morning when the patient has an empty stomach.

iii. Extra-pulmonary specimens

The laboratory may receive a variety of specimens for diagnosis of extra pulmonary TB-body fluids, tissues, urine etc. These specimens may be broadly divided into groups which are processed in different ways:

1- Aseptically collected specimens (spinal fluids, pericardial, synovial and ascetic fluid, blood, bone marrow, etc.), which are usually free from contaminating flora.

2- Specimens with resident or contamination flora, such as (urine specimen, sperm and prostate secretions, menstrual blood samples, stool samples.)

iv. Other respiratory specimens

Other respiratory specimens such as (bronchial secretion, pleural effusions, Tran bronchial and other biopsies.)

When you get a TB skin test, your doctor

4.11.2 Interpretation of the TB Results

TB results are divided to two type negative result or positive result.

Negative results

A negative test results usually means you do not have TB germs in your body. Sometimes the test may not work if the TB germs are new in your body, or if your immune system is weak (for example, if you have HIV) in this case you may need a chest X-ray. Your health care provider will use the test results as part of a complete medical exam to determine if you have TB germs in your body.

Positive results

A positive test generally means that a person is infected with the TB germ, but does not necessarily mean that there is active TB disease or that active TB disease will develop. Only 10% of people who test positive for TB infection ever develops active disease .for HIV positive people the risk are much higher). After a positive test, an X-ray or sputum cultures (a test on mucus coughed up from your lungs), to look for signs of TB to confirm active disease. If TB is suspected, seek the advice of a physician.

 Anyone who is HIV positive should be tested for TB, and anyone with active TB disease should be tested for HIV.
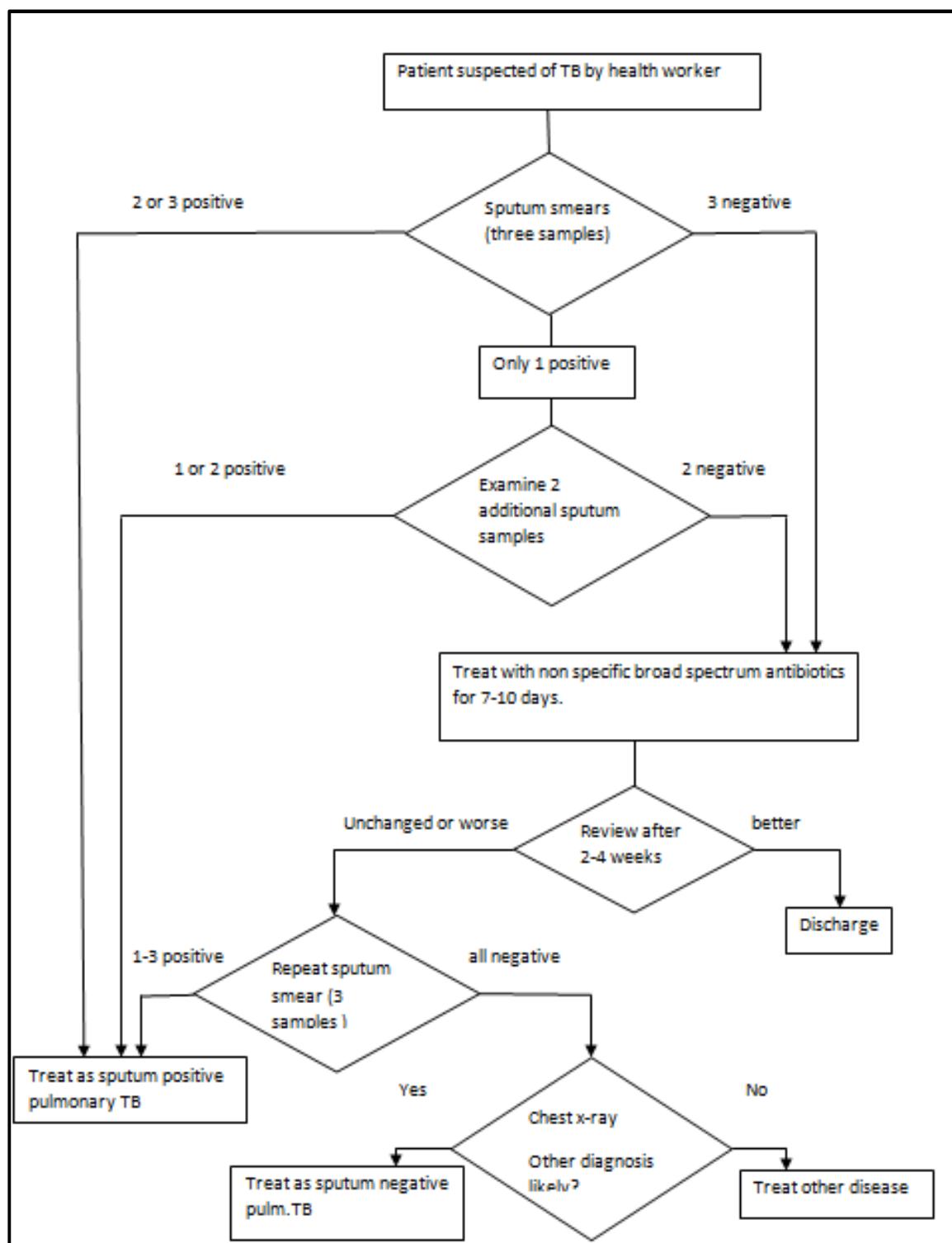
Figure 4.3: management flowchart for pulmonary tuberculosis

4.12 TB Risk Factors

Not all people need a TB test. You should get a TB test if you are at increased risk. Generally people at high risk for developing TB disease are:

1- People who have recently spent a long time around someone who has active TB.

2- People with weakened immune systems, especially those with HIV infection or very young children.

3- People who have symptoms of TB disease (fever, night sweats, cough and weight loss)

4- People with diabetes, chronic kidney failure, some cancers, or other medical conditions.

5- People who abuse drugs and/or alcohol and cigarette smokers.

6- People who have received an organ transplant.

7- People who take medications that suppress the immune system, such as chemotherapy for cancer, steroids, or TNF alpha blockers.

8- Poor or homeless people.

9- Foreign-born people who come from countries with endemic TB. 9-Those who suffer from malnutrition.

10- Health-care workers.

11- Workers in refugee camps or shelters.

12- People whose TB test changed from negative to positive recently.

13- Children younger than 5 years of age.

4.13 Way to protect people who are close to the patient

If you have active TB, a specially trained health care worker will ask you to name people you spend a lot of time with. This is a normal part of treatment for TB, and it's the best way to make sure others don't get sick from your TB germs. These people include your family, friends, and co-workers, and are called contacts.

Until you take TB medicine, you can pass the TB germs to your contacts. Your health care worker will talk to some of your contacts, especially those people you spent a lot of time with before you started taking medicine. This is so they can get tested for TB and avoid getting sick.

It's important to know your privacy will be protected. Even if one of your contacts knows you have TB, the health care worker will not use your name when talking to them. In some cases, the health care worker may need to talk to your supervisor at work. The health care worker will tell your supervisor your name so that the right co-workers can get tested. But your supervisor will be asked not to tell other people you have TB. It's important to talk to your health care worker about contacts. It helps keep the people you care about your family and friends from getting sick with TB.

4.14 Tuberculosis treatment

Treatment for TB depends on the whether the disease is active of latent. If TB is in an inactive state, an antibiotic called Isoniazide (INH) is prescribed for six to twelve months. INH is not prescribed to pregnant women, and it can cause side effects such as liver damage and peripheral neuropathy.

Active TB is treated with INH as well as drugs such as Rifampcin, Ethambutol, and Pyrazinamide. It is also not uncommon for TB patients to receive streptomycin if the disease is extensive. Drug therapies for TB may last many months or even Years. If a patient has a drug-resistant strain of TB, several drugs in addition to the main four are usually required. In addition, treatment is generally much longer and can require surgery to remove damaged lung tissue. The largest barrier to successful treatment is that patients tend to stop taking their medicines because they begin to feel better. It is very important that people who have TB disease finish the medicine, taking the drugs exactly as prescribed. If they stop taking the drugs too soon, they can become sick again ; if they do not take the drugs correctly the TB bacteria that are still alive may become resistant to those drugs.TB that is resistant to drugs is harder and more expensive to treat.

4.15 General guidelines on the treatment of tuberculosis

DOs and DON'Ts for doctors

4.15.1 Dos: for the doctor to do

1. Do always examine the sputum when there are symptoms suggestive of possible tuberculosis.

2. Do make sure the patient understands that he needs a full period of treatment through symptoms will soon clear. (Give the patient a leaflet on treatment if available.

3. Do explain this to his relatives.

4. **-**Do be kind and sympathetic: then the patient is more likely to come back for drug supplies and continue treatment. Think of him as a friend you want to help.

5. Do examine all family/home contacts, especially if they are ill.

6. Do put this name in the tuberculosis register and give him a treatment card with the next date of attendance. Make sure he understands and remembers the date.

7. Do send someone to his home if he fails to comeback on the date. (A letter is usually less effective but may be all you can do).

