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DEVELOPING AN ADVISORY EXPERT SYSTEM FOR SOIL TRANSMITTED HELMINTHS INFECTIOUS DISEASES USING RULE BASED TECHNIQUE

MATEBIE, HAYMANOT

BAHIR DAR UNIVERSITY

BAHIR DAR INSTITUTE OF TECHNOLOGY

SCHOOL OF RESEARCH AND POSTGRADUATE STUDIES

FACULTY OF COMPUTING

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HAYMANOT MATEBIE YIGZAW

BAHIR DAR, ETHIOPIA

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Haymanot Matebie Yigzaw

A thesis submitted to the school of Research and Graduate Studies of Bahir Dar Institute of Technology, Bahir Dar University in partial fulfillment of the requirements for the degree of Master of Science in Information Technology in the faculty of Computing.

Advisor Name: Gebeyehu Belay (PhD)

Bahir Dar, Ethiopia

August, 2020

DECLARATION

I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have acknowledged and refereed all materials used in this work. I understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/ fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

Name of the student Haymanot Matebie Yigzaw Signature ____________

Date of submission: August, 2020

Place: Bahir Dar, Ethiopia

This thesis has been submitted for examination with my approval as a university advisor.

Advisor Name: Gebeyehu Belay (PhD)

Advisor's Signature: ____________________

Bahir Dar University

Bahir Dar Institute of Technology-

School of Research and Graduate Studies

FACULTY OF COMPUTING

Approval of thesis for defense result

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

Name of Student Haymanot Matebie Signature ______ Date Aug/12/2020

As members of the board of examiners, we examined this thesis entitled "Developing an Advisory Expert System for Soil Transmitted Helminths Infectious Diseases Using Rule Based Technique" by *Haymanot Matebie*. We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Masters of Science in "Information Technology".

Board of Examiners

Name of Advisor	Signature	Date
Gebeyel B (Dr)		15/08/2020
Name of External Examiner	Signature	Date
Dr. Kindie Biredagn		Aug-12-2020
Name of Internal Examiner	Signature	Date
Belete Biazen		14/08/2020
Name of Chairperson	Signature	Date
Esubalew Alemneh (PhD)		14 Aug 2020
Name of Chair Holder	Signature	Date
Derejew C.		14 Aug 2020
Name of Faculty Dean	Signature	Date
Belete Biazen		14/08/2020

Faculty Stamp

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ABSTRACT

Health care is one of the crucial components of basic social services that have a direct linkage to the growth and development of a country as well as to the welfare of the society. Ethiopian government has implemented different health policies such as disease prevention and control for neglected tropical disease, which aims to improve the health status of the community, particularly in the rural areas. To implement the program, the government needs many experts (health center staffs including extension workers). However, there are problems in implementing the automate program to provide information for the community and diagnosis the disease related to soil transmitted helminths infectious disease like they have not full knowledge on the implementation of the program, they are not be available on time to provide information for the community and diagnosis the disease related to soil transmitted helminths infectious disease in the country, they are not enough in number to reach to all rural areas, difficult for them to remember all health related information in mind. These problems collectively affect the health center coverage and performance, including Ethiopian health system.

The objective of this study is to design an advisory expert system for Soil transmitted Helminths infectious diseases using one branch of artificial intelligence called expert system, specifically for Ascaris, whipworm and hookworm to reduce the above problems. This expert system is composed of knowledge base, inference engine and user interface. The user interface was designed using Java NetBeans IDE 8.2 with jdk1.8.0. The data was collected by interview from two nurses, three health extension workers in Bahir Dar health Center and rural areas and from different documents.

The proposed system was evaluated by six health professionals using user acceptance testing by preparing questionnaire and four domain experts using system performance testing by preparing test cases. The developed expert system achieves 85.7% of user acceptance and 84.5% system performance results. The overall performance of the proposed system is 85.1%.

.**Keywords**: Expert systems, soil transmitted helminths infectious diseases, STHs advisory, knowledge base.

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LIST OF ABBREVIATIONS

AI: Artificial Intelligence

CASNET: Causal Associational Networks

CDC: Centers for Disease control and Prevention

CommonKADS: standard for knowledge analysis and knowledge intensive system development

DMS: Data Matching Systems

DSS: Decision Support System

HDEAS: Health Diagnose Expert Advisory System

IDE: Integrated Development Environment

JDK: Java Development Kit

JESS: Java Expert System Shell

KBS: knowledge based system

NTD: Neglected Tropical Diseases

PROLOG: Programming in Logic

QMR: Quick Medical Reference

STHs: Soil Transmitted Helminths

TB: Tuberculosis

TDS: Training Data Sets

UML: Unified Modelling Language

USAID: United States Agency for International Development

UTF-8: Unicode Transformation Format 8-bit

WHO: world health organization

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CHAPTER ONE

INTRODUCTION

1.1. Background

Good health information and diagnosis is the key activity in tackling the health related problems of the society. Millions of Ethiopians, especially those who live in rural areas, are exposed to a variety of preventable diseases, including malaria, tuberculosis (TB), childhood illnesses and neglected tropical disease(NTD). Ethiopia's maternal, infant and under-five mortality rates are still among the highest in the world (federal ministry of health, 2007). According to World Health Organization (WHO), Neglected tropical diseases (NTDs) are a diverse group of communicable diseases that prevail in tropical and subtropical conditions in 149 countries that affect more than one billion people and cost developing economies billions of dollars every year. One of the NTD diseases that affect the Ethiopian community mostly in rural areas is Soil Transmitted Helminths infectious diseases.

Soil-transmitted Helminths infectious diseases refer to the intestinal worms infecting humans that are transmitted through contaminated soil. Soil-transmitted helminths infectious disease is found mainly in areas with warm and moist climates where sanitation and hygiene are poor, including in temperate zones during warmer months. The Ethiopian government implements a program in collaboration with United States Agency for International Development (USAID) named “Centers for Disease Control and Prevention (CDC)” to reduce these health problems. This health program focuses mainly on providing quality promotive, preventive and selected curative health care services in an accessible and equitable manner to reach all segments of the population, with a particular emphasis on establishing an effective and responsive health delivery system for those who live in rural areas.

To implement the program the government trains health extension workers. But health extension workers are not enough to implement the program because they do not stay long in the area of their deployment and they are not available on time (Ethiopian public health institute, 2014). It is also difficult for extension workers to remember all health related information in mind. This problem leads to wrong information dissemination and wrong treatment of disease. To remove this problem, it is good to transfer the knowledge and information of experts (health extension workers) to the required body by using computerized Artificial Intelligence applications called expert systems. Artificial Intelligence is a branch of computer science, which is the ability of machines to simulate human intelligence. This technology can be used in different sectors like in agriculture, education, construction, healthcare, etc. It plays a great role in healthcare systems like diagnosis of diseases, advising healthcare workers and users (Kamble et. al., 2018).

An expert system, a branch of Artificial Intelligence, is a computer program designed to model the problem solving ability of a human expert. It is an intelligent computer program that uses knowledge and inference procedures to solve problems that were difficult enough to acquire significant human expertise for their solutions. To do so, it simulates the human reasoning process by applying specific knowledge and interfaces in a specific area. It performs reasoning over representations of human knowledge (yogesh, yogyata, 2012).

Expert systems typically have three components: knowledge base (the component that contains the knowledge obtained from the domain expert), inference engine (the component that manipulates the knowledge found in the knowledge base as needed to arrive at a result or solution) and user interface (the component that allows the user to query the system and receive the results of those queries) (James R.et al., 1990). This research work titled as “Developing an advisory expert system for soil-transmitted helminths infectious diseases using Rule Based Technique” describes the development of an advisory expert system for soil transmitted helminths infectious diseases as a product using Rule Based Technique. It presents the application of expert systems in the field of health care systems, particularly focuses on providing information about Soil Transmitted Helminths infectious disease and diagnosis the diseases based on the symptoms. This research work helps NTD workers as a supportive tool during their work.

1.2. Statement of the Problem

Health care is one of the crucial components of basic social services that have a direct linkage to the growth and development of a country as well as to the welfare of society. The Ethiopian government has implemented different health policies and strategies to increase the health coverage of the society. One policy is disease prevention and control for neglected tropical disease (NTD), which aims to improve the health status of the community, particularly in the rural areas. To implement the program, the government needs many experts (health center staffs including extension workers) (Federal Ministry of Health, June 2007).

However, there are problems in implementing the program using health center staffs; they have not full knowledge on the implementation of the program, they are not be available on time to provide information for the community and diagnosis the disease related to soil transmitted helminths infectious disease in the country (Ethiopian public health institute, 2014). These problems collectively affect the health center coverage and performance in the country. It is also difficult for NTD workers to remember all health related information in mind. This problem leads to wrong information dissemination and wrong treatment of disease. To solve the above mentioned problems, an advisory expert system for soil transmitted helminths infectious diseases is proposed. The proposed system assists the NTD workers in diagnosis the disease and provides information related to Soil Transmitted Helminths infectious diseases. Supporting NTD workers (health extension workers) activity with the expert system can simplify their work and increase performance. In order to analyze these problems, the following research questions are formulated.

- How model performance is important to identify soil transmitted helminths infectious diseases from user input and providing accurate information for users?
- How expert system supports healthcare workers in the diagnosis and treatment for soil transmitted helminths infectious disease?
- How to design an advisory expert system for soil transmitted helminths infectious disease?

1.3. Objectives of the study

1.3.1. General objective

The general objective of this research work is Developing an advisory expert system for soil transmitted helminths infectious diseases using Rule Based Technique.

1.3.2. Specific Objectives

To achieve the general objective described above, we have listed the following specific objectives.

- Identify the soil transmitted helminths infectious disease with their symptoms.
- Develop a system model to support soil transmitted helminths infectious disease treatment based on soil transmitted helminths infectious disease symptom.
- Introduce the prevention methods of soil transmitted helminths infectious diseases for any individuals.

1.4. Scope and limitation of the study

This research work is intended to develop an advisory expert system for one of the neglected tropical disease called soil transmitted helminths infectious diseases. Soil transmitted helminths infectious diseases contains three basic diseases named; Ascaris, whipworm and hookworm. The research work is implemented using English language. It does not consider other language because it needs much time.

1.5. The Significance of the Study

Getting the right information about the disease and other health related knowledge is very important. The disease diagnosis and information dissemination can be supported by using an advisory expert system. This research work provides many advantages for health center staffs including NTD workers and farmers. NTD workers can use the system to get information and to diagnosis the soil transmitted helminths infectious diseases. Any person also can use the system to get information about soil transmitted helminths infectious diseases. It also acts as a source of data for health care researchers.

1.6. Thesis Organization

This study has five chapters. The first chapter is introduction which describes the background information of the study, the problem statement, objective, and the methodologies the study used. The second chapter is Literature review which discusses about the uses of AI and Expert systems for healthcare and related works. The third chapter describes the methodologies used in the study including knowledge representation methods. The fourth chapter discusses about the experimental activities, tools and the results obtained from the experiment and evaluation of the study. The fifth chapter describes the conclusion and recommendation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Application of Artificial Intelligence for Healthcare systems

One of the rapidly changed technology in the field of information technology is Artificial Intelligence. Artificial Intelligence is a field of computer science that includes the creation of intelligent machines and software that work and reacts like human beings. AI and its Applications gets used in various fields of life and solves the complex problems in various areas as science, engineering, business, medicine, video games and Advertising (Kamble et. al., June 2018).

Today there has been an increased focus on the use of Artificial Intelligence in health domains to resolve complex issues. Many intelligent systems have been developed for the purpose of enhancing health care and provide a better healthcare facility. The adoption of Artificial Intelligence in healthcare is growing while radically changing the face of healthcare delivery. The main purpose of artificial intelligence is to make machines more useful in solving problematic health care challenges and by using machines it is possible to interpret data which is obtained from the diagnosis of different diseases. Artificial Intelligence is being employed in many of settings including hospitals, clinical laboratories, and research facilities. Artificial Intelligence approaches employing machines to sense and interpret data like humans (Sandeep Reddy, August 2018). AI has many applications in healthcare. One application is clinical care. AI has the potential to aid the diagnosis of disease and it has the following uses in clinical care.

Medical imaging: - medical scans have been systematically collected and stored for some time and are readily available to train AI systems (HaincN, et al., 2017). Artificial Intelligence could reduce the cost and time involved in analyzing scans, potentially allowing more scans to be taken to better target treatment. AI has shown promising results in detecting conditions such as pneumonia, breast and skin cancers, and eye diseases (Wang D, et al., 2016).

Echocardiography: - the Ultromics system which uses AI to analyze echocardiography scans that detect patterns of heartbeats and diagnose coronary heart disease (Building the power of echocardiography, 2017).

Screening for neurological conditions: - AI tools are being developed that analyze speech patterns to predict psychotic episodes and identify and monitor symptoms of neurological conditions such as Parkinson's disease (Bedi G, et al. 2015).

Surgery: - the robotic tools controlled by AI have been used in research to carry out specific tasks in keyhole surgery, such as tying knots to close wounds (Kassahun Y, et al. 2016).

The other application area of AI is patient and consumer-facing Applications. Several applications that use artificial intelligence to offer personalized health assessments and home care advice are currently on the market. The app Ada Health Companion uses AI to operate a chat-bot, which combines information about symptoms from the user with other information to offer possible diagnoses (Medical News Bulletin, January 2017). Information tools or chat-bots driven by AI are being used to help with the management of chronic medical conditions. For example, the Arthritis Virtual Assistant developed by IBM for Arthritis is learning through interactions with patients to provide personalized information and advice concerning medicines, diet, and exercise (IBM press release, 13 Mar 2017). Artificial intelligence also has a great application in public health. It has the potential to be used to aid early detection of infectious disease outbreaks and sources of epidemics, such as water contamination (Jacobsmeyer B, 2012). AI has also been used to predict adverse drug reactions.