8. Do check frequently your supplies of anti-tuberculosis drugs and see that you don't run out.

4.15.2 DON'Ts: for the doctor to not do

Avoid the following errors which are common in some countries:

1- Never treat a patient with pulmonary tuberculosis without examining the sputum (where ever microscopy is available) .children often have no sputum: diagnosis may have to be largely clinical.

2- Never give a single drug alone: drug resistance usually follows and is permanent.

3- Never add a single drug to a drug combination if the patient becomes worse. First make sure that he is taking the drug combination regularly. If he is and is getting worse, his bacilli will be resistant to all the drugs being used. Adding one drug is the same as giving one drug alone; the patient's TB will soon be resistant to this also.

4- Never fail to follow up the patient and make sure he has the full recommended course of treatment (6 or 8 months with rifampicin), if at all possible make sure some one sees the patient taking every dose for the first 2 months.

5- Never use a combination of streptomycin and penicillin for non tuberculous conditions. It is seldom better than penicillin alone or tetracycline and may induce streptomycin resistance if the patient has undiagnosed tuberculosis. Only use rifampicin to treat either TB or leprosy.

6- Never treat only on the advice of the drug firm representatives. Their advice will be prejudiced and may well be wrong.

4.16 Tuberculosis Global Facts

Regarding to world health organization:

I. Tuberculosis (TB) is contagious and airborne. It's a disease of poverty affecting mostly young adults in their most productive years. The vast majority of TB deaths are in the developing world.

II. Million people died from TB (including600 000 women) in 2009, including 380 000 people with HIV, equal to 4700 deaths a day.

III. The TB death rate has fallen by 35% since 1990, and the number of deaths is also declining.

IV. TB is among the three greatest causes of death among women aged 15-44.

V. There were 9.4 million new TB cases (including 3.3 million women) in 2009, including 1.1 million cases among people with HIV.

VI. The estimated global incidence rate fell to 137 cases per 100 000 population in 2009, after peaking in 2004 at 142 cases per 100 000. The rate is still falling but too slowly.

VII. Globally, the percentage of people successfully treated reached the highest level at 86% in 2008.

VIII. Since 1995, 41 million people have been successfully treated and up to 6 million lives saved through DOTS and the Stop TB Strategy. 5.8 million TB cases were notified through DOTS programs in 2009.

IX. Multidrug-resistant TB (MDR-TB) is a form of TB that is difficult and expensive to treat and fails to respond to standard first-line drugs.

X. There were an estimated 440 000 new MDR-TB cases in 2008, and 150 000 deaths from MDR-TB.

XI. It was estimated that in 2009, 3.3% of all new TB cases had MDR-TB.

Chapter Five

System design

The design of the system was divided into two parts:

5.1 data base knowledge

Knowledge is a key factor in the performance of intelligent systems. The knowledge-base of the system is composed of structured and concise representation of the knowledge of domain experts of tuberculosis. The structure knowledge is concerned with facts, rules of tuberculosis diseases, which were commonly agreed upon by experts in the field of tropical medicine. For the purpose of this research, TB as a known tropical disease is considered. The knowledge-base of the designed system has many rules which were developed with the help of domain experts. The first step is Knowledge acquisition which is the process of collecting knowledge from domain experts before implementing the expert system. This aspect is the bottleneck in the development of a knowledge-based expert system. Different techniques for knowledge acquisition exist and each technique is suitable for a specific situation.

The most important part of this aspect is the source of knowledge and the experience contained in it. There are many sources of knowledge such as books, internet and experts. Hence, the knowledge acquisition for this work was obtained through interviews with a tuberculosis human expert. During the meeting, a lot of tuberculosis basic knowledge was provided including symptoms, complications, and treatment and diagnosis procedures. Since the beginning of this project, TB experts were met to discuss the knowledge concluded into the system and the

manipulation of this knowledge. The main important part was also to look at all the cases that the system should consider.

The second step is how to represent this knowledge. This part contained a formal representation of the information provided by the domain expert this information might be in the form of problem- solving rules, procedure, or data intrinsic to the domain. The three common methods of knowledge representation evolved of the years are IF–THEN rules, semantic networks, and frames. In this project we used if–then rules.

5.2 System design issues

Software design is the first step in the development phase for any engineering system. It interactive processes through which requirements are translated into a high level of abstraction for constructing the system. This expert system was interactive processes through which requirements are translated into a high level of abstraction for constructing the system. This system was designed to give medical diagnosis of TB for determining whether a patient suffers from TB or not. And it designed by using the C sharp programming language. The system provided a guide for diagnosis of TB within the decision making framework.

 The process for the medical diagnosis of TB starts when physicians or other healthcare practitioners present a set of complaints (symptoms). The physician or the health care practitioner then requests further information from the patient or from others close to him who knows about the patient's symptoms in severe cases. Data collected include patient's previous state of health, living condition and other medical conditions. A physical examination of the patient condition is conducted and in most cases, a medical observation along with medical test(s) is carried out on the patient prior to medical treatment.

From the symptoms presented by the patient, the physician or the health care practitioner narrows down the possibilities of the illness that corresponds to the apparent symptoms and clicks all the patient symptoms in the symptoms table in our program. These are usually ranked in possibility order. physicians then conducts a physical examination of the patient, studied his or her medical records and ask further questions, as he goes in an effort to rule out as many of the potential conditions as possible. When the list has been narrowed down to a single condition, it is called differential diagnosis and provided the basis for a hypothesis of what is ailing the patient. Until the physician is certain of the condition present; further medical test are performed or schedule such as laboratory examinations, medical imaging like CT- scan, X-rays in part to conform or disprove the diagnosis or to update the patient medical history.

The two primary components of this system are:

1- The actual program code

This is a set of instructions that tells the computer how to perform a given task. A computer does not know what to do unless there is some sort of program or code that tells it exactly what must be done and how it is to be done.

The first step to write the code was how to extract the information from experts after that write the code to represent this information in the program to solve the problems. Figure 5.1 shows the process of the information extraction and the codes process. [17].
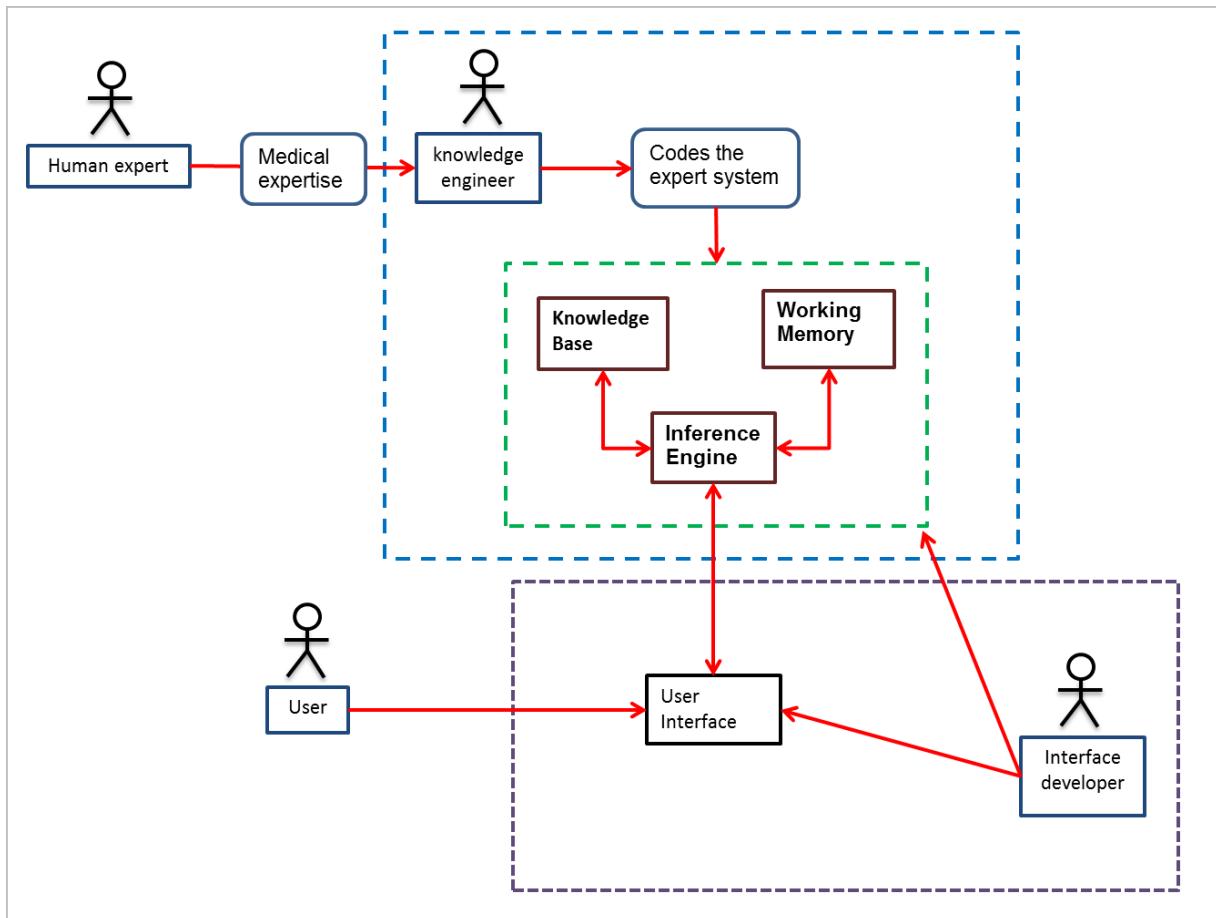
Figure 5.1: general medical system architecture.

In this system the possible symptoms of TB and disease similar to TB will present to the user in a screen where the user can click the specific symptom in order to start a searching process, the system showing the probability of the presence of the disease and the right type of examination, if the search result indicate to the presence of TB such as tuberculin skin test, TB blood test, chest x-ray and sample of sputum to see whether the person has TB disease.

The existence of the system in the lab explains to the technician the steps that must be followed for an examination and what is appropriate medical device for use of each examination, technician will send the result directly to the doctor via a

network system then the doctor sent medicines to pharmacy via a network also. There is also in the system guidance for patient and information about how to deal with TB without causing infection for people.

We expect this system can help in the early diagnosis of the disease despite the presence of symptoms similar to other diseases and therefore limit the spread of TB, reduce the cost because any doctor can detect the disease and also reduce the time wasted for the doctor and patient. Figure 5.2 shown flowcharts explain how system works.

2-The Graphical User Interface (GUI)

This part show what the user sees and works with. In this system the possible symptoms of TB and disease similar to TB presented to the user in a screen where the user can click the specific symptom in order to start a searching process, the system showing the probability of the presence of the disease and the right type of examination, if the search result indicate to the presence of TB such as tuberculin skin test, TB blood test, chest x-ray and sample of sputum to see whether the person has TB disease.

The System has been designed to be user friendly and it is easy to navigate. To Design the Knowledge Base System for diagnosis of TB, which consists of a set of parameters needed for diagnosis here, 13 basic and major parameters presented are used. Table 4.1shown symptoms of tuberculosis (TB) that used as parameters.

```
                    ┌─────────────────────┐
                    │  Start the program  │
                    └─────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────────────┐
│ Click the specific patient symptoms from the table of TB and similar disease symptoms. │
└────────────────────────────────────────────────────────────────────┘
                              │
                              ▼
                 ┌─────────────────────────┐
                 │  Click diagnosis button │
                 └─────────────────────────┘
                              │
                              ▼
                         ╱         ╲
         No        ╱   Is there a possibility  ╲
       ◄──────────     of the existence of
                  ╲        the TB?         ╱
                         ╲         ╱
                              │ Yes
                              ▼
┌────────────────────────────────────────────────────────────────────┐
│ The system shows the stage of the TB and appropriate examination.   │
└────────────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────────────┐
│ Doctor send the examination type to lab via network and the system  │
│ explain to the technician the step that must be followed & appropriate │
│ medical device for use.                                             │
└────────────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────────────┐
│ Send a result report to the doctor.                                 │
└────────────────────────────────────────────────────────────────────┘
```

Verification of the correct symptoms

Is it a TB? — No

Yes

Send medicines to pharmacy and print dietary & preventive guidelines to patient.

End the program

Figure 5.2: Flowchart show the system

Table 5.1: symptoms of tuberculosis (TB)

1-	Feeling sickness or weakness
2-	Weight loss
3-	Slight fever
4-	Night sweats
5-	Coughing for more than 2 weeks
6-	Chest pain
7-	Shortness of breath
8-	Coughing up of blood or sputum
9-	Feeling tired all the time
10-	Loss of appetite
11-	Chills
12-	Fatigue
13-	Lumps and bumps (lymphdenopathy)

5.3 System Operation

When the program is run the user will see the main screen, which contains several components as shown in the figure 4.3.

Each button in this main screen has a specific role for example when the user click on diagnosis button will see the patient information screen as shown in figure 4.4.
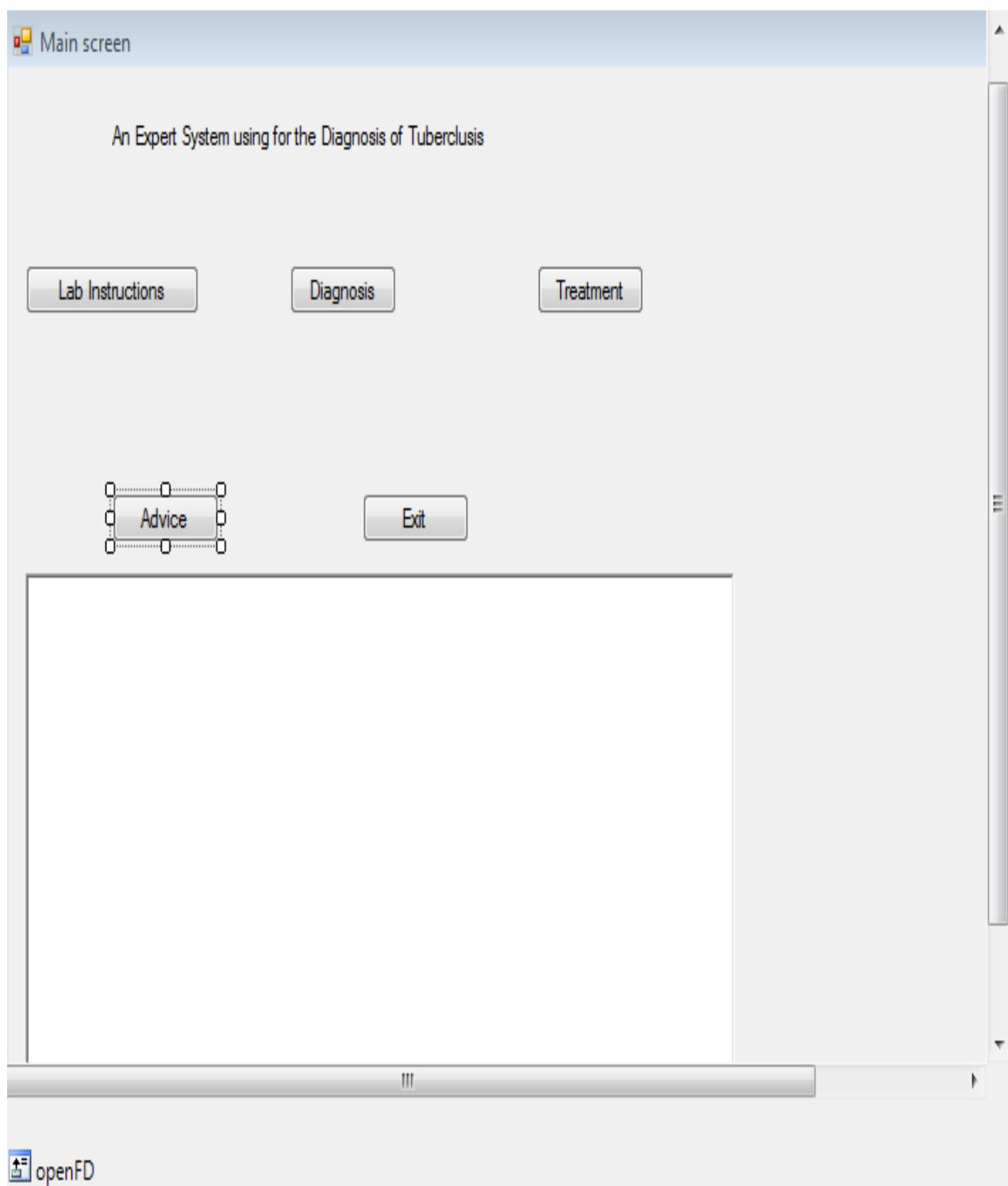
Figure 5.3: The main screen of the system

Figure 5.4: The basic information requested from patients

After the user write the basic information about the patient, click the symptoms button which represent number of symptoms.
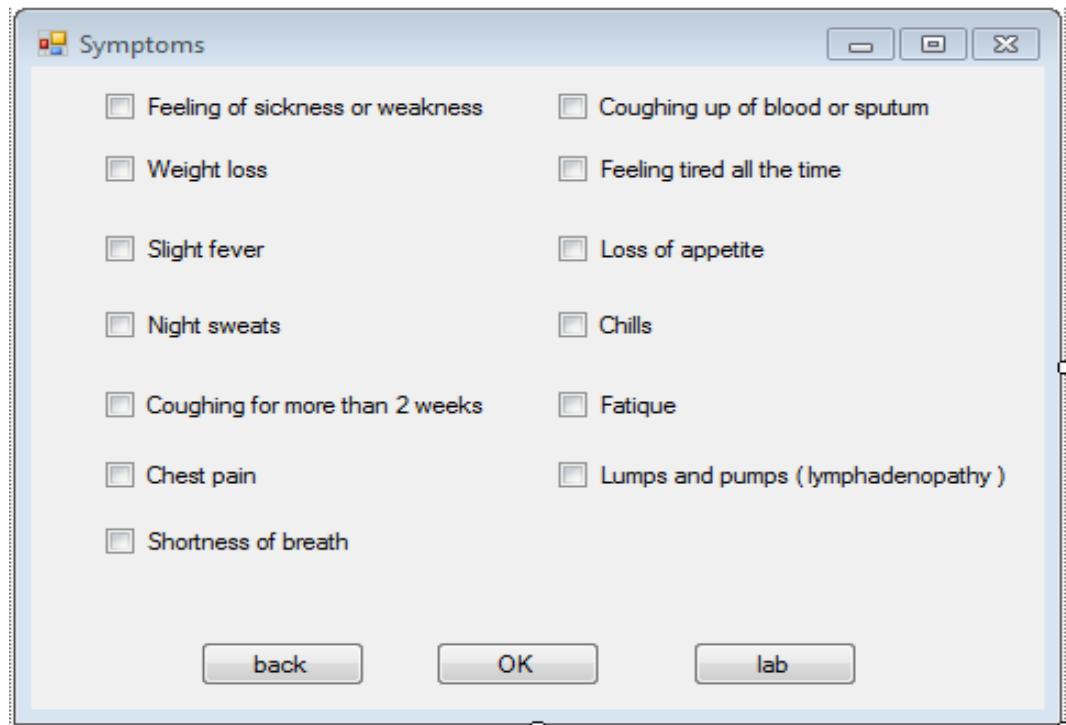
Figure 5.5: Symptoms screen