The other aspect of Artificial Intelligence in medicine is reasoning and knowledge representation. In AI, reasoning involves manipulation of data to produce actions. Unlike traditional programming, the emphasis in AI is on what is to be computed rather than how it is to be computed. Structuring of this computation happens through design-time reasoning, offline computation and online computation. Earlier forms of AI involved algorithms based on the step-by-step reasoning model used to address predicated problems. However, these models were not useful for uncertain situations or when there was incomplete information. AI reasoning models have now evolved to respond to these situations by drawing upon concepts from probability and economic theories. To resolve problems-certain or uncertain, AI systems require widespread knowledge about the relevant environment and then be able to represent this knowledge in a computable form. For this to occur, AI uses a Representation and Reasoning System. An Representation and Reasoning System is comprised of a programming language to communicate with a computer, a method to allocate meaning to the language and after input a process to figure out the answers. Knowledge is represented in different forms.

In the past, stand-alone computers and their limited processing power had restricted the advancement of AI. In recent years, AI reasoning and knowledge representation has immensely benefited from the rapid technological advances in computing power and wireless technology. These advances have helped in the deployment of sophisticated algorithms designed to resolve problems that could not have been addressed by AI applications in the past (Sandeep Reddy, August 2018). Improving Hospital Inpatient care is one of the effective applications of Artificial Intelligence which concentrates primarily on the analysis of a patient's condition given his indications and statistic data (Kamble et. al., 2018). Artificial intelligence has importance for the treatment and diagnosis of infectious diseases. One of the infectious diseases that affect most African country is Soil Transmitted Helminths infectious disease, which can be treated by using Rule Based Technique.

2.2 Soil Transmitted Helminths infectious diseases

The soil-transmitted helminths infectious diseases are a group of intestinal parasites belonging to the phylum Nematoda that are transmitted primarily through contaminated soil. It is the intestinal worms infecting humans that are transmitted through contaminated soil ("helminths" means parasitic worm): Ascaris lumbricoides (sometimes called just "Ascaris"), whipworm (Trichuris trichiura), and hookworm (Anclostoma duodenale and Necator americanus). Soil-transmitted helminths infections are among the most common infections worldwide and affect the poorest and most deprived communities (Fikresilasie Samuel, 2015**)**. A large part of the world's population is infected with one or more of these soil-transmitted helminths infectious diseases. As CDC report in 2018, approximately 121-807 million people are infected with Ascaris, 604-795 million people are infected with whipworm and 576-740 million people are infected with hookworm. Soil-transmitted helminths infection is found mainly in areas with warm and moist climates where sanitation and hygiene are poor, including in temperate zones during warmer months. These STHs are considered Neglected Tropical Diseases (NTDs), because they inflict tremendous disability and suffering yet can be controlled or eliminated. In Ethiopia soil transmitted infectious diseases mostly affects rural areas that do not use health extension packages. Infection occurs when tiny worms that cannot be seen enter a person's body through bare feet, dirty hands or unwashed food (Federal ministry of health, September 2014).

According to CDC, Soil-transmitted helminths live in the intestine and their eggs are passed in the feces of infected persons. If an infected person defecates outside (near bushes, in a garden, or field) or if the feces of an infected person are used as fertilizer, eggs are deposited on soil. Ascaris and hookworm eggs become infective as they mature in soil. People are infected with Ascaris and whipworm when eggs are ingested. This can happen when hands or fingers that have contaminated dirt on them are put in the mouth or by consuming vegetables and fruits that have not been carefully cooked, washed or peeled.

Hookworm eggs are not infective. They hatch in soil, releasing larvae (immature worms) that mature into a form that can penetrate the skin of humans. Hookworm infection is transmitted primarily by walking barefoot on contaminated soil. One kind of hookworm (Anclostoma duodenale) can also be transmitted through the ingestion of larvae. STHs can be diagnosed by health professionals in healthcare. It is also very necessary to support the diagnosis and advising activities of the health professionals with Artificial intelligence particularly using expert systems.

2.2.1. Ascaris (Roundworm)

Ascaris results from infection of the small intestine with a helminths parasite called Ascaris lumbricoides. It is the largest of the intestinal roundworms; mature worms can measure 15–35 centimeter (cm) in length. It mainly affects children, particularly between three to eight years of age. In Ethiopia, around 37% of the population is estimated to be infected with Ascaris lumbricoides. Ascaris has a worldwide distribution and it is particularly common in regions with poor sanitation. Man may acquire Ascaris by the ingestion of eggs in contaminated foods or rarely drinks (federal ministry of health Ethiopia, communicable diseases).

The signs and symptoms of an Ascaris infection are abdominal discomfort, abdominal cramping, abdominal swelling (especially in children), fever, coughing and/or wheezing, nausea, vomiting, passing roundworms and their eggs in the stool.

There are effective anthelmintic treatments available for Ascaris (Tadesse A et al., 2008):

Mebendazole

- Adults and children >10 kilogram(kg) = 100 milligram(mg) po bid (twice a day) for 3 days
- Children < 10 kg = 50 mg po bid for 3 days

Albendazole

- Adult and children >10 kg = 400 mg po single dose or for 3 days in heavy infections
- Children < 10 kg = 200 mg po single dose or for 3 days in heavy infections

Pyrantel pamoate

- 10 mg/kg up to a maximum of 1gm po once

Piperazine

- citrate 75mg/kg po once to a maximum of 3.5 gm. for adults and children over 12 years;
- And a maximum of 2.5 gm. for children between 2 – 12 years.

Levamisole

- 120 – 150 mg po once.

The prevention mechanism for Ascaris are wash hands with soap and water before handling or eating any food and avoid drinking any local water sources when traveling, Use only boiled water or bottled water and avoid raw vegetables and fruits unless you can clean them yourself, Eat only foods that are cooked well and served hot.

2.2.2. Hookworm

The main infectious agents for hookworm are called Necator americanus and Ancylostoma duodenal. Hookworms live in the small intestine and suck blood from blood vessels in the intestinal walls. Hookworm infection is endemic in Ethiopia, especially in areas where people walk barefooted and sanitary conditions allow faeces to contaminate the soil. In Ethiopia the prevalence of hookworm infection is estimated to be around 16% of the population. During the transmission process, immature parasites (larvae) in the soil enter the body by penetrating the skin, usually through bare feet. The larvae then migrate to the small intestine, after passing through different body systems (federal ministry of health Ethiopia, communicable diseases).

The sign and symptom of hookworm is itching rash at the site of skin penetration, diarrhea, abdominal pain, anemia due to blood loss caused by the blood-sucking worms, blood in your stool, loss of appetite, weight loss, fever and fatigue.

The Treatment for hookworm infections aims to get rid of the parasites, improve nutrition, and treat complications from anemia. Use Mebendazole, albendazole or Pyrantel pamoate: similar to Ascaris (Tadesse A et al., 2008).

The prevention method for hookworm includes wearing shoes when you walk outdoors especially in areas that might have feces in the soil, drinking safe water, properly cleaning and cooking food.

2.2.3. Whipworm

Whipworm is an infection of the human intestinal tract, caused by the nematode Trichuris trichuira. The distribution of Whipworm is worldwide, being most abundant in the warm moist regions of the world. The parasite commonly occurs together with *Ascaris* lumbricoides and likewise mainly affects children. In Ethiopia it is found in 90% of 50 communities in the central and northern plateaus with a mean prevalence of 49%.Infection results from the ingestion of eggs in contaminated soil. Transmission may occur through the medium of food or water or directly from the hands of individuals (Tadesse A et al., 2008).

A whipworm infection can cause a variety of symptoms, ranging from mild to severe. They include the following: bloody diarrhea, painful or frequent defecation, abdominal pain, nausea, vomiting, headaches, sudden and unexpected weight loss, fecal incontinence, or the inability to control defecation.

The treatment for Whipworm infection:

Mebendazole

- Adults and children >10 kg = 100 mg po bid for 3days.
- Children < 10 kg = 50 mg po bid for 3 days.

Albendazole

- Adults and children >10 kg = 400 mg po daily for 3 days.
- Children <10 kg = 200 mg po daily for 3 days.

The prevention methods for Whipworm are washing hands thoroughly especially before handling food, Wash, peel, or cook foods thoroughly before eating them, teach children not to eat soil and to wash their hands after playing outdoors, boil or purify drinking water that may be contaminated and avoid contact with soil contaminated with fecal matter.

2.3 Expert systems for health advisory systems

The recent advancement in the field of artificial intelligence has led to the emergence of expert systems. Expert systems are computer programs designed to simulate the cognitive problem-solving behavior of human experts in a specified, well-defined area. These programs contain stores of knowledge, usually in the form of facts and rules, together with procedures for processing this knowledge to infer solutions to problems normally requiring the attention of a human expert (James et. al., 1990).

Now a day's many researches have been done on the development of expert system to cope up with the complex medical decision making processes. Expert systems can support the novice health professionals and users in rural areas. These systems also act as a guide for the doctors to collect the patient information leading to possible diagnosis and suggested treatment for diseases.
Previously many advisory expert systems have been developed in the field of medical sciences. MYCIN is one of the advisory expert system designed to advice about an infectious disease treatment (Harmon, king, 1985). ONCOCIN is also another medical consultation system for the management of cancer therapy (Nancy McCauley, Mohammad Ali, 1992). Another research on advising is Health Diagnose Expert Advisory System (HDEAS) (Prasad et. al., September 2014). It was designed for diagnosing the hyperthyroid disease by enabling a list of symptoms that the person is likely to suffer from. The prototype Knowledge Based System which provides advice for Health Workers and Patients in Amharic Language about Visceral Leishmaniasis was developed (Tesfamariam, 2015). An expert system was developed as a computer aided learning system for

medical students and doctors about family planning using Arity Prolog (Chan et. al., 1995). The system designed using a rule-based representation of knowledge to simulate the learning processes.

2.4 Components of Expert Systems

There are three primary integrated components in an expert system, as it is indicated in figure 2.1. These components are a knowledge base to store information, an inference engine to draw conclusions from the information, and a user interface to gather and disseminate the information (Jemes R., et al., 1990). The following diagram shows the three components of Expert system (Artificial Intelligence - Expert Systems, 2019).

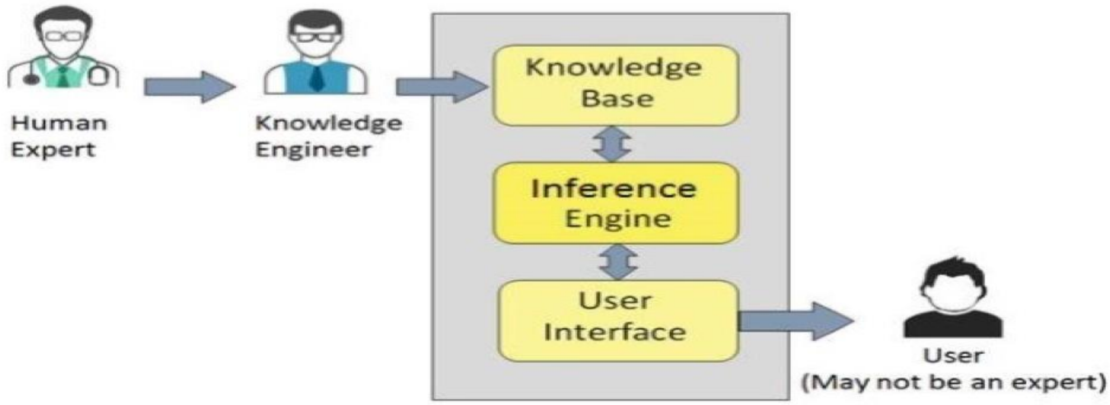

Figure 2.1 Components of expert system [Adopted from "Artificial Intelligence Expert Systems", 2019, by tutorialspoint.com]

The Knowledge Base contains domain-specific and high-quality knowledge. The knowledge base of an Expert System is a store of both, factual and heuristic knowledge. Factual Knowledge is the information widely accepted by the Knowledge Engineers and scholars in the task domain, and Heuristic Knowledge is about practice, accurate judgment, one's ability of evaluation, and guessing. The inference engine implements the search and pattern matching strategy of the expert system. It uses the control structure (rule interpreter) and provides methodology for reasoning. It acts as an interpreter which analyzes and processes the rules. It is used to perform the task of matching antecedents from the responses given by the users and firing rules. The major task of inference engine is to trace its way through a forest of rules to arrive at a conclusion (K P Tripathi, 2011).

The two inference strategies commonly used in expert system inference engines are forward chaining and backward chaining. Backward chaining is the process of reasoning that starts with conclusions and working backward to the supporting facts. Forward chaining starts with the facts and works forward to the conclusions (Abraham, Ajith, 2005).

User Interface is the final element of the expert system. It is the part of the computer program that allows the user to communicate with the system. The user interface asks questions or presents menu driven choices for entering initial information. It provides a means of communicating the answer or solution once it has been found (James R.et al., 1990).

2.5 Expert system Development processes

The process of building an expert system is called knowledge engineering. A knowledge engineer is a person who builds an expert system, performs the task of extracting knowledge from the domain expert. Knowledge acquisition, knowledge representation and evaluation are the main processes in knowledge engineering.

2.5.1 Knowledge Acquisition

Knowledge acquisition is the process of acquiring knowledge from the domain expert, books, documents, sensors or computer files and structuring, organizing that knowledge into suitable form for knowledge representation. So in this phase an expert can enter his/her knowledge into the expert system to refine it later as it is needed. It is the most important and difficult task in the expert system development because of the communication gap between knowledge engineer and domain expert. The reason is domain experts may not be willing to share their knowledge, domain experts may not know how to express their knowledge, sometimes the knowledge engineer may miss the relevant knowledge as they refer only a single source, etc.

There are many knowledge acquisition techniques are available, like interview, questionnaire, document analysis, observation, etc. for our work we used primary and secondary sources of data and we performed interview with health professionals (domain experts), document analysis, literatures reviews, books, etc. the knowledge acquisition process has three common basic stages.