From the symptoms presented by the patient, the physician narrows down the possibilities of the TB that corresponds to the apparent symptoms and makes a list of the conditions that could account for what is wrong with the patient and if the patient suspected for TB either was an active TB or latent TB. Until the physician is certain of the condition present; further medical test are performed or schedule such as sputum test, mantoux test or chest X-ray. Beside this steps physician or any health care worker could ask questions like when did the symptoms start, how severe are the symptoms and have the symptoms occurred before.

Each symptom has a certain weight .these weights were given based on domain experts. After that we used the if-—then rules.

When the lab instruction button is selected the user will see how sputum is collected in addition to three types of test as shown in figure 5.6, 5.7, 5.8, 5.9.
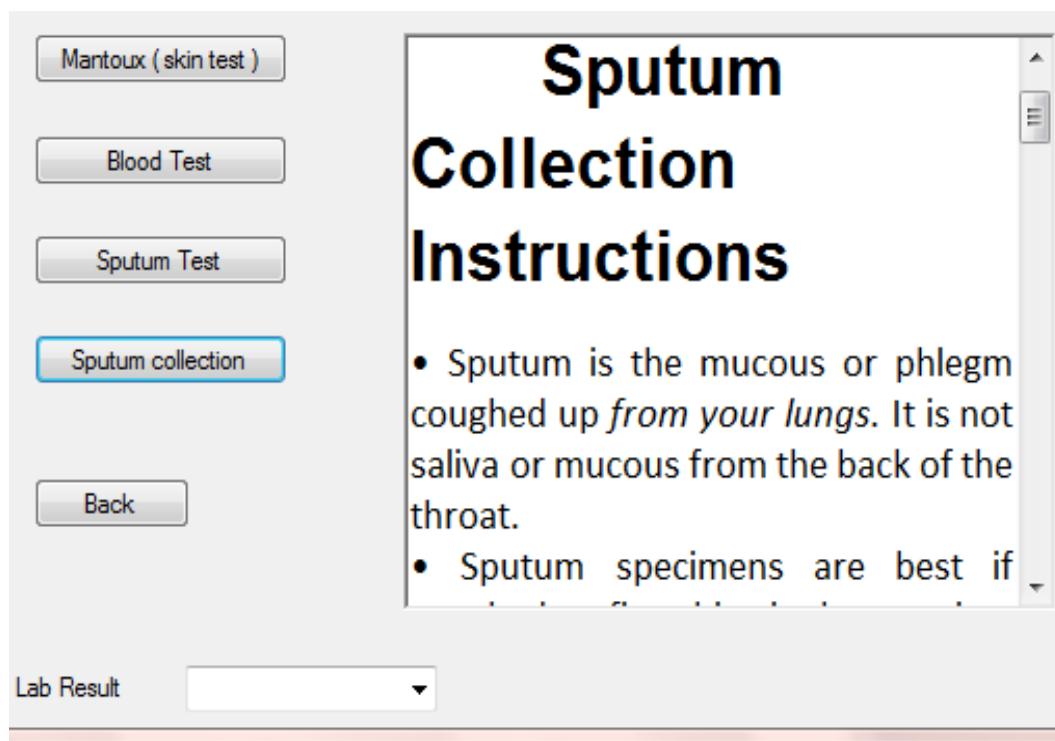
Figure 5.6: how technician will collect the sputum
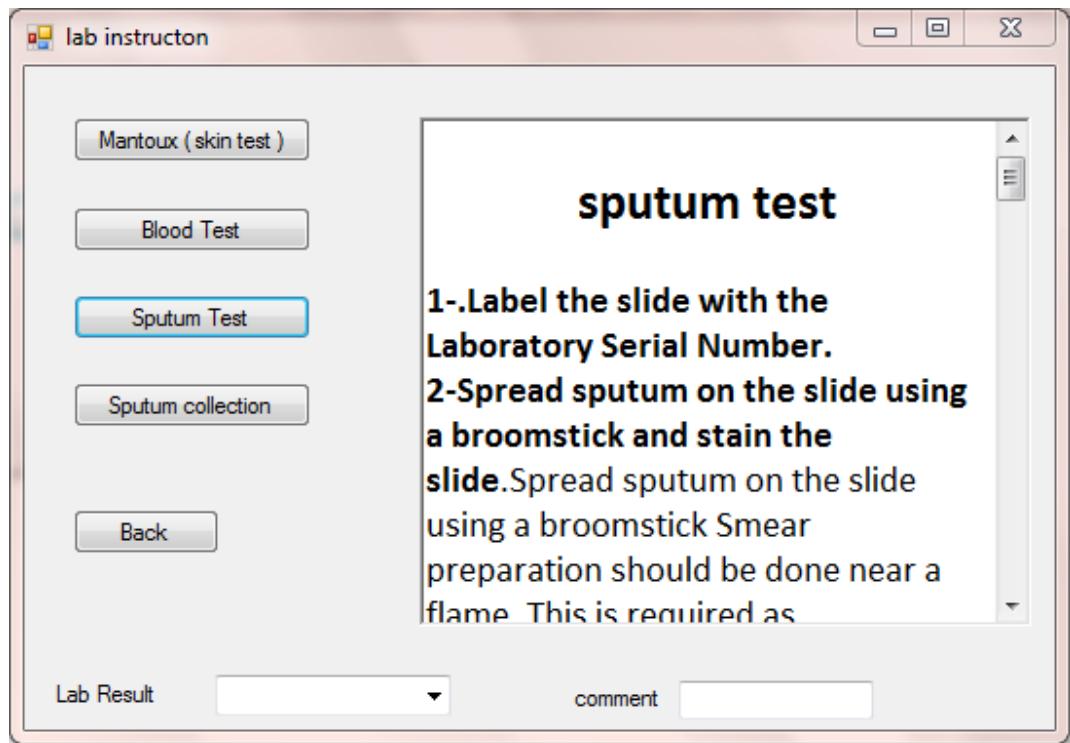
Figure 5.7: how technician do the sputum test
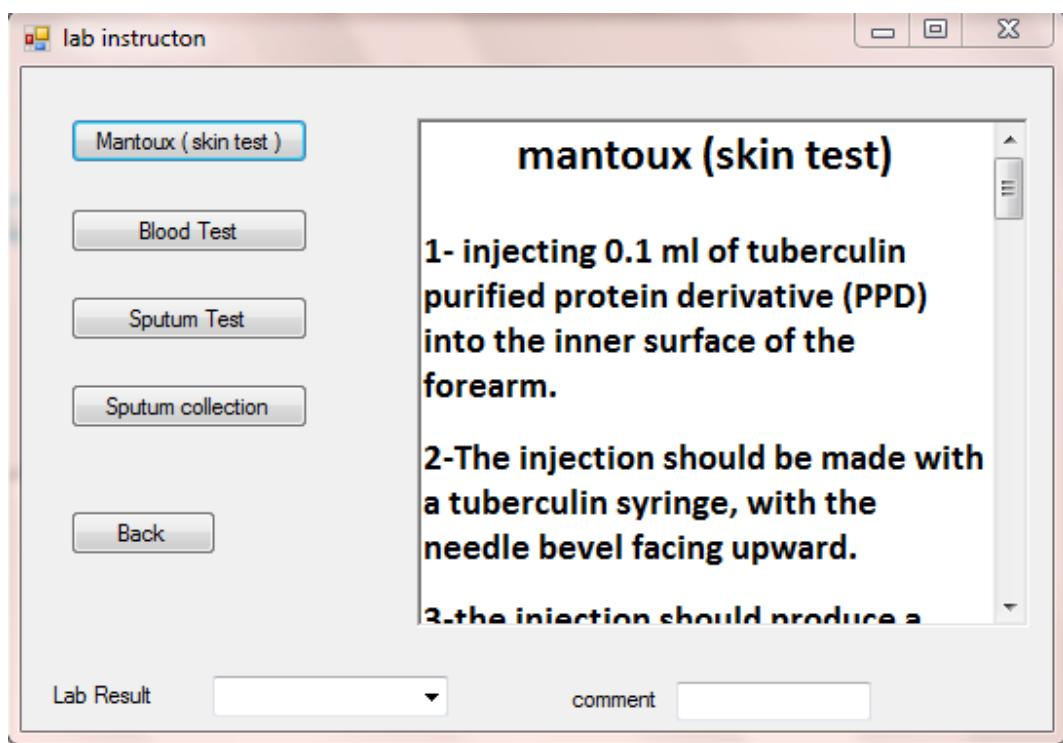
Figure 5.8: how technician do the mantoux test
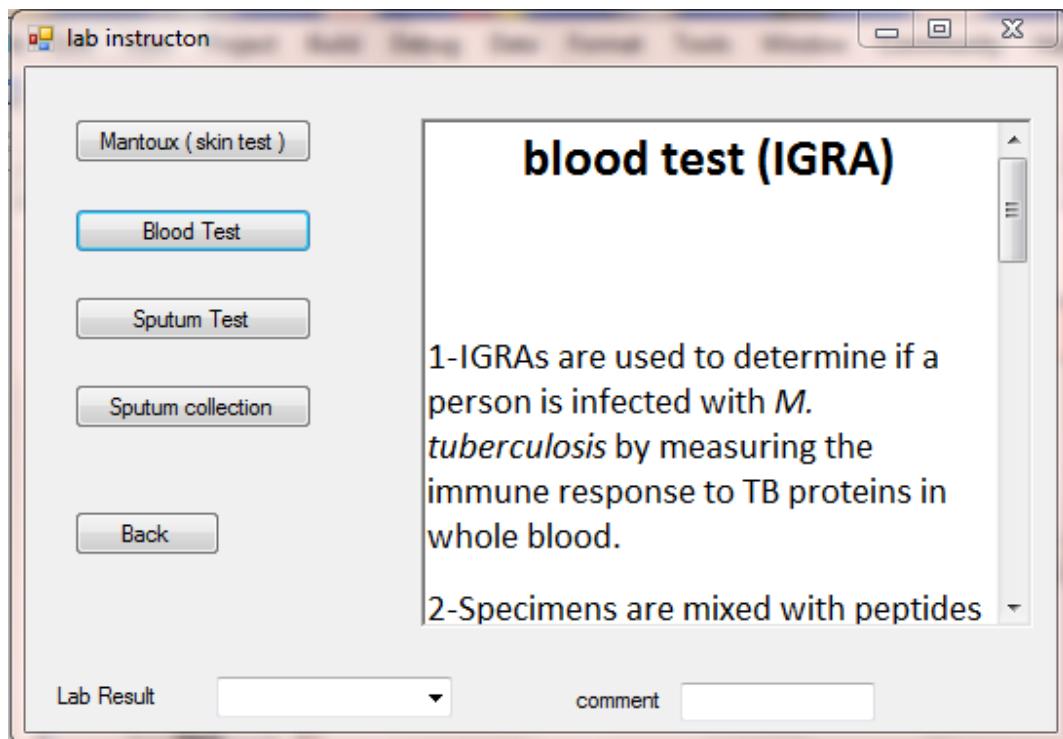
Figure 5.9: how technician do the blood test

After the user click the symptoms that you have and enter the lab result the system will give the result whether there are TB or not as shown in figure 5.10.
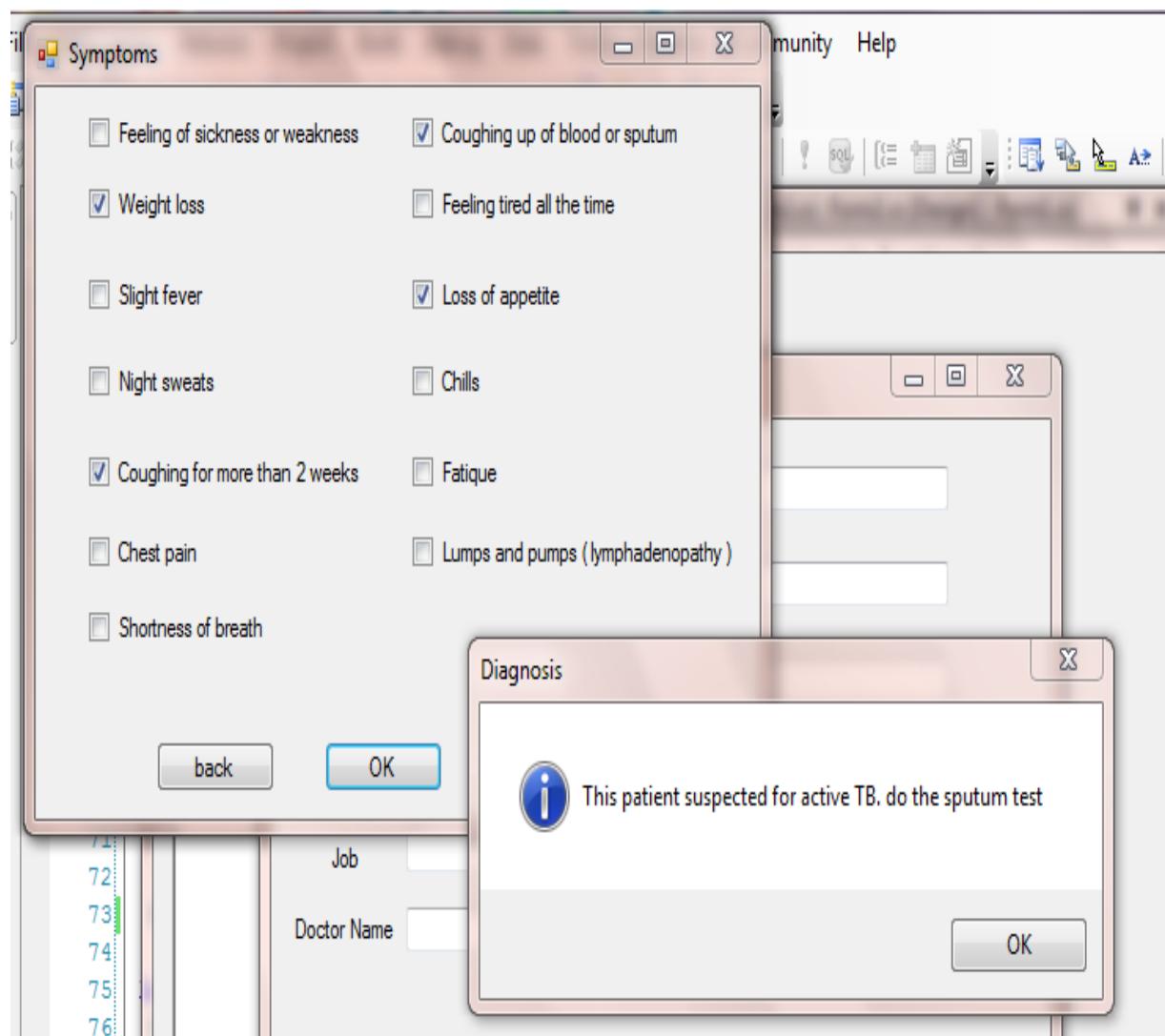
Figure 5.10: the result if the patient did not have TB

Finally if the patient has TB the system can help by giving him an advice as shown in figure 5.11.

Figure 5.11: how the program gives advice for patients

Chapter Six

Results and Discussion

6.1 Output Result

The Expert System has been designed to be user friendly and it is easy to navigate. The user can easily access the whole Implementation of An Expert System for Medical Diagnosis of the Complications of TB application from the home page where there is menu bar from which the user can perform the desired functions as illustrated in the system design chapter.

Figure below show the whole screen when the user opens the GUI.
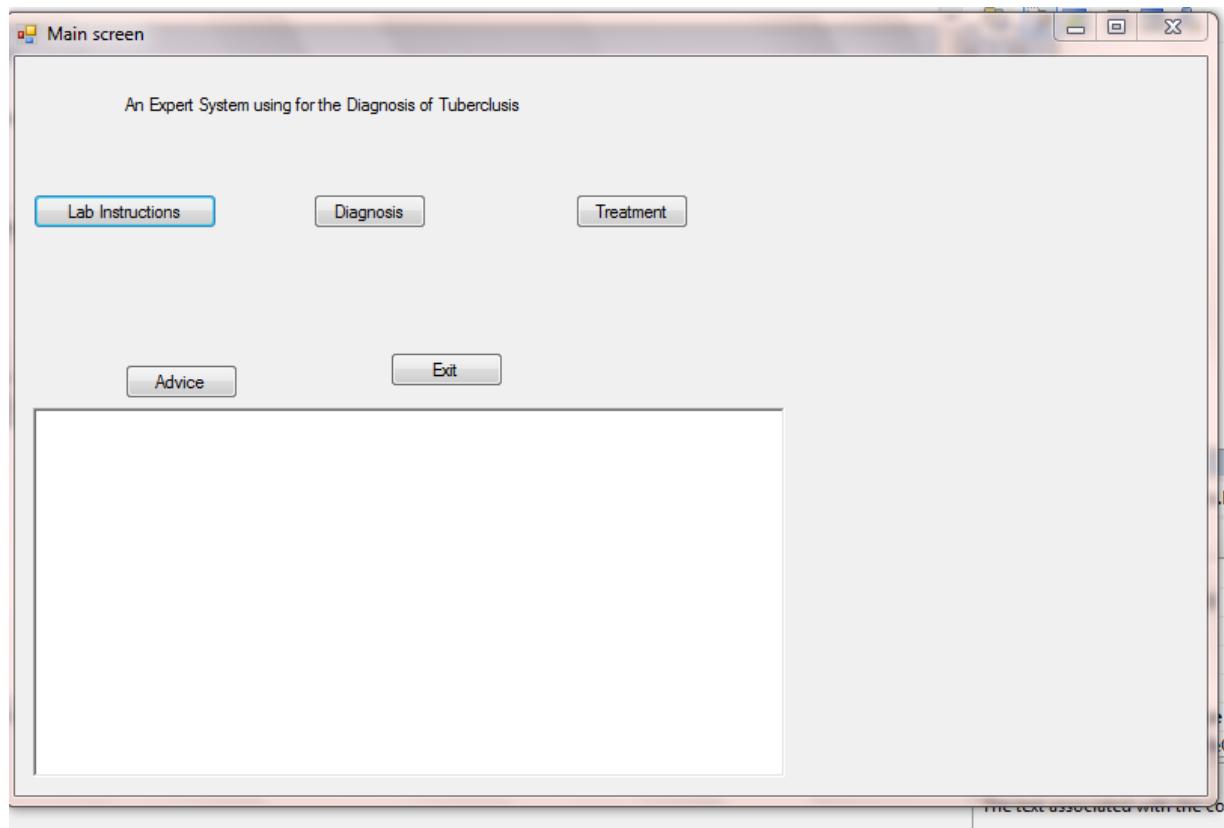
Figure 6.1: screen shot for main screen