The first stage is Knowledge elicitation. Knowledge elicitation is the interaction between the expert and the knowledge engineer to obtain the expert knowledge in some systematic way. As the result, it is concerned with obtaining information directly from domain experts in a systematic way.

The second stage is intermediate representation. In this stage the knowledge that is obtained is usually stored in some form of human friendly medium. The third stage is changing into executable form. In this stage the intermediate representation of the knowledge is then compiled into an executable form (e.g. production rules) that the inference engine can process (Sasikumar, M. et. al., 2007).

2.5.2. Conceptual Modeling of knowledge

Modeling should be the perquisite activity for implementing expert systems. Models are applied to acquire the important characteristics of problem domains by decomposing them into more controllable parts that are simple to know and to use (Henok, 2019).

Conceptual modeling is a technique that helps to clarify the structure of a knowledge-intensive business task. The knowledge model of an application provides a specification of the data and knowledge structures required for the application. This activity takes the form of a specialized type of requirements engineering. KBS construction methods typically provide tools for knowledge analysis in the form of so-called conceptual models of knowledge or simply knowledge models (Speel, P. H et al, 2001). A knowledge model provides an implementation-independent specification of knowledge in an application domain. Typically, a knowledge model provides formats for writing down both static domain knowledge (rules, classes, relations) as well as reasoning strategies in which this domain knowledge is used to solve a particular problem(Speel, P. H et al, 2001).

There are different tools available to model the conceptual modeling of knowledge base systems. The most commonly used tools are commonKADS and Decision trees. In this research we used commonKADS to model the conceptual modeling of “Developing an advisory expert system for Soil Transmitted Helminths infectious diseases using Rule Based Technique”.

CommonKADS is a collection of structured methods for building expert systems. CommonKADS views the construction of a KBS as a modelling activity, and so these methods require a number of models to be constructed which represent, different views on problem solving behavior, in its organizational and application context (Speel, P. H et al, 2001). CommonKADS recommends the construction of six models (Speel, P. H et al, 2001, Kingston, John, Nigel Shadbolt, and Austin Tate, 1996):

- A model of the organization's function & structure. The key elements of this model are business processes, structural units, business resources and the various relationships between them.
- A model of the tasks (activities) required to perform a particular operation. The key elements in this model are the tasks required for a single business process, and the assignment of tasks to various agents.
- A model of the capabilities required of the agents who perform that operation. The key elements of this model are agents (human or automated) and their capabilities.
- A model of the communication required between agents during the operation. The key elements of this model are transactions.
- A model of the expertise required to perform the operation.
- A model of the design of a KBS to perform all or part of this operation. The key step in a CommonKADS design model is (usually) a functional decomposition of knowledge based process into its component functional units.

From the above models, the key model is the expertise model which is divided into three levels representing different viewpoints on the expert knowledge (John K et al 1996):

- The domain knowledge which represents the declarative knowledge in the knowledge base. The key elements in domain knowledge are concepts, properties of concepts, and relations.
- The inference knowledge which represents the knowledge-based inferences which are performed during problem solving. Inference knowledge is represented using inference functions (inferences which must be made in the course of problem solving) and knowledge roles (domain knowledge which forms the input and output of the inference functions).

- The task knowledge which defines a procedural ordering on the inferences, often using a semi-formal textual representation. The key elements at this level are tasks and their decomposition.

2.5.3. Knowledge Representation

Knowledge Representation is the preparation of a knowledge map and encoding of the knowledge in the knowledge base. The acquired data and knowledge are represented in the knowledge base as rules. The rule is defined by the key word RULE with some description about it in square bracket. This is followed by the rule premises with the key word If. The logical expression consists of an attribute name, relational operators and comparison operators. The rule consequent is represented with key word then.

2.5.4. Knowledge evaluation (validation)

Evaluation is the process of justifying inferences and decisions by evidence. For expert systems, this requires analyzing the decision-making capabilities of a system. There are three methods to validate the knowledge base. The first method is construct validation. In construct validation the system must perform like an expert, and expert decisions must differ from novice decisions. the second method is content validation. In content validation the system's logic mimics the process experts use to make their decisions. The third method is criterion-related validation. In criterion-related evaluation, a system would be evaluated by comparing system decisions to the correct answers. A valid system would produce the same answers as the experts. As the result, criterion-related validation measures the relationship between the decisions developed by the system and decisions developed by human experts. The knowledge was acquired from health professionals and different sources and it is represented using rule based method and finally the system was evaluated by domain experts (Michael C. et. al., 1992).

2.6. **Approaches of Expert Systems (forms of knowledge representation)**

Choosing a suitable method to represent the knowledge concerning the real world is one of the major issues involved in Artificial Intelligence. Knowledge can be represented in different forms. It can be represented using semantic networks, logic, ontology, rules and cases.

2.6.2. Case based

Cases are the basis of any Case Based Reasoning system. It uses past experience of human specialists to represent as case, Provides case based solution. Case-based reasoning is a process that uses similar problems to solve the current problem. It consists of two steps. In the first step, it find those cases in memory that solved problems similar to the current problem, and in the second case, it adapt previous solutions to fit the current problem. The case library forms an extra important component in case-based reasoning.

The inference cycle using Case Based Reasoning consists of Retrieving solutions, Adapting solutions, and Testing solutions. 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 (Klein & Methlie 1995). Knowledge acquisition is easier in case-based reasoning because of the granularity of the knowledge. Knowledge is presented in precedent or resultant cases.

2.6.3. Ontology based

Ontology is the working model of entities and interactions, either generically or in some particular domain of knowledge or practice. Ontology may take a variety of forms, but necessarily it will include a vocabulary of terms, and some specification of their meaning. This includes definitions and an indication of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretations of terms (Robert S. et. al., 2000).

In ontology, concepts are formal representation of nations from the real world. To represent the knowledge of concepts and the relationship between them, logical expressions such as subsumption, equivalence, Disjointness and negation methods can be used (Czarnecki, A. et. al., 2013).

Creating the hierarchy of concepts is one of the most common applications of ontology. It is based on the use of a subsumption which is defined in description logic in the following way: $B \subseteq A$, where concept A subsumes concept B, this means that concept B is contained in concept A. A subsumption has a transitive nature and thus a classic syllogism takes place: $B \subseteq A \wedge C \subseteq B \Rightarrow C \subseteq A$. The equivalence or identicalness of concepts appears when individuals which are instances of these concepts are always identical. This is written as follows: $B \equiv A$.

Disjointness of two concepts means that there can be no individual which would simultaneously belong to both of them. Thus, the intersection of the two disjoint concepts is an empty concept ($\bot$), which can be written as: $A \cap B \subseteq \bot$. In general Ontology based knowledge representation enables knowledge to be used within systems for communication, specification and other processing tasks.

2.6.4. Semantic networks

A semantic network is a form of knowledge representation that focuses on the graphic presentation of objects and relationships within the domain. A semantic network is a collection of objects known as nodes. The various nodes are connected to one another via a series of relations. Both nodes and relations have names or designations. It is possible to develop relatively complex system structures using semantic networks, while continuing to maintain a clear presentation of the system. When knowledge is represented by means of semantic networks, it also becomes possible to translate the information contained in the semantic network into other forms of knowledge representation, such as logic ones. However, this does not mean that translation can take place the other way, from a logic language to a semantic network. (Lars H, et. al., 2008).

The semantic network form of knowledge representation is especially suitable for capturing the taxonomic structure of categories for domain objects and for expressing general statements about the domain of interest. Inheritance and other relations between such categories can be represented in and derived from subsumption hierarchies.

On the other hand, the representation of concrete individuals or even data values, like numbers or strings, does not fit well the idea of semantic networks (Stephan Grimm, Pascal Hitzler, and Andreas Abecker).

2.6.5. Logic

A logic-based representation scheme is one in which knowledge about the world is represented as assertions in logic, usually first-order predicate logic or a variant of it. First order logic allows one to describe the domain of interest as consisting of objects, i.e. things that have individual identity, and to construct logical formulas around these objects formed by predicates, functions, variables and logical connectives. Logic-based languages allow quantified statements and all other well-formed formulas as assertions, the rigor of logic is an advantage in specifying precisely what is known and knowing how the knowledge will be used. A disadvantage has been dealing with the imprecision and uncertainty of plausible reasoning (Bruce G et al., 1982).

Example: Variables: R, S, C (“Rainy”, “Sunny,” “Cloudy”)

KB: $R \lor S \lor C$; (”It is either Rainy or Sunny or Cloudy.”)

$R \rightarrow C \land \neg S$; (“If it is Rainy then it is Cloudy and not sunny.”)

$C \leftrightarrow \neg S$ (”If it is Cloudy then it is not Sunny, and vice versa”)

2.6.6. Rules Based

Rule based systems are most commonly used methods to represent domain knowledge in expert systems. Rules represent a very human friendly knowledge representation. In rule based representation, experts can express their knowledge in the form of rules and the knowledge represented as if ... then ... production rules. Rule-based knowledge representation systems operate on facts, which are often formalized as a special kind of rule with an empty body. They start from a given set of facts and then apply rules in order to derive new facts, thus drawing conclusions ((Stephan Grimm, Pascal Hitzler, and Andreas Abecker).

A classical rule based system has three major components. The first component is a global database that contains facts or assertions about the particular problem being solved, the second component is a rulebase that contains the general knowle1dge about the problem domain, and the third component is a rule interpreter that carries out the problem solving process. The facts in the global database can be represented in any convenient formalism, such as arrays, strings of symbols, or list structures (Bruce G et al., 1982). The rules have the form: IF <condition> THEN <action>

The left-hand-side or condition part of a rule can be any pattern that can be matched against the database. It is usually allowed to contain variables that might be bound in different ways, depending upon how the match is made. Once a match is made, the right-hand-side or action part of the rule can be executed. In general, the action can be any arbitrary procedure employing the bound variables. In particular, it can result in addition of new facts to the database, or modification of old facts in the database.

The rule interpreter has the task of deciding which rules to apply. It decides how the condition of a selected rule should be matched to the database, and monitors the problem-solving process. When it is used in an interactive program, it can turn to the user and ask for information (facts) that might permit the application of a rule. The strategy used by the rule interpreter is called the control strategy. The rule interpreter for a classical rule based system executes rules in a “recognize-act” cycle. Here the rule interpreter cycles through the condition parts of the rules, looking for one that matches the current data base, and executing the associated actions for (some or all) rules that do match (Bruce G. Buchanan, Rechard O. Duda, 1982). In a rule-based STHs advisory expert system, information is represented in the form of deductive rules within the knowledge base.

For our research work we have selected rule based knowledge approaches because of the following reasons. Rule based systems are most commonly used methods to represent domain knowledge in expert systems. Rules represent a very human friendly knowledge representation. In rule based method there is the separation of knowledge base from inference engine. the representation has uniform structure.

2.7. **Architecture of Rule based Expert systems**

As it is indicated in figure 2.2, a rule based expert system has the following basic components. The first component is the Working memory. It is a small allocation of memory into which only appropriate rules are copied. The second component is Rule base. The Rule base is the rules themselves, possibly stored specially to facilitate efficient access to the antecedent. The third component is the Interpreter. The interpreter is the processing engine which carries out reasoning on the rules and derives an answer. An expert system will likely also have an Explanation Facility that keeps track of the chain of reasoning leading to the current answer. This can be queried for an explanation of how the answer was deduced. The following diagram (figure 2.3) represents the structure of rule based expert systems (Robert Duvall, 2014).

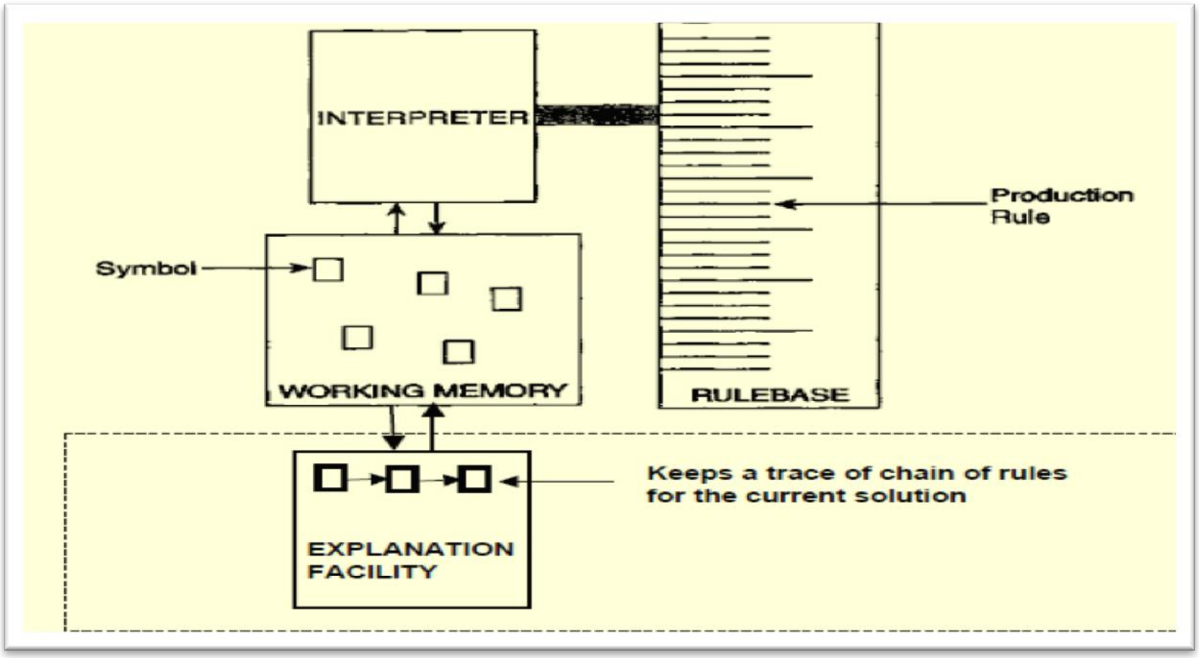

Figure 2.2 Architecture of Rule Based Expert systems [Adopted from "Knowledge representation, Rule-Based Systems", by Robert Duvall, 2014].

2.8. **Related works**

Distance and medical expert availability to get medical advice are two great problems for societies living in rural areas. Hence medical expert systems can play a significant role in solving such problems where medical experts are not readily available and it can be used as a supportive tool for medical workers. Expert systems are extensively used as a diagnostic and advisory tool in the medical industry. There are many researches that have been done on medical expert systems.

MYCIN (Harmon, king, 1985) was the first well known rule based medical expert system. It was designed to identify infectious blood diseases based on the patients' medical data provided and to suggest a prescription or recommend treatment. It uses backward chaining inference procedure. The knowledge base consisted of approximately 450 rules derived from human knowledge through extensive interviews. The EMYCIN (Essential MYCIN) expert system shell, employing MYCIN's control structures was developed at Stanford in 1980. This domain-independent framework was used to build diagnostic rule-based expert systems such as PUFF, a system designed to interpret pulmonary function tests for patients with lung disease.

INTERNIST I is one of the clinical decision support expert systems, designed to support diagnosis. It was a rule-based expert system designed for the diagnosis of complex diagnosis of complex problems in general internal medicine. It uses patient observations to deduce a list of compatible disease states (based on a tree-structured database that links diseases with symptoms). By the early 1980s, it was recognized that the most valuable product of the system was its medical knowledge base. This was used as a basis for successor systems including Quick Medical Reference (QMR), a commercialized diagnostic DSS for internists (Miller A et al., 1982)

The other research on medical expert system was CASNET/Glaucoma. CASNET (Causal Associational NETworks) was a general tool for building expert system for the diagnosis and treatment of diseases. The most significant Expert System application based on CASNET was CASNET/Glaucoma for the diagnosis and treatment of glaucoma. Expert clinical knowledge was represented in a causal-associational network (CASNET) model for describing disease processes. CASNET/Glaucoma was developed and implemented in FORTRAN (Kulikowski, C. A. and Weiss, S. M., 1982).

ONCOCIN is a rule-based medical expert system for oncology protocol management developed at Stanford University. ONCOCIN was designed to assist physicians with the treatment of cancer patients receiving chemotherapy. ONCOCIN was one of the first DSS which attempted to model decisions and sequencing actions over time, using a customized flowchart language. It extended the skeletal-planning technique to an application area where the history of past events and the duration of actions are important (Nancy McCauley, 1992).

The researcher (kulani, 2012) proposed the design of a knowledge based expert system that aims to provide the patients with medical advice and basic knowledge of diabetes. They used JESS (Java Expert System Shell) tool for designing the knowledge-based expert system. This system uses the forward chaining inference mechanism.

Another research on advising is Health Diagnose Expert Advisory System (HDEAS) (Prasad, Srinivasa, Veera, and Chaitanya, September 2014). It was designed for diagnosing the hyperthyroid disease by enabling a list of symptoms that the person is likely to suffer from. Here the diagnosis is done by the method of prediction using Trained Data Sets (TDS) and the results are compared by using suitable Data Matching Systems (DMS). This system predicts the actual level of hyperthyroid in human body.

The prototype Knowledge Based System which provides advice for Health Workers and Patients in Amharic Language about Visceral Leishmaniasis was developed using SWI-Prolog 6.4.0 with UTF-8. The proposed Knowledge Based System has Knowledge Base, Inference Engine, Explanation Facility, Knowledge Base Editor and User Interface. Then 20 test cases were prepared to evaluate the performance of the proposed system (Tesfamariam, 2015).

An expert system was developed as a computer aided learning system for medical students and doctors about family planning using Arity Prolog (Chan, H.K.Ma, IET. Chan, H.Y. CHEN and Chen, 1995). The system designed using a rule-based representation of knowledge to simulate the learning processes. The system uses indexing techniques based on B-trees and hash tables to handle the knowledge database of the system.

The expert system which was proposed in (Apurba, AmnKumar, and Anupam, 1994) explains that an environment with multiple expert modules is essential for proper handling of diagnosis and monitoring of chronic endemic diseases. The proposed system works based on fuzzy production rules where the rules have been partitioned using suitable clustering criteria.

The expert system designed for prescribing drugs for patients was developed using the Rete Algorithm (Noor, Mahmood, 2016). The system diagnosis the heart diseases based on the symptoms and the medical history of the patient. Different expert systems have been done in the health care sectors. It is necessary to support health care activities using expert systems, where human experts are not available there. Especially in our country, particularly in rural areas, there are problems in preventing disease. This research work assists health extension workers to get information and diagnosis soil transmitted helminths infectious disease.

CHAPTER THREE

METHODOLOGY

This chapter describes the methodologies like knowledge acquiring methods from domain experts and secondary sources on soil transmitted helminths infectious diseases and diagnosis techniques as well as modeling acquired knowledge which was used for knowledge representation.

3.1. Research Design

In this research work, we use Qualitative research design, specifically descriptive design. The information and the symptom of the diseases are described properly by collected data or facts from medical staffs and health extension workers.

3.2. Data collection

The data was collected from different primary and secondary data sources to conduct this research work. To get relevant knowledge on the area to design advisory expert system for soil transmitted helminths infectious diseases, interview was conducted with health center staffs; health extension workers and the document were analyzed. We also used secondary data sources like books, internet resources, manuals, etc.

3.3. Implementation tools

To implement the proposed system, the researcher used SWI-Prolog 8.1.11 to represent rules in the knowledge base and construct the prototype of STHs Advisory Expert System. The researcher used Java NetBeans 8.2 with JDK 1.8.0 to develop the Graphical user interface.

3.4. Evaluation methods

The system was evaluated by test cases and users' acceptance testing questionnaires to make sure weather the intended system users' would like to use the proposed system frequently or not and weather the proposed systems meets' user requirements or not.

3.5. Knowledge acquisition

One of the primary tasks of a knowledge engineer in the development of expert system is capturing the expert's knowledge for representation in the knowledge base. For this thesis Knowledge capturing process is performed in two different ways, namely by interviewing individual experts and by reviewing and analysis of related documents.

3.5.1. Knowledge acquired from Documents Analysis and Interview

The researcher uses different documents which are Guideline and references for Diagnosis, Treatment and Prevention of soil-transmitted helminths (STHs) infectious diseases. The major documents are: Intestinal Parasitosis for the Ethiopian Health Center Team, Neglected Tropical Diseases (NTD) in Ethiopia: Handbook for Health Extension Workers, Eliminating soil-transmitted helminths as a public health problem in children by WHO, Communicable Diseases Part 4 Other Diseases of Public Health Importance and Surveillance by Federal Democratic Republic of Ethiopia Ministry of Health, Status of Soil-Transmitted Helminths Infection in Ethiopia by Fikresilasie Samuel.

The researcher also conducts domain expert interview with health center staffs. We have selected a total of five domain experts for interview using a simple random sampling technique. Simple random sampling technique is easy to implement and analyze. Among domain experts those two of them are nurses and three of them are health extension workers that work in Bahir Dar health Center and rural areas. We selected this area because Bahir Dar health Center has good information system which provides details of diseases symptoms and treatment guideline for health center workers. In addition to this, the STHs diseases have common diagnosis and treatment ordering guideline in every area. Accordingly the researcher presents the knowledge that is acquired from document analysis and interview by using rules.

3.6. Knowledge Modeling and Representation

Knowledge Modeling and Representation are the basic task for developing knowledge base systems. Knowledge modeling is widely recognized as the critical phase of knowledge engineering. Before KBS can be built, knowledge must somehow be identified and collected and a model of domain knowledge must be constructed. Knowledge representation is a process of transferring the knowledge from a human expert to a knowledge base of an expert system.

3.6.1. Conceptual Modeling of Domain Knowledge

Modeling domain knowledge implies capturing the static structure of information and knowledge types. Just like in regular data modelling, a schema is constructed containing the major types and relations occurring in the application domain. The notation used to model the conceptual modeling of Domain knowledge is similar to a UML class model (Speel, P. H et al, 2001). Figure 3.1 below describes the conceptual modelling of Domain knowledge for STH advisory expert system.

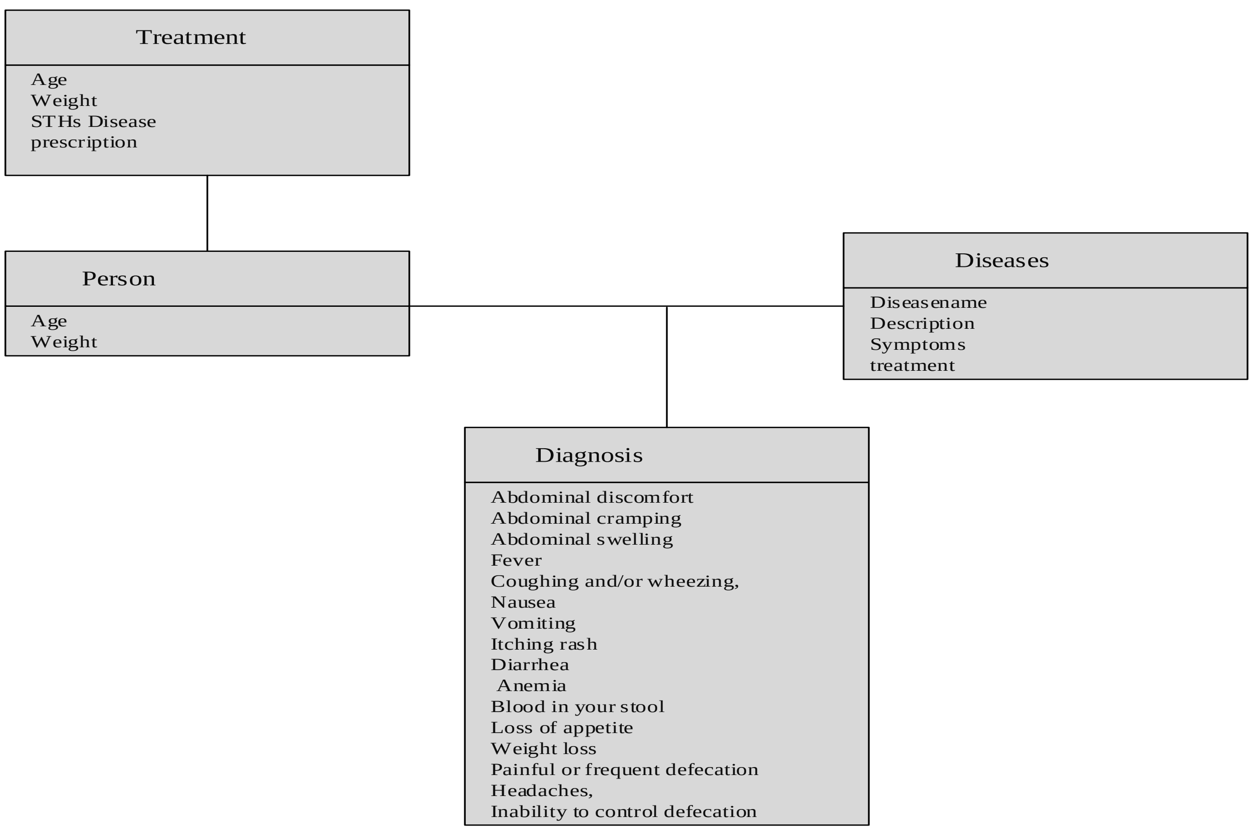

Figure 3.1 Conceptual modeling of Domain knowledge for the proposed system

The conceptual modelling of the proposed system which is described in figure 3.1 can be decomposed into three main modules called diagnosis rule based, treatment rule based and prevention rule based as shown below in figure 3.2.

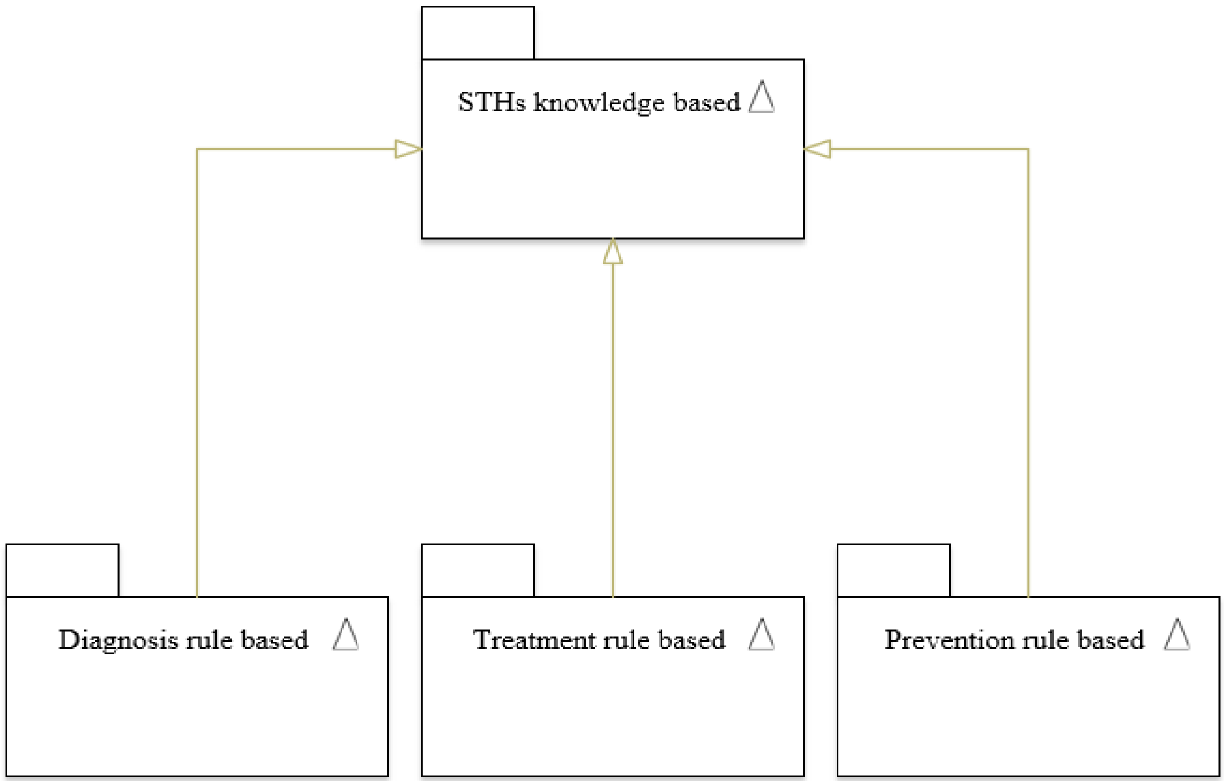

Figure 3.2 Decomposition of rule based of the proposed system

3.6.2. Conceptual Modeling of Task/Inference Knowledge

Task/inference knowledge describes the objectives of an application together with a method how to achieve these objectives. Tasks can be decomposed into subtasks or into basic inferences. Upon decomposition, the control over the subtasks should be specified: which tasks to perform first, tasks to iterate, etc. A task is composed of a number of combined inferences yielding an inference diagram. An inference specifies a basic step in a reasoning process in terms of inputs, outputs and the knowledge needed for the step (Speel, P. H et al, 2001). There are two knowledge inferences in the proposed system. These are the diagnosis inference knowledge as shown in figure 3.3 and the treatment inference knowledge as shown in figure 3.4.