6.2 Testing and Assessment

Now three cases are chose to show how the system gives the results for them step by step to show how the system works.

Case one

This case for patient suffered from different symptoms as shown below. After clicked diagnosis button on figure 6.1the patient information screen was appeared then the first step is to write the basic information about the patient.

Figure 6.2: the basic information of patient

From the symptoms screen the user checked the patient symptoms and click ok to know the result.
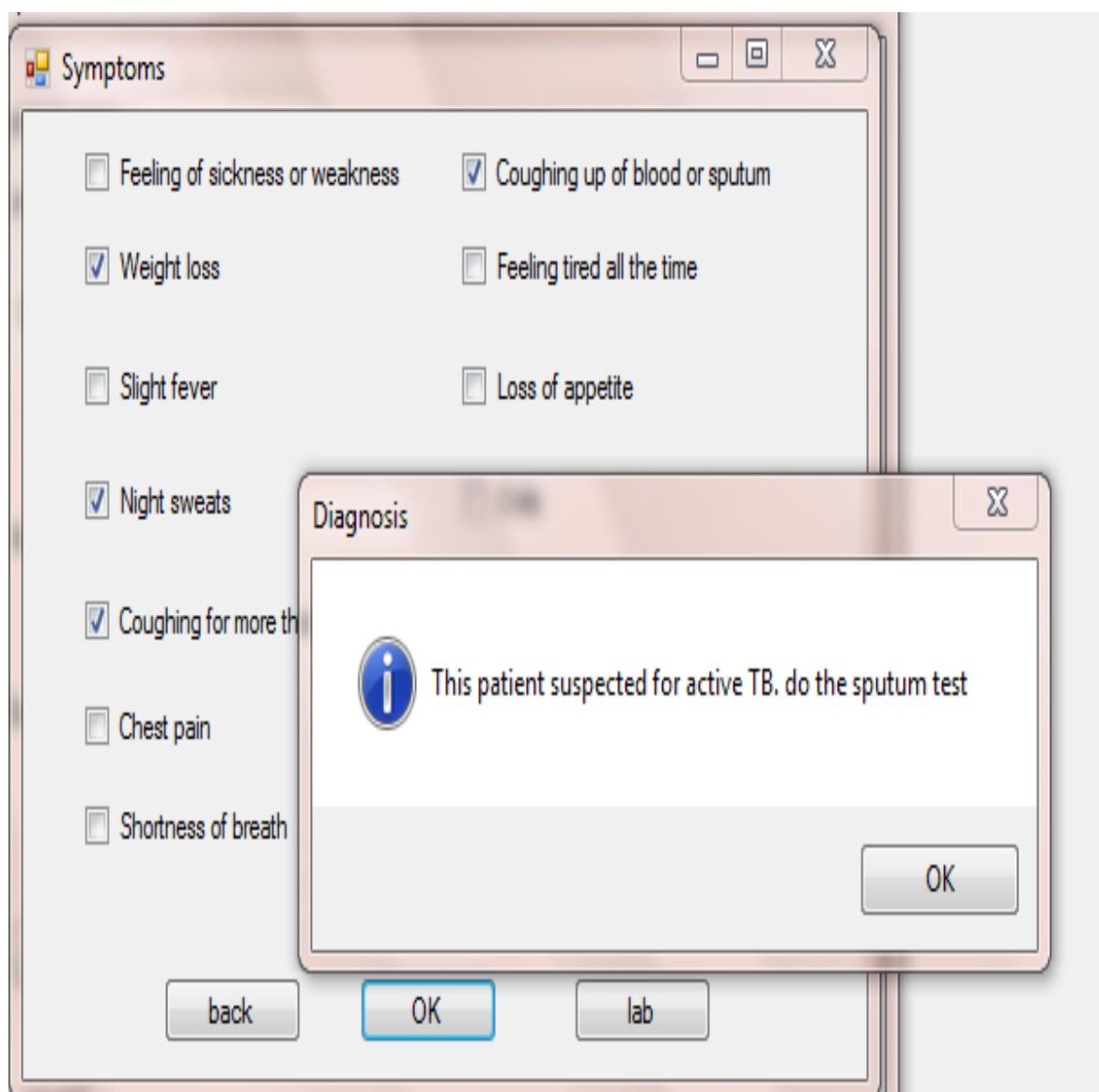
Figure 6.3: the initial result of TB patient.

After that patient will go to the lab to do the sputum test, the lab instruction can guide the technician to do this test even he has no idea about it before.
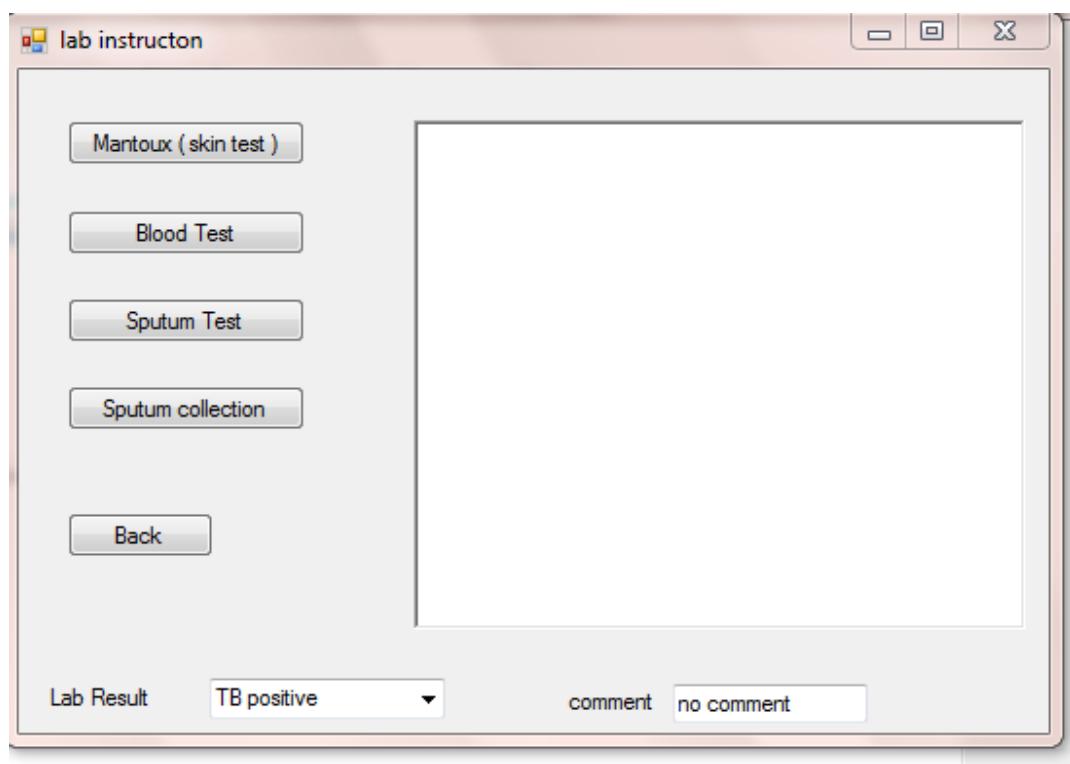
Figure 6.4: the lab result for a TB patient

The system also can give the patient the correct medicines to take as shown below.
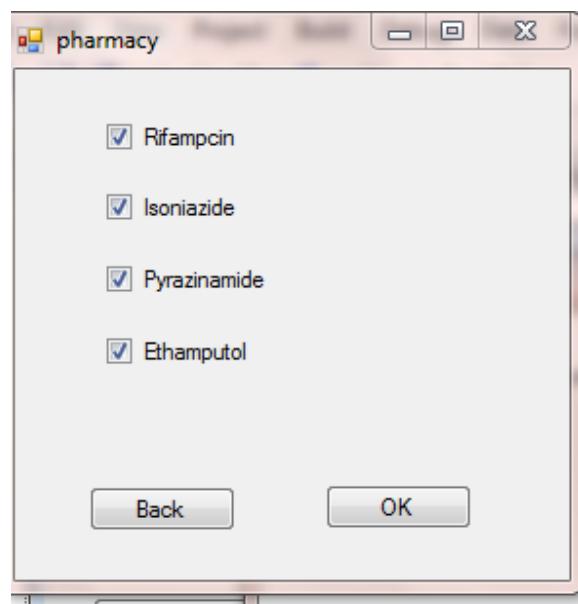

Figure 6.5: the medicines for an active TB patient

Case two

This patient suffered from symptoms like TB symptoms but the first step need to checked his symptoms from symptoms screen to see whether the patient suspected for TB or not.
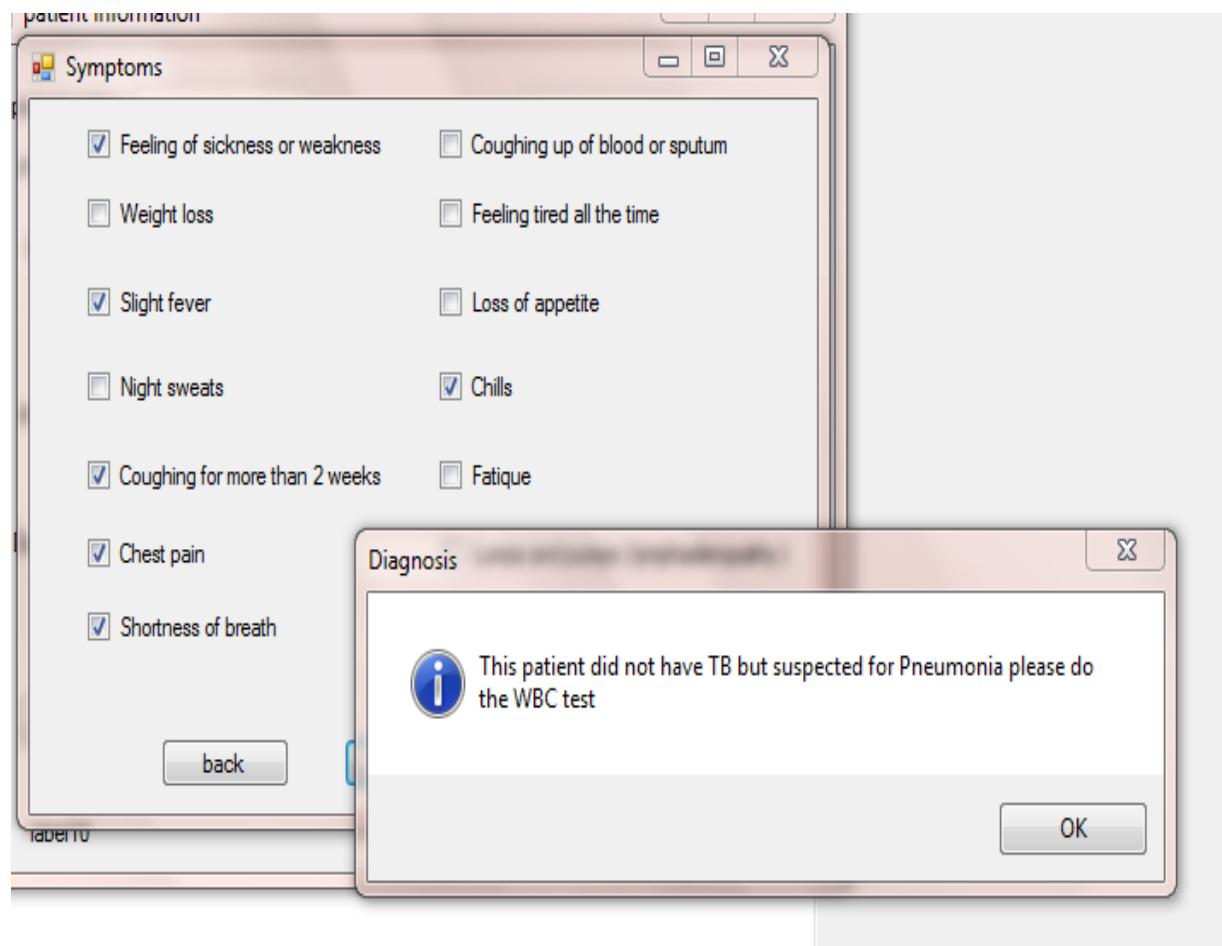

Figure 6.6: the initial diagnosis for none TB patient

In this case no need to open the lab screen because patient already did not have TB to be sure can do the sputum test to see the result
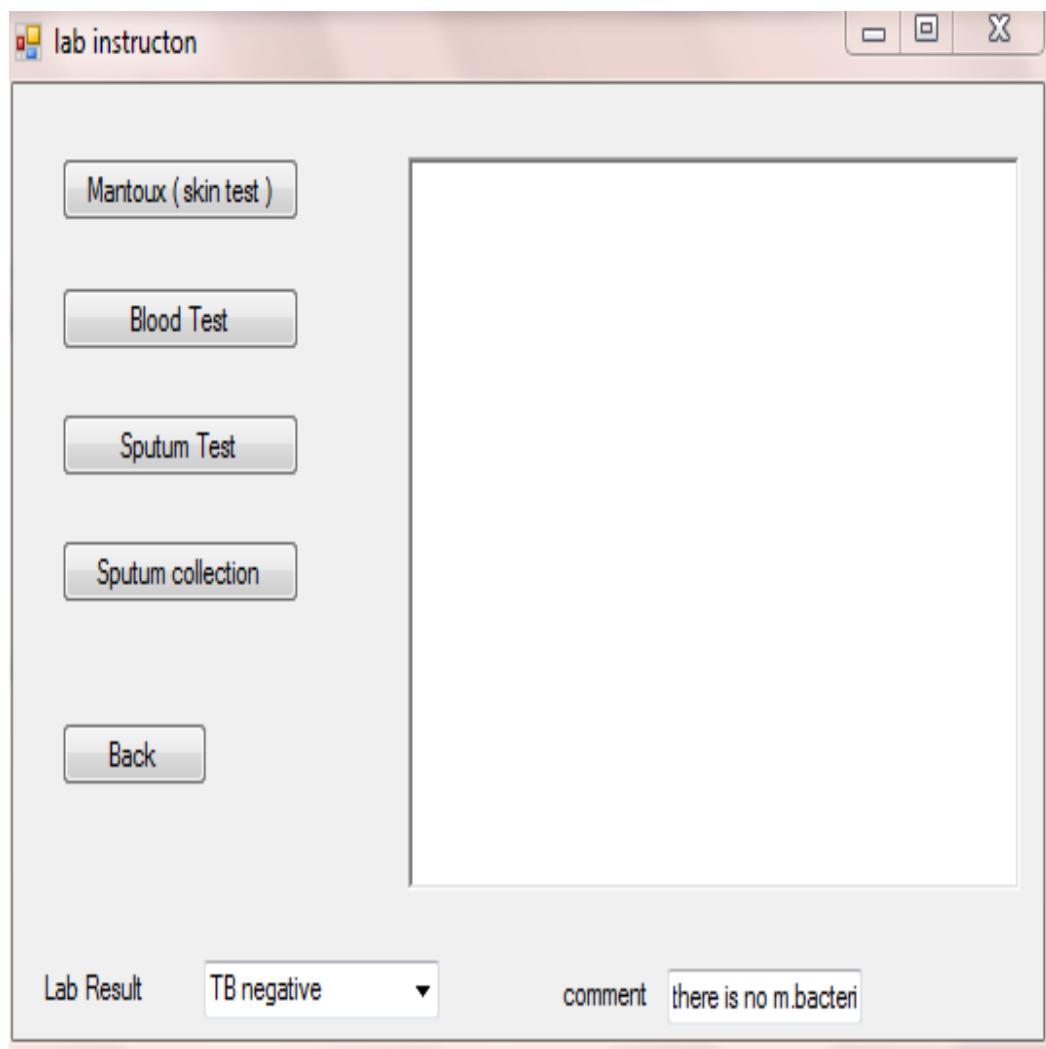
Figure 6.7: the labs result for none TB patient