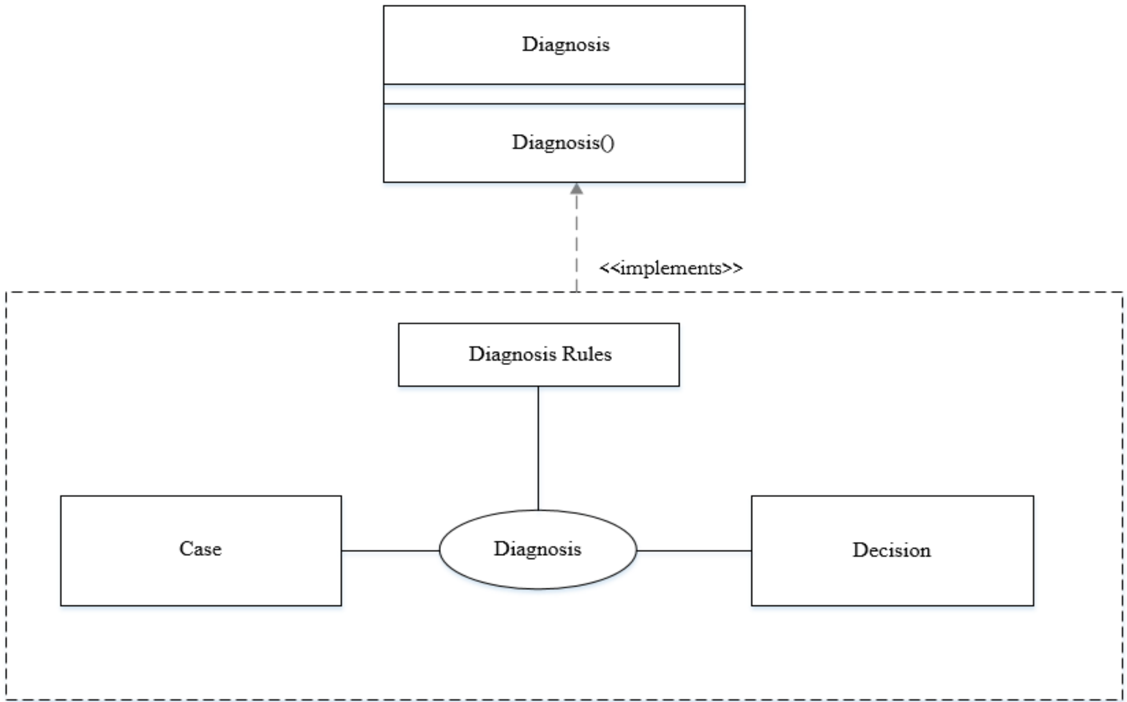

Figure 3.3 conceptual modeling of inference knowledge for diagnosis

The goal of diagnosis task is to evaluate a particular case against diagnosis rules that exist in the knowledge base to take a decision. In the diagnosis a decision needs to made weather a person is infected with STHs disease or not. The input knowledge role consists of data about the person case and the static knowledge roles consist of rules which are used to evaluate the new case in order to take a decision based on the input data. The output knowledge role consists of the yes or no decisions.

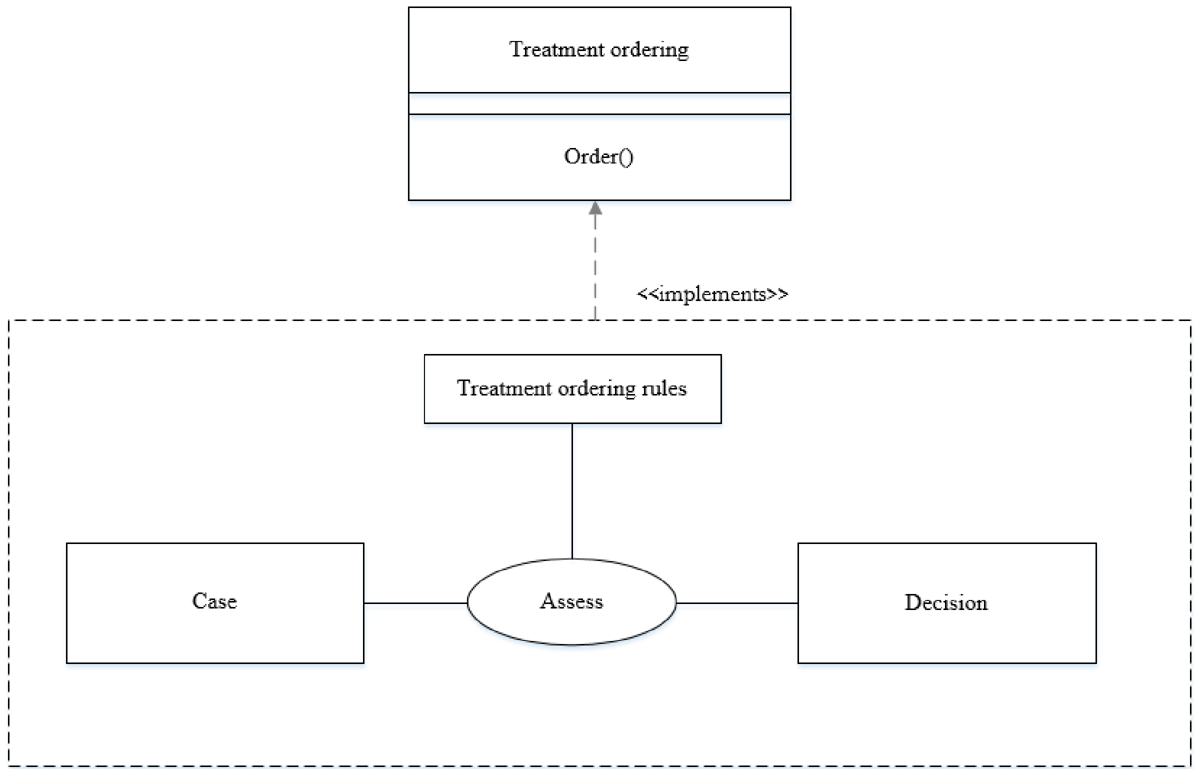

Figure 3.4 conceptual modeling of inference Knowledge for treatment ordering

The goal of treatment ordering task is to evaluate a particular case against treatment ordering rules that exist in the knowledge base to take decision. In treatment ordering a decision needs to be made on which treatment the infected person should take. The input knowledge role consists of data about the person case (type of disease). The static knowledge roles consist of rules which are used to evaluate the new case in order to take a decision based on the person data. The output knowledge role consists of the decision about the type of the treatment the person should take.

3.7. Rules Representation

For the representation of knowledge into knowledge base, the knowledge acquired by knowledge acquisition process must be represented in a structured form. There are different knowledge representation methodologies used in knowledge base system development, But the predominant means of representing domain specific knowledge in knowledge base system is by production rules.

In this research work the researcher uses production rule (IF…..THEN) method to represent the knowledge because the knowledge that are acquired from domain expert interview and document analysis can be easily converted to rules. The IF portion of the rule is called the antecedent and the THEN portion is called the consequent of the rule. The reasoning mechanism of Knowledge base system (inference engine) uses these IF…THEN rules to reach at a conclusion. Expert knowledge is often represented in the form of rules or as data within the computer. Depending upon the problem requirement, these rules and data can be recalled to solve problems. Rule-based expert systems have played an important role in modern intelligent systems and their applications in strategic goal setting, planning, design, scheduling, fault monitoring, diagnosis and so on (Abraham, Ajith, 2005).

A rule is a conditional statement that links given conditions to actions or outcomes. A rule based reasoning system has an inference engine that uses rules to reach conclusions based on premises and a certain context state. This system performs rule based reasoning by firing the elements of a set of rules in order to solve a specific problem. This system is comprised of three main parts: inference engine, rule base, and working memory. Accordingly the researcher represents the knowledge that is acquired from domain expert interview and document analysis using rules as follows.

Rule 1:

IF the patient has

Abdominal discomfort AND

Abdominal cramping AND

Abdominal swelling AND

Fever AND

Coughing and/or wheezing AND

Nausea AND

Vomiting AND

Passing roundworms and their eggs in the stool

THEN

The patient is Roundworm infected

Rule 2:

IF the patient has

Itching rash at the site of skin penetration AND

Diarrhea AND

Abdominal pain AND

Anemia due to blood loss caused by the blood-sucking worms AND

Blood in your stool AND

Loss of appetite AND

Weight loss AND

Fever and fatigue

THEN

The patient is hookworm infected

Rule 3:

IF the patient has

Bloody diarrhea AND

Painful or frequent defecation AND

Abdominal pain AND

Nausea AND

Vomiting AND

Headaches AND

Sudden and unexpected weight loss AND

Fecal incontinence or the inability to control defecation

THEN

The patient is whipworm infected

Rule 4:

IF the patient's

Diagnosis= Roundworm AND Age=Adults (>14) OR Children (5-14) AND Weight>10kg

THEN

100 mg Mebendazole for 3 days OR

400 mg Albendazole single dose or for 3 days in heavy infections OR

10 mg/kg Pyrantel pamoate up to a maximum of 1gm once OR

120 – 150 mg Levamisole once

Rule 5:

IF the patient's

Diagnosis= Roundworm AND Age=Children (1-4) AND Weight<10kg

THEN

50 mg Mebendazole for 3 days OR

200 mg Albendazole single dose or for 3 days in heavy infections OR

10 mg/kg Pyrantel pamoate up to a maximum of 1gm once OR

120 – 150 mg Levamisole once

Rule 6:

IF the patient's

Diagnosis= Roundworm AND Age= (0-1)

THEN

Mebendazole 2.5 teaspoons (250mg oral suspension)

Rule 7:

IF the patient's

Diagnosis= Roundworm AND Age= (2-12)

THEN

Citrate Piperazine 75mg/kg once to a maximum of 2.5 gm

Rule 8:

IF the patient's

Diagnosis= Hookworm AND Age=Adults (>14) OR Children (5-14) AND Weight>10kg

THEN

100 mg Mebendazole for 3 days OR

400 mg Albendazole mg single dose or for 3 days in heavy infections OR

10 mg/kg Pyrantel pamoate up to a maximum of 1gm once

Rule 9:

IF the patient's

Diagnosis= Hookworm AND Age=Children (1-4) AND Weight<10kg

THEN

50 mg Mebendazole for 3 days OR

200 mg Albendazole single dose or for 3 days in heavy infections OR

10 mg/kg Pyrantel pamoate up to a maximum of 1gm once

Rule 10:

IF the patient's

Diagnosis= Whipworm AND Age=Adults (>14) OR Children (5-14) AND Weight>10kg

THEN

100 mg Mebendazole OR 400 mg Albendazole for 3 days

Rule 11:

IF the patient's

Diagnosis= Whipworm AND Age= Children (1-4) AND Weight<10kg

THEN

50 mg Mebendazole OR 200 mg Albendazole for 3 days

CHAPTER FOUR

EXPERIMENT AND RESULT DISCUSSION

4.1 Architecture of the System

System architecture is the blueprint of the system that defines the structure and guidelines of the system. It also describes the interaction of expert system components. Figure 4.1 shows the architecture of the proposed system [adopted from "Integrating Data Mining Results with the Knowledge Based System for Diagnosis and Treatment of Visceral Leishmaniasis", by TESFAMARIAM, 2015].

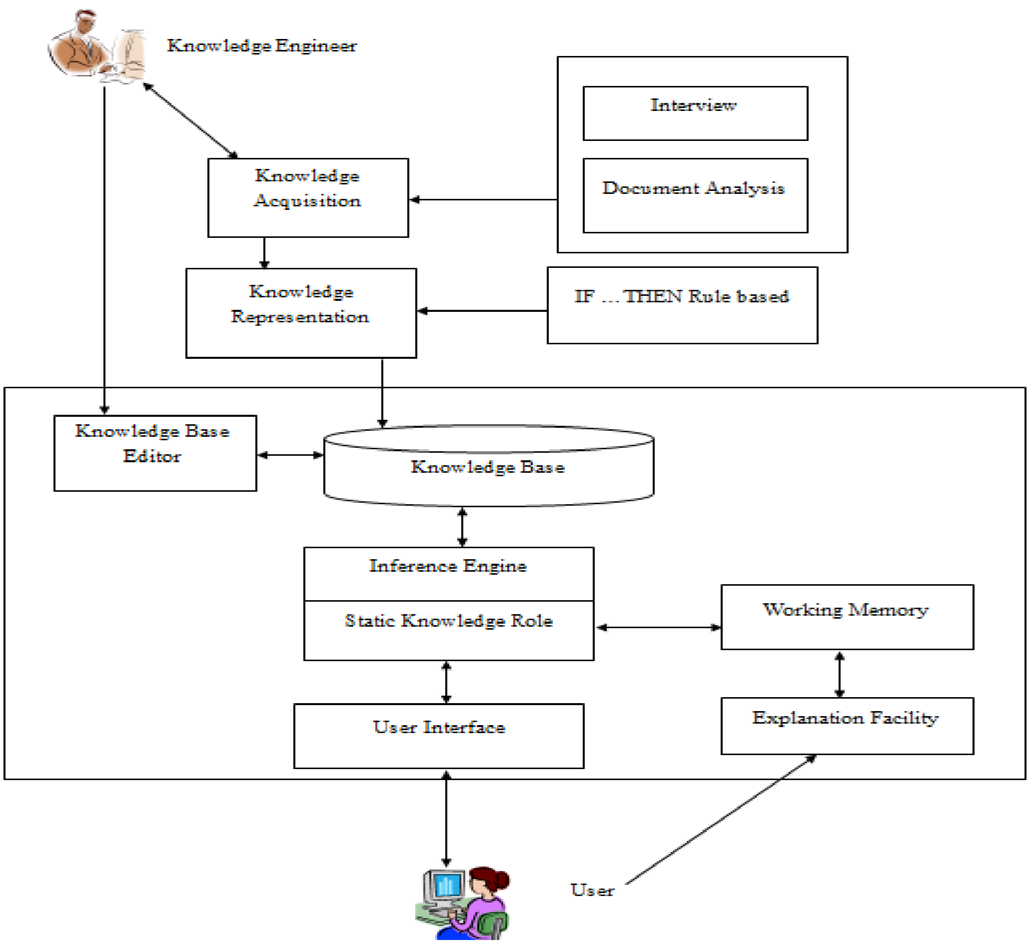

Figure 4.1 Architecture of STHs advisory expert system

The architecture of the proposed system has the following basic components.

4.1.1. Knowledge Base

The knowledge base incorporates the relevant knowledge that was acquired from the domain experts and document analysis. The researcher stores all knowledge that is collected from domain experts and document analysis in the knowledge base as a set of rules by using rule based knowledge representation method. The knowledge base prototype contains the collected knowledge which is used to identify the type of disease based on symptoms and recommends a treatment. The knowledge base is constructed by using SWI-Prolog programming language tool in the form of if…then rules. The reason is that prolog is open source software and it is the preferred programming language tool for knowledge base development. Prolog contains a number of features that are not found on other programming language tools (Dennis, 1989). These features include a powerful built-in pattern matching mechanism, a powerful search and backtracking inference mechanisms. This research collects knowledge about symptoms, the diagnosis as well as the treatment mechanisms of soil transmitted helminths infectious diseases and represents as follows.

Diagnosis Knowledge base:

```
disease(Patient,roundworm):-
symptom(Patient, abdominal_discomfort),abdominal_discomfort=='yes',nl,
symptom(Patient, abdominal_cramping),abdominal_cramping=='yes',nl,
symptom(Patient, abdominal_swelling),abdominal_swelling=='yes',nl,
symptom(Patient, fever),fever=='yes',nl,
symptom(Patient, coughing),coughing=='yes',nl,
symptom(Patient, nausea),nausea=='yes',nl,
symptom(Patient, vomiting),vomiting=='yes',nl,
symptom(Patient,passing_roundworms_and_eggs_in_the_stool),passing_roundworms_and_eggs_
in_the_stool=='yes',nl,
Write ('------------------------------------------------------------------------------------------'),nl,
Write ('you are infected with roundworms (Ascaris)'),
```

```
treatmentfor(patient,roundworm).

disease(Patient,hookworm):-
symptom(Patient,itching_rash_at_the_site_of_skin_penetration),itching_rash_at_the_site_of_skin
_penetration=='yes',nl,
symptom(Patient, diarrhea),diarrhea=='yes',nl,
symptom(Patient, abdominal_pain),abdominal_pain=='yes',nl,
symptom(Patient, anemia),anemia=='yes',nl,
symptom(Patient, blood_in_the_stool),blood_in_the_stool=='yes',nl,
symptom(Patient, loss_of_appetite),loss_of_appetite=='yes',nl,
symptom(Patient, weight_loss),weight_loss=='yes',nl,
symptom(Patient, fever),fever=='yes',nl,
symptom(Patient, fatigue),fatigue=='yes',nl,
Write ('-----------------------------------------------------------------------------------------'),nl,
Write ('you are infected with Hookworm'),
treatmentfor(patient,hookworm).

disease(Patient,whipworm):-
symptom(Patient, bloody_diarrhea),bloody_diarrhea=='yes',nl,
symptom(Patient, painful_or_frequent_defecation),painful_or_frequent_defecation=='yes',nl,
symptom(Patient, abdominal_pain),abdominal_pain=='yes',nl,
symptom(Patient, nausea),nausea=='yes',nl,
symptom(Patient, vomiting),vomiting=='yes',nl,
symptom(Patient, headache),headache=='yes',nl,
symptom(Patient,sudden_and_unexpected_weignt_loss),sudden_and_unexpected_weignt_loss=='
yes',nl,
Write ('-----------------------------------------------------------------------------------------------'),nl,
Write ('you are infected with whipworm'),
treatmentfor(patient,whipworm).
```

Treatment knowledge base:

```
treatmentfor(patient,roundworm):-
Write ('\n--------------------------------------------------------------------------------------------'),nl,nl,
Write (' What is the age of the patient? (greaterthan14/1to4/5to14/0to1) :'),
read(AGE),nl,assert(age(patient,AGE)),nl,
write(' What is the weight of the patient ? (above10kg/below10kg) :'),
read(WEIGHT),nl,assert(weight(patient,WEIGHT)),nl,
write('\n--------------------------------------------------------------------------------------------'),
roundwormtreatment(patient,AGE,WEIGHT).
treatmentfor(patient,hookworm):-
Write ('\n---------------------------------------------------------------------------------------'),nl,nl,
Write (' what is the age of the patient? (greaterthan14/1to4/5to14/0to1) :'),
read(AGE),nl,assert(age(patient,AGE)),nl,
write(' What is the weight of the patient ? (above10kg/below10kg) :'),
read(WEIGHT),nl,assert(weight(patient,WEIGHT)),nl,
write('\n-----------------------------------------------------------------------------------------------'),
hookwormtreatment(patient,AGE,WEIGHT).
treatmentfor(patient,whipworm):-
write('\n------------------------------------------------------------------------------------------'),nl,nl,
write(' What is the age of the patient? (greaterthan14/1to4/5to14/0to1) :'),
read(AGE),nl,assert(age(patient,AGE)),nl,
write(' What is the weight of the patient ? (above10kg/below10kg) :'),
read(WEIGHT),nl,assert(weight(patient,WEIGHT)),nl,
write('\n------------------------------------------------------------------------------------------------'),
whipwormtreatment(patient,AGE,WEIGHT).

roundwormtreatment(patient,AGE,WEIGHT):-
age(patient,AGE),AGE=='greaterthan14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,
nl,
write(' Please take one of the following medicines:'),nl,nl,
```

```
write('100 mg Mebendazole for 3 days OR'),nl,
write('400 mg Albendazole single dose or for 3 days in heavy infections OR'),nl,
write('10 mg/kg Pyrantel pamoate up to a maximum of 1gm once OR'),nl,
write('120 to 150 mg Levamisole once \n');
age(patient,AGE),AGE=='5to14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,nl,
write(' Please take one of the following medicines:'),nl,nl,
write('100 mg Mebendazole for 3 days OR'),nl,
write('400 mg Albendazole single dose or for 3 days in heavy infections OR'),nl,
write('10 mg/kg Pyrantel pamoate up to a maximum of 1gm once OR'),nl,
write('120 to 150 mg Levamisole once \n');
age(patient,AGE),AGE=='1to4',weight(patient,WEIGHT),WEIGHT=='below10kg',nl,nl,nl,
write(' Please take one of the following medicines:'),nl,nl,
write('50 mg Mebendazole for 3 days OR'),nl,
write('200 mg Albendazole single dose or for 3 days in heavy infections OR'),nl,
write('10 mg/kg Pyrantel pamoate up to a maximum of 1gm once OR'),nl,
write('120 to 150 mg Levamisole once \n'),
age(patient, AGE),AGE=='0to1',nl,nl,
write(' Please take the following medicine:'),nl,nl,
write('250mg Mebendazole oral suspension (2.5 teaspoons)'),nl.

hookwormtreatment(patient,AGE,WEIGHT):-
age(patient,AGE),AGE=='greaterthan14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,
nl,
write(' Please take one of the following medicines:'),nl,nl,
write('100 mg Mebendazole for 3 days OR'),nl,
write('400 mg Albendazole mg single dose or for 3 days in heavy infections OR'),nl,
write('10 mg/kg Pyrantel pamoate up to a maximum of 1gm once \n');
age(patient,AGE),AGE=='5to14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,nl,
write(' Please take one of the following medicines:'),nl,nl,
write('100 mg Mebendazole for 3 days OR'),nl,
```

```
write('400 mg Albendazole mg single dose or for 3 days in heavy infections OR'),nl,
write('10 mg/kg Pyrantel pamoate up to a maximum of 1gm once \n');
age(patient,AGE),AGE=='1to4',weight(patient,WEIGHT),WEIGHT=='below10kg',nl,nl,nl,
write(' Please take one of the following medicines:'),nl,nl,
write('50 mg Mebendazole for 3 days OR'),nl,
write('200 mg Albendazole single dose or for 3 days in heavy infections OR'),nl,
write('10 mg/kg Pyrantel pamoate up to a maximum of 1gm once \n').

whipwormtreatment(patient,AGE,WEIGHT):-
age(patient,AGE),AGE=='greaterthan14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,
nl,
write(' Please take the following medicine:'),nl,nl,
write('100 mg Mebendazole OR 400 mg Albendazole for 3 days \n');
age(patient,AGE),AGE=='5to14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,nl,
write(' Please take the following medicine:'),nl,nl,
write('100 mg Mebendazole OR 400 mg Albendazole for 3 days \n');
age(patient,AGE),AGE=='1to4',weight(patient,WEIGHT),WEIGHT=='below10kg',nl,nl,nl,
write(' Please take the following medicine:'),nl,nl,
write('50 mg Mebendazole OR 200 mg Albendazole for 3 days \n').
```

4.1.2. Inference engine

The inference engine implements the search and pattern matching strategy of the expert system. It is the brain of the expert system which leads the system how it can drive a conclusion by looking for possible solutions from the knowledge base and recommend the solution. In expert system two common inference strategies are used, forward chaining inference mechanism and backward chaining inference mechanism. The objective of the proposed expert system is to develop an advisory expert system for Soil Transmitted Helminths infectious diseases and the prolog's built-in inference mechanism is backward chaining (goal driven reasoning), the researcher prefers to use backward chaining inference mechanism which tries to prove or disprove the goal and it is suitable for diagnosis systems.

For example if the user of the proposed system wants to know the treatment order for the identified STHs infectious disease, he/she must answer the questions asked by the system. This helps for the system to order appropriate drugs for the patient based on treatment ordering rules. The following prolog code shows how the system reaches on conclusion to decide and order which type of drug the whipworm infected person should take by referring available rules in the treatment ordering knowledge base.

```
treatmentfor(patient,whipworm):-
write('\n------------------------------------------------------------------------------------'),nl,nl,
write(' What is the age of the patient? (greaterthan14/1to4/5to14/0to1) :'),
read(AGE),nl,assert(age(patient,AGE)),nl,
write(' What is the weight of the patient ? (above10kg/below10kg) :'),
read(WEIGHT),nl,assert(weight(patient,WEIGHT)),nl,
write('\n---------------------------------------------------------------------------------------------'),
whipwormtreatment(patient,AGE,WEIGHT).
```

From the above prolog code the system asks the user about the age and the weight of the infected person and calls the treatment knowledge base which is found below and orders the appropriate drug for the patient.

```
whipwormtreatment(patient,AGE,WEIGHT):-
age(patient,AGE),AGE=='greaterthan14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,
nl,
write(' Please take the following medicine:'),nl,nl,
write('100 mg Mebendazole OR 400 mg Albendazole for 3 days \n');
age(patient,AGE),AGE=='5to14',weight(patient,WEIGHT),WEIGHT=='above10kg',nl,nl,nl,
write(' Please take the following medicine:'),nl,nl,
write('100 mg Mebendazole OR 400 mg Albendazole for 3 days \n');
age(patient,AGE),AGE=='1to4',weight(patient,WEIGHT),WEIGHT=='below10kg',nl,nl,nl,
write(' Please take the following medicine:'),nl,nl,
write('50 mg Mebendazole OR 200 mg Albendazole for 3 days \n').
```

4.1.3. User Interface

User Interface is the final element of the expert system that allows the user to communicate with the system. The researcher has tried to make the user interface simple and easier to use. Since the graphical user interface of SWI-Prolog is not user friendly for non-computer professionals, we preferred to develop the graphical user interface for the proposed system using Java NetBeans IDE 8.2 with jdk1.8.0. When we open the system we get the home window as shown below in Figure 4.4.