Case Three

This case for a healthy person who did not suffer from any symptoms, so in this case user did not check any symptoms from the symptom screen, the figure below show the result in this case.
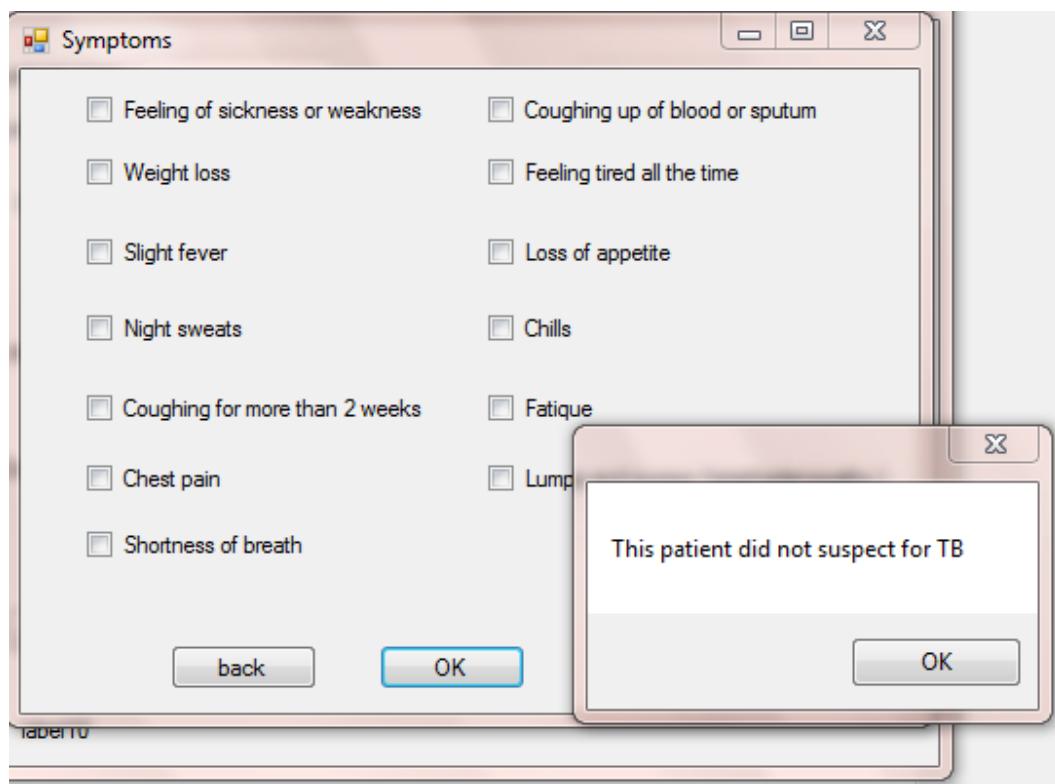
Figure 6.8: the result for a healthy person

The above different cases show how the system can determine the TB disease and whether the patient has a TB or not sometimes it determines the diagnosis of diseases has symptoms near or similar to TB like case two.

The program gives result by combining all the weights and compared it with specific weight and according to this the result is shown with determining the appropriate examination.

The system used all the rules in the knowledge-base and derives conclusion base on the rules. The inference engine for the designed system uses a forward chaining mechanism to search the knowledge for the symptoms of a disease.

Chapter Seven

Conclusion and Recommendations

7.1 Conclusion

The main purpose for this research work was to develop a prototype of a knowledge-based system to help people who are living with tuberculosis especially in rural areas.

The system was designed and implemented as outlined in the methodology. The knowledge implemented in this system was obtained from a human expert and other sources such as books and the Internet. The system will be very useful in rural areas because there is a shortage of expertise and medical facilities in rural areas and could reduce some of the workload for medical assistants especially during peak times.

The system was able to give advice to tuberculosis patients with different conditions and People can learn with the system whether they have tuberculosis or not. The system has been designed to help patients provides an efficient way and to assist inexperienced physicians to arrive at the final diagnosis of TB more quickly and efficiently not to replace them.- The advice given by the system can be understood by patients with poor literacy. This system can help to limit the spread of TB, reduce the cost because any doctor can detect the disease and also reduce the time wasted for the doctor and patient.

7.2 Recommendations

1- The system can use to diagnosis the rarely type of TB such as TB in the brain, liver or bone morrow by add the symptoms of these diseases.

2- It will be better if data base was added to the system to save the data of the patients and keep patients contact with the tuberculosis national program.

3- Systems similar to this system can be designed for the diagnosis of other diseases that need a great experience to be diagnosed.

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Appendix A

The diagnosis program code

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;

namespace rasha_1
{
    public partial class Form3 : Form
    {
        public Form3()
        {
            InitializeComponent();
        }

        private void button2_Click(object sender, EventArgs e)
        {
            Form2 f = new Form2();
            f.Show();
            this.Close();

        }

        private void button1_Click(object sender, EventArgs e)
        {
            double wieght = 0.0;

            double symptom1 = 0.01;
            double symptom2 = 0.25;
            double symptom3 = 0.1;
            double symptom4 = 0.25;
            double symptom5 = 0.25;
            double symptom6 = 0.01;
            double symptom7 = 0.01;
            double symptom8 = 0.25;
            double symptom9 = 0.01;
            double symptom10 =0.01;
            double symptom11 = 0.01;
            double symptom12 = 0.01;
            double symptom13 = 0.1;

            if (checkBox1.Checked)
                wieght = wieght + symptom1;
            if (checkBox2.Checked)
                wieght = wieght + symptom2;
            if (checkBox3.Checked)
```

```
              wieght = wieght + symptom3;
        if (checkBox4.Checked)
            wieght = wieght + symptom4;
        if (checkBox5.Checked)
            wieght = wieght + symptom5;
        if (checkBox6.Checked)
            wieght = wieght + symptom6;
        if (checkBox7.Checked)
            wieght = wieght + symptom7;
        if (checkBox8.Checked)
            wieght = wieght + symptom8;
        if (checkBox9.Checked)
            wieght = wieght + symptom9;
        if (checkBox10.Checked)
            wieght = wieght + symptom10;
        if (checkBox11.Checked)
            wieght = wieght + symptom11;
        if (checkBox12.Checked)
            wieght = wieght + symptom12;
        if (checkBox13.Checked)
            wieght = wieght + symptom13;

        if (wieght >= 0.75 && wieght <= 1)

            MessageBox.Show("This patient suspected for active TB. do the
sputum test", "Diagnosis", MessageBoxButtons.OK, MessageBoxIcon.Information);


 Else

            if (wieght >= 0.5 && wieght <= 0.75)

                MessageBox.Show(" This patient suspected for latent TB
please do sputum test to be sure", "Diagnosis", MessageBoxButtons.OK,
MessageBoxIcon.Information);

 Else

            if (wieght == 0.25)

                    MessageBox.Show(" This patient may suspect for TB ",
"Diagnosis", MessageBoxButtons.OK, MessageBoxIcon.Information);

 Else

      if (checkBox3.Checked && checkBox5.Checked && checkBox11.Checked)

MessageBox.Show("This patient did not have TB but suspected for Pneumonia
please do the WBC test", "Diagnosis" ,
MessageBoxButtons.OK,MessageBoxIcon.Information);

    Else

            MessageBox.Show("This patient did not suspect for TB");
```

```
    }

    private void button3_Click(object sender, EventArgs e)
    {
        Form5 f = new Form5();
        f.Show();
    }
}
                                                }
```

Appendix B

The main screen code

```csharp
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;

namespace rasha_1
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
        }

        private void Form1_Load(object sender, EventArgs e)
        {

        }



        private void button5_Click(object sender, EventArgs e)
        {

    DialogResult  r;

    r = MessageBox.Show("Do you really want to close?");



        }

        private void button1_Click(object sender, EventArgs e)
        {
            Form5 f5 = new Form5();
            f5.Show();
            button1.CreateControl();
        }

        private void button2_Click(object sender, EventArgs e)
        {
```

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```
        Form2 f2 = new Form2();
        f2.Show();
    }

    private void button3_Click(object sender, EventArgs e)
    {
        Form4 f4 = new Form4();
        f4.Show();
    }

    private void view_Click(object sender, EventArgs e)
    {
        openFD.ShowDialog();


    }

    private void openFD_FileOk(object sender, CancelEventArgs e)
    {

        rich.LoadFile(openFD.FileName);
    }




    }
}
```

Appendix C

Lab instruction code

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;

namespace rasha_1
{
    public partial class Form5 : Form
    {
        public string labResult = "";
        public Form5()
        {
            InitializeComponent();
        }



        private void button4_Click(object sender, EventArgs e)
        {
            openFD1.ShowDialog();
        }

        private void openFD1_FileOk(object sender, CancelEventArgs e)
        {


                richTextBox1.LoadFile(openFD1.FileName);

        }

        private void button5_Click(object sender, EventArgs e)
        {
            labResult = comboBox1.Text;
            Form2 f = new Form2();
            f.Show();
            this.Close();
        }

        private void Form5_Load(object sender, EventArgs e)
        {

        }

        private void button3_Click(object sender, EventArgs e)
        {
            openFD1.ShowDialog();
        }
```

```
        private void button2_Click(object sender, EventArgs e)
        {
            openFD1.ShowDialog();
        }

        private void button1_Click(object sender, EventArgs e)
        {
            openFD1.ShowDialog();
        }


    }
}
```

Appendix D

Patient information code

```csharp
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;

namespace rasha_1
{
    public partial class Form2 : Form
    {
        public Form2()
        {
            InitializeComponent();
        }

        private void button1_Click(object sender, EventArgs e)
        {
            Form1 f = new Form1();
            f.Show();
            this.Close();

        }

        private void button4_Click(object sender, EventArgs e)
        {
            Form3 f3 = new Form3();
            f3.Show();
        }

        private void comboBox1_SelectedIndexChanged(object sender, EventArgs
e)
        {

        }
```

Appendix E

Pharmacy code

```csharp
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;

namespace rasha_1
{
    public partial class Form4 : Form
    {
        public Form4()
        {
            InitializeComponent();
        }

        private void button1_Click(object sender, EventArgs e)
        {
            Close();
        }
    }
}
```