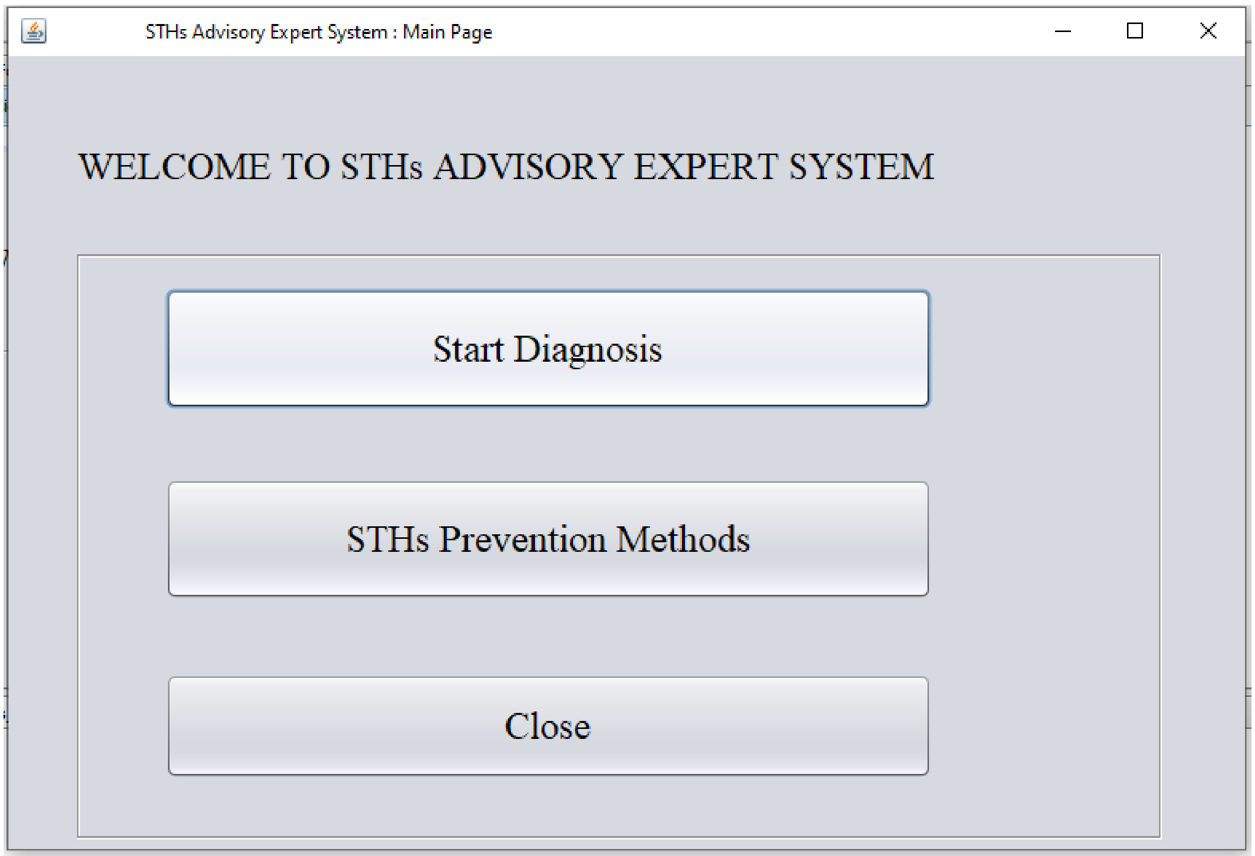

Figure 4.2 Main GUI of the proposed system

The user has three options as we can see from the above user interface. If the user wants to know the type of STHs disease the patient is infected with, then s/he has to click on start diagnosis button and s/he will get the interface as shown in Figure 4.5 below.

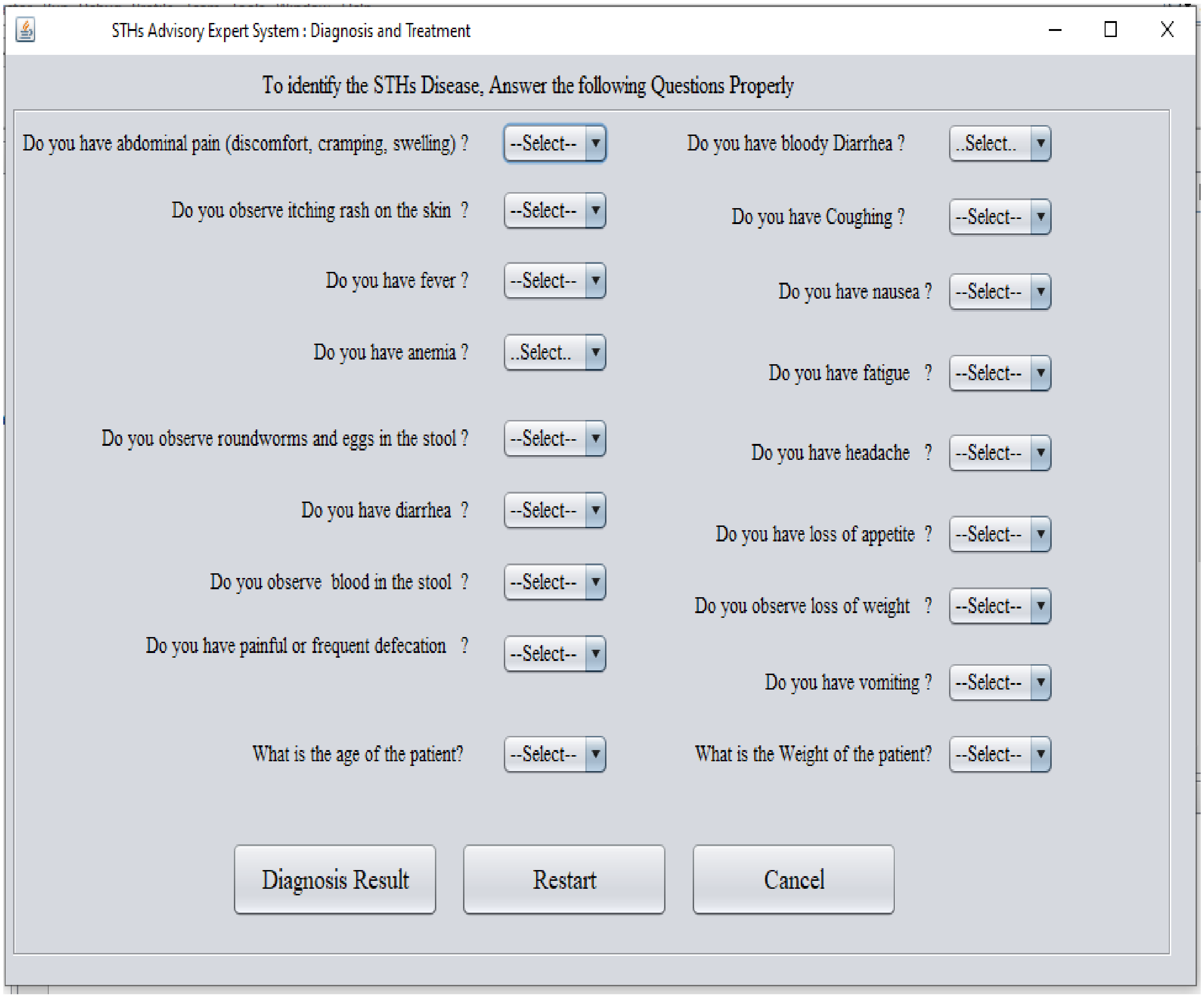

Figure 4.3 STHs Advisory Expert System Diagnosis page

When the user is selecting the sign and symptom of the disease and clicks the diagnosis result button the result will be displayed for the user. The interface in figure 4.6 shows the diagnosis result and treatment recommendation for Whipworm disease.

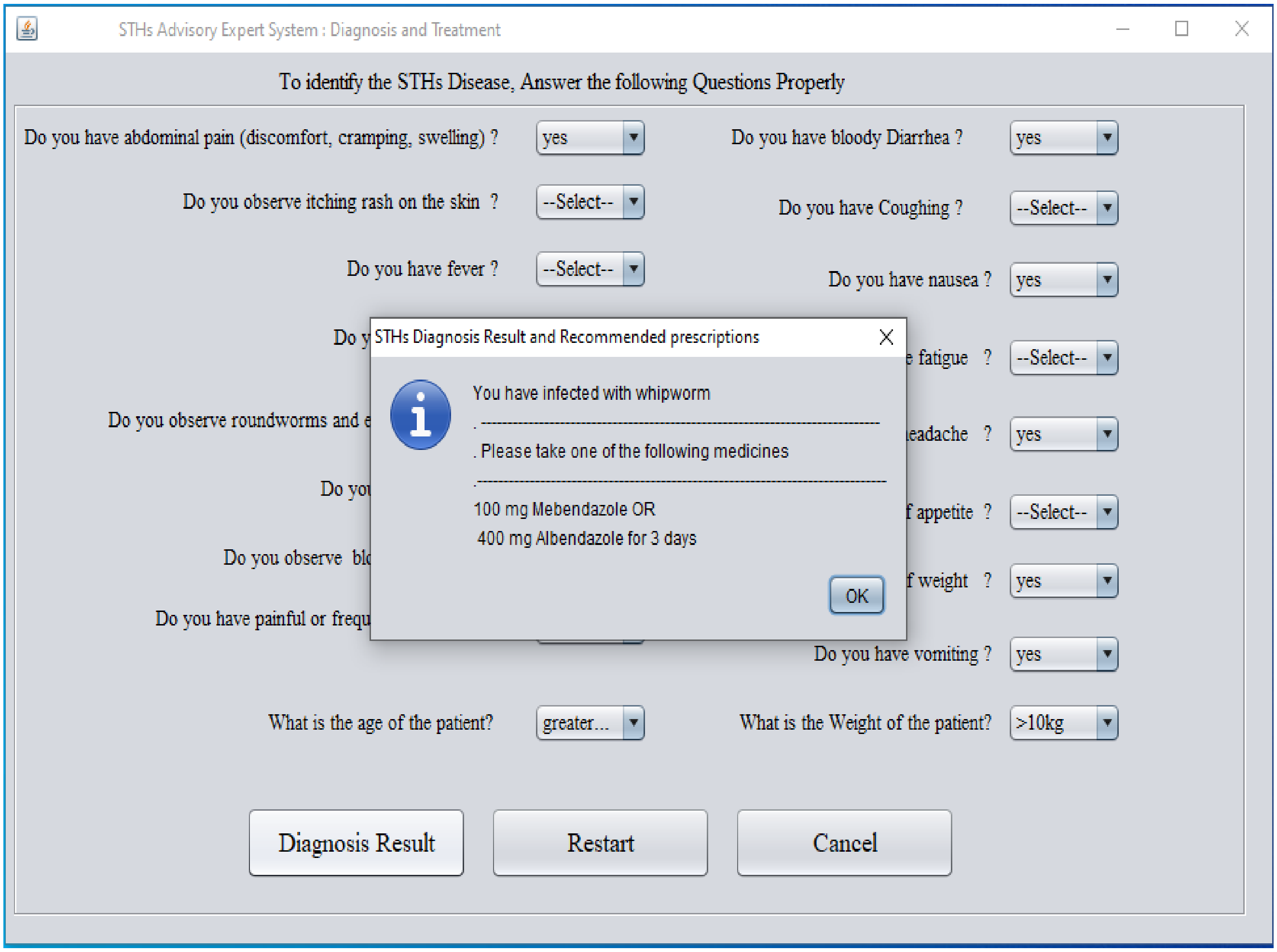

Figure 4.4 STHs Advisory Expert System Diagnosis result and treatment ordering for whipworm disease

After diagnosis the STHs disease, the user can see the both the identified disease as well as the treatment ordering (recommended prescription) for the disease. The system orders the treatment based on the age of the patient. When the user wants to see the preventive methods for STHs infectious diseases, then he/she can click on STHs prevention methods button on the main interface of the system and will get the information to prevent soil transmitted helminths infectious disease.

4.1.4. Knowledge Base Editor

The Knowledge Base Editor is used to edit the Knowledge Base by the knowledge engineer in collaboration with the domain expert whenever there is an update that has to be included in the knowledge base. The knowledge base has to be updated every time because knowledge is dynamic and the knowledge base must be up to date to provide full information for the users of the system. The knowledge base engineer adds new knowledge in cooperation with the Domain expert because to add new knowledge to the knowledge base first it must be checked and verified by the domains. So in this proposed system the knowledge base engineer can add the new knowledge by opening the knowledge base in Notepad editor.

4.2. Evaluation of the proposed system

System evaluation is the basic means for expert systems to check or verify whether the proposed expert system achieves the Objectives set by the researcher or not. The evaluation of Expert systems can be done using different methods or parameters. One method is by using system performance testing by preparing test cases and another method is by using user acceptance testing.

4.2.1. System performance testing using Test cases

The proposed system can be evaluated interms of its performance to know its accuracy. The test cases are used to evaluate the performance of the proposed system, which helps the researcher to compare the domain experts' decision and the proposed system's response and to conclude that the proposed system could work with the absence of domain expert or not. In order to do this evaluation, the researcher prepares the following test cases in collaboration with Domain experts. The test cases are prepared for diagnosis and treatment. The diagnosis test cases are used to determine whether the person is infected with which type of soil transmitted helminths infectious diseases and the treatment test cases are used to order the correct treatment/medication for the identified STHs infectious diseases. To evaluate the performance of the proposed system interms of accuracy, we selected four domain experts randomly (two nurses from Ambo university referral hospital and two health extension workers from Ambo town health center). The researcher prepares thirteen test cases, Appendix III, and gives them to the selected domain experts and the proposed system and the researcher the obtained result as follows.

For the first test case the domain expert identify as the person is infected with whipworm and the proposed system replies the same with domain expert response. In the second test case the domain expert identify as the person is infected by hookworm and the proposed system replies the same with domain expert response. For the third test case the domain expert say the person is infected by roundworm and hookworm but, the proposed system replies the unable to identify the disease which is a different response from the domain expert response. For the fourth test case the domain expert say the person is infected by roundworm and the proposed system replies the same response with domain expert response. In the test case 5 the domain expert identified the patient as infected by hookworm disease and the proposed system replies the same result as domain experts. In the sixth test case the domain expert identified the patient as it is infected by roundworm (Ascaris) and the proposed system reply the same. For test case 7, the domain expert order the roundworm infected person who is adult is to take 100gm Mebendazole or 400mg albendazole and the proposed system replies the same response with domain expert response. For test case 8 the domain expert orders the patient to take 50mg Mebendazole or 200mg albendazole and the proposed system replies the same response with domain expert response. In test case 9 the domain expert say the patient should take 50mg Mebendazole or 200mg albendazole and the proposed system replies the same response with domain expert response. For test case 10 the domain expert order the patient to take 400mg albendazole or 100mg Mebendazole for three days and the proposed system replies the same response with domain expert response. For test case eleven, the domain expert orders Mebendazole 2.5 teaspoons (250mg oral suspension) for the patient whose age is 5 month, but the proposed system orders 100 mg Mebendazole for 3 days OR 400 mg Albendazole single dose or for 3 days in heavy infections OR 10 mg/kg Pyrantel pamoate up to a maximum of 1gm once, which is different from domain expert response. for test case twelve, the domain expert orders 50 mg Mebendazole for 3 days OR 200 mg Albendazole single dose OR 10 mg/kg Pyrantel pamoate up to a maximum of 1gm for the patient whose age is three year and whose weight is less than 10kilogram and the proposed system reply the same with domain expert response. for the last test case, the domain expert orders 50 mg Mebendazole for 3 days OR 200 mg Albendazole single dose or for 3 days in heavy infections OR 10 mg/kg Pyrantel pamoate up to a maximum of 1gm for the patient whose age is two year and whose weight is less than ten kilogram and the proposed system reply the same as the domain expert.

As described above, there are two categories of test case (Diagnosis test case and Treatment test case). We have six diagnosis test cases and from those the results of five test cases are the same in both domain expert and proposed system response. So the performance of the diagnosis system interms of accuracy is 83.3%. There are seven treatment test cases and from those test cases the result of six of them are the same in both domain expert and proposed system response. From this, the performance of the treatment system interms of accuracy is 85.7%. The total (diagnosis and treatment) performance interms of the accuracy of the proposed system is 84.5%. this result shows that the proposed system can perform the advising operation for the user when the domain expert are not available which implies that the knowledge base of the proposed system has necessary knowledge to advise about soil transmitted helminths infectious diseases.

4.2.2. User Acceptance Testing

User acceptance testing is another mechanism for evaluating the proposed system. In user acceptance testing the researcher could evaluate whether the intended user use the proposed system frequently or not and to check whether the proposed system fulfills the requirements of the user.

To evaluate the proposed system, the researcher prepares the user acceptance testing questionnaires which contains eight close ended questions, Appendix II, and the evaluators have five options for each question. The evaluators are allowed to rate the options as Excellent, Very good, Good, Fair and Poor and researcher assigned numeric value for each of the options given in words as Excellent=5 (100%), Very good=4 (80%), Good=3 (60%), Fair=2 (40%) and Poor=1 (20%). To evaluate the proposed system, the researcher randomly selects three health extension workers from ambo town health center, two nurses from ambo university clinic and one medical doctor from Ambo referral hospital. Then the researcher shows how to use the system for the evaluators and allow them to interact with the proposed system by running number of cases. After that the researcher gave the prepared questionnaire for the evaluators and the researcher discusses the result as shown in table 4.1.

Table: 4.1 User Acceptance Testing Result

S/no	Questions	Evaluators' Responses						
		Excellent	Very good	Good	Fair	Poor	Average (5)	Average (100%)
1	How do you rate the easiness to sue and interactivity of the system?	3	2	1	0	0	4.3	86%
2	How do you rate the system in response to giving the correct diagnosis result?	4	2	0	0	0	4.6	92%
3	How do you rate the proposed system in helping the people to improve the health care services in rural areas?	3	1	2		0	4.1	82%
4	How do you rate the proposed system in giving the right treatment?	4	1	1	0	0	4.5	90%
5	Do you like to use the proposed system frequently?	3	2	1	0	0	4.3	86%
6	How do you rate the proposed system in providing full information about the disease?	4	2	0	0	0	4	80%
7	How do you rate the significance of the proposed system in your understanding?	3	1	2	0	0	4.2	84%
8	How do you rate the overall performance of the system?	3	2	1	0	0	4.3	86%
		Total Average					4.2	85.7%

As table 1 indicates that the easiness of the system is rated as 86%. The correctness of the diagnosis is rated as 92%. Improvement of healthcare service by the proposed system in rural areas is rated as 82%. The correctness of treatment is rated as 90%. Frequent usage of the proposed system is rated as 86%. The system provides full information for the disease is rated as 80%. The significance of the proposed system is rated as 80%, the performance of the proposed system is rated as 84% by selected evaluators. The overall average user acceptance of the proposed system is 85.7%.

From the above result, the researcher understands that the system would have contribution by assisting health center staffs and the NTD workers in rural areas. It helps to improve the healthcare services in remote areas where healthcare professionals are not available, which is one objectives of this study. Finally, the researcher understands that it is good to use the proposed system for the diagnosis and treatment of Soil Transmitted helminths infectious diseases in rural areas because the study achieves 85.7% which is the promising result to implement the proposed system.

4.3. Discussion

As it is described in the evaluation section the proposed system was evaluated by two methods. The first section discusses on system performance testing to know the accuracy of the proposed system and achieves 84.5% system performance testing result (with test cases). The second section discusses on user acceptance testing and achieves 85.7% user acceptance testing result. The overall performance of the proposed system is 85.1%. From this result we can say that using the proposed system can improve health care services especially, in areas where healthcare professionals are not available.

This study has three research questions which were listed at the starting of the study. Based on the result gained above let us discuss on how these research questions have been answered by this study. The first research question was "how model performance is important to identify soil transmitted helminths infectious diseases from user input and providing accurate information for users?" To answer this question, the researcher conducts performance measurements on the developed prototype and obtained 84.5% result.

The second research question was "How expert system supports healthcare workers in the diagnosis and treatment for soil transmitted helminths infectious disease?" To answer this question, we prepared different questionnaire and gave to different users of the system. Based on the users' response the researcher assesses the importance of STHs expert system to improve the diagnosis of STHs infectious diseases and the evaluation shows promising result.

The third research question was "How to design an advisory expert system for soil transmitted helminths infectious disease?" To answer this question, the STHs advisory expert system prototype is constructed by collecting knowledge from domain expert using interview and different document analysis. The proposed system was constructed by using rule based knowledge representation method and stored in Swi-Prolog as knowledge base and Java NetBeans programming environment to design the user interface.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

According to federal ministry of health Ethiopia, the coverage of healthcare service still is not sufficient. This is due to different factors like shortage of healthcare workers in rural areas, distance and medical expert availability, problems in implementing health extension packages, quality of healthcare service.

Currently the government of Ethiopia has implementing different health strategies and policies to improve healthcare services of the societies. One policy to address the above listed problem is prevention of neglected tropical diseases including soil transmitted helminthes infectious diseases using health care staffs (extension workers).

Therefore to help health extension workers and any other non-professionals to have knowledge on STHs disease prevention and treatment, developing AI based application contributes a lot. One of dominant application area of artificial intelligence is expert systems. Now days' many medical expert systems are developed. The researcher constructs STHs advisory expert system prototype which aims to assist healthcare workers and any person who is not healthcare staffs in identifying the sign and symptom as well as the treatment for STHs diseases.

To develop the proposed system, the researcher has conducted interview with health center staffs and analysis different documents related to STHs infectious diseases and obtaining interesting result with 85.7% user acceptance and 84.5% system performance respectively. So developing and using such kind of expert system in healthcare can improve the healthcare service by assisting individuals when experts are not available.

The developed STHs advisory expert system has the following **contributions**. The first contribution is the proposed system assists the health extension workers in diagnosis the disease and provides information related to Soil Transmitted Helminths infectious diseases. Supporting NTD workers (health extension workers) activity with this expert system can simplify their work. The turnover rate of NTD workers is very high due to many problems, especially in remote areas. Due to this problem the peoples who live in remote areas did not get immediate treatment which leads to death. So the community can use the proposed expert system to get treatment and it reduces the death rates associated with Soil transmitted helminths infectious diseases.

5.2. Recommendation

As we have seen the results in the evaluation section, this study achieves its main objective by providing the advisory services for health center workers and other peoples. Based on the findings of the study, the researcher identifies the following problem for further research as a recommendation.

The domain expert knowledge might not be clearly expressed or understood and the user might be unsure of the answer to the questions. So the future works on this area should use some probabilistic techniques to deal with uncertainty.

The knowledge base of the system should incorporate other categories of neglected tropical diseases knowledge with different local languages to increase its importance and to improve its performance.

If there is correct and accurate knowledge, Rule based systems can be implemented for any domain specific problem. But, sometimes it is difficult to express domain knowledge in texts. The text may be long and it is difficult to convert the knowledge into rules. To make available such kind of knowledge in the knowledge base of the system to users, it is good to integrate the knowledge base of the system with information retrieval.

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APPENDIX

Appendix I: Domain Expert Interview questions

Bahir Dar University

Bahir Dar Institute of Technology

Faculty of Computing

Department of Information Technology

Domain Expert Interview Questions

Dear Interviewees,

This interview is prepared for Domain experts to acquire knowledge about Soil Transmitted Helminths Infectious diseases. The researcher would like to thank you for your willingness to make yourself available for this interview.

The knowledge that are going to be collected from you will be used to develop an advisory expert system for Soil Transmitted Helminths infectious diseases that gives an advice in English Language about Diagnosis and Treatment as well as the prevention of Soil Transmitted Helminths infectious diseases to health extension workers, junior nurses, farmer or any person who do not have deep knowledge about Soil Transmitted Helminths infectious diseases and work in the remote areas of Ethiopia. The research is conducted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Information Technology in Bahir Dar institute of technology, Bahir Dar University.

1. What is Soil Transmitted Helminths Infectious disease?

2. What are their types?

3. How does Soil Transmitted Helminths Infectious diseases transmitted to human being?

4. What are the prevention mechanisms for Soil Transmitted Helminths Infectious diseases?

5. What are the symptoms of Soil Transmitted Helminths Infectious diseases?

6. How can we diagnosis Soil Transmitted Helminths Infectious diseases?

7. What are the treatment mechanisms of Soil Transmitted Helminths Infectious diseases?

Appendix II: User Acceptance Testing Questionnaires

Bahir Dar University

Bahir Dar Institute of Technology

Faculty of Computing

Department of Information Technology

User Acceptance Testing Questionnaires

Dear evaluators,

The following questionnaire is prepared for you to evaluate the proposed expert system for soil transmitted helminths infectious diseases. The researcher would like to say thank you for making yourself available for this task. The proposed expert system is developed for providing an advice in English Languages about Diagnosis and Treatment as well as the prevention of Soil Transmitted Helminths infectious diseases to health extension workers, junior nurses, farmer or any person who do not have deep knowledge about Soil Transmitted Helminths infectious diseases and work in the remote areas of Ethiopia. Please read the following 8 questionnaires and select your answer from the given five options.

S/no	Questions	Evaluator Response
1	How do you rate the easiness to sue and interactivity of the system?	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor
2	How do you rate the system in response to giving the correct diagnosis result?	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor
3	How do you rate the proposed system in helping the people to improve the health care services in rural areas?	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor
4	How do you rate the proposed	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor

	system in giving the right treatment?	
5	Do you like to use the proposed system frequently?	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor
6	How do you rate the proposed system in providing full information about the disease?	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor
7	How do you rate the significance of the proposed system in your understanding?	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor
8	How do you rate the overall performance of the system?	☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor

Appendix III: System Performance Test Cases

Bahir Dar University

Bahir Dar Institute of Technology

Faculty of Computing

Department of Information Technology

System Performance Test Cases to evaluate the proposed system

S/no	Test cases for diagnosis	Domain experts' response	Proposed system response
1	A person having abdominal pain		
	A person having bloody diarrhea		
	A person having nausea		
	A person having headache		
	A person having weight loss		
	A person having fecal incontinence		
	A person having frequent defecation		
	A person having vomiting		
2	A person having Anemia		
	A person having diarrhea		
	A person having Abdominal pain		
	A person having itching rash on skin		

	A person having blood in the stool		
	A person having loss of appetite		
	A person having fever		
	A person having loos of weight		
	A person having loos of fatigue		
3	A person having malnourishment		
	A person having listlessness		
	A person having abdominal distension		
	A person having anemia		
	A person having cognitive impairment		
	A person having stunted growth		
	A person having abdominal pain		
4	A person having fever		
	A person having coughing		
	A person having nausea		
	A person having vomiting		
	A person having roundworms in the stool		
	A person having abdominal discomfort		
	A person having abdominal cramping		
	A person having abdominal swelling		

5	A person having loss of appetite		
	A person having anemia		
	A person having diarrhea		
	A person having blood in the stool		
6	A person having abdominal cramping		
	A person having wheezing		
	A person having fever		
	A person having coughing		
Test cases for treatment			
7	A patient has whipworm		
	A patient is children		
	A patient weight is less than 10 kg		
8	A patient has roundworms		
	A patient is adult		
	A patient weight is greater than 10 kg		
9	A patient has roundworm		
	A patient is children		
	A patients weight is less than 10 kg		
10	A patient has hookworm		

	A patient is adult		
	A patients weight is greater than 10 kg		
11	A patient has roundworm		
	The patient age is 5 month		
12	A patient has hookworm		
	A patient age is 3 year		
	A patient weight less than 10kg		
13	A patient has roundworm		
	The patient age is 2 year		
	The patient weight is less than 10kg		