ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

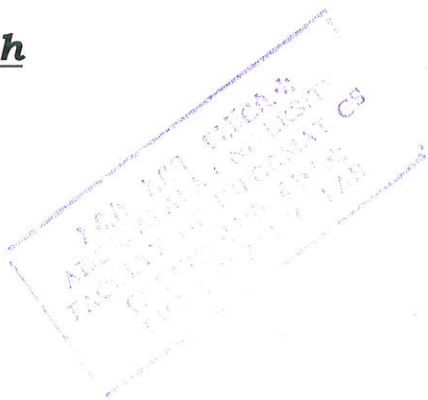
FACULTY OF INFORMATICS

DEPARTMENT OF INFORMATION SCIENCE

SEXUAL TRANSMITTED INFECTIONS MANAGEMENT

KNOWLEDGE BASE SYSTEM:

Syndromic Approach



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SEXUAL TRANSMITTED INFECTIONS MANAGEMENT KNOWLEDGE BASE SYSTEM: Syndromic Approach

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Acronyms

AI	Artificial Intelligence
AIDS	Acquired Immuno Deficiency Syndrome
AIM	Artificial Intelligence In Medicine
CDC	Center For Disease Control U.S.A
FHI	Family Health International
FDRE	The Federal Democratic Republic Of Ethiopia
HIV	Human Immuno Deficiency Virus
HSV2	Herpes Simplex Virus2
ICT	Information And Communication Technology
KBS	Knowledge Base System
LGV	Lympho Granuloma Venerelium
MoH	Ministry of Health, Ethiopia
PID	Pelvic Inflammatory Disease
SETIKOBS	Sexual Transmitted Infections Knowledge Base System
STI	Sexually Transmitted Infections
UNAIDS	United Nation AIDS Program
WHO	World Health Organization

Abstract

This study is based on developing an Artificial Intelligence program called Knowledge Base System (KBS). It describes an investigation of the conventional Sexual Transmitted Infections (STI) syndromic approach problems, opportunities and the alternative approach to manage STI.

The conventional approach which is currently used for managing STI, as evidences indicated, has little impact on STI management or neither reduces most curable STI nor HIV transmission. In addition to this, stigmatizing those who visit, unnoticed asymptomatic STI infections and difficulty of notifying and managing sexual partner are other drawbacks of the conventional approach. Thus, significant portions of the population, especially young people, still remain under information poverty about STI.

According to FHI (2001), a comprehensive approach to manage STI is crucial to alleviate such problems by promotion of partner treatment, prevention of reinfection, improve health care seeking behavior, effective STI detection, and increase awareness of Symptoms or risk. One way considered here is designing and developing a prototype of KBS called ***Se****xual* ***T****ransmitted* ***I****nfections* ***Kno****wledge* ***B****ase* ***S****ystem (SeTIKoBS). To build this system more than 16 medical staff, nine patients and twenty-five historical cases were involved. Moreover to assess SeTIKoBS performance for the task for which it is designed, two evaluation techniques were used.*

From the experiment undertaken, SeTIKoBS evaluators judge the system effectiveness as an average rating of 87.3 percent to manage STI which indicate a success and in some situations it is also noteworthy that the system is able to provide more accurate management than using conventional methods.

CHAPTER ONE

1.1 Introduction

Since the past few decades, the world is moving through tremendous technological transformations which hugely affect the way people live and work. Computer science has played a major role in this wave of changes and one of its fields, Artificial Intelligence (AI), has helped some previously unthinkable things materialized.

Artificial Intelligence (AI) is one of the significant branches of computer science since the mid 1970's. Robotics, neural networks, machine learning and knowledge base systems are some of the applications in AI (Stefic, 1995).

Knowledge Base System/KBS/ is a computer program that relies on knowledge and reasoning to perform a difficult task usually undertaken by human expertise (Russell and Norvig, 1995). KBS has proven successful in solving problems associated with shortage of human expertise and other arenas of life. KBS is gaining ground in quite a number of areas. Medicine is one of those, which has enjoyed the early innovative works in the field of expert systems (Coiera et al., 1994); among which MYCIN and INTERNIST are worth mentioning.

In particular, there is a clear role for clinician knowledge based application which include drug advisor system, image recognition and interpretation, and diagnostic assistance for clinicians (Lucas, 2000). Diagnostic assistance is applied when a patient's case is complex, rare or the person making the diagnosis is simply inexperienced. A knowledge base system, hence, can help come up with likely diagnoses based on the data provided by the patient (Giarratano, 1998).

This study looks into the possibility of using the knowledge base technology to assist in diagnoses of Sexual Transmitted Infections (STI), especially for inexperienced patients taking as an alternative approach to manage STI.

1.2 Background to the Problem

1.2.1 Sexual Transmitted Infections (STI)

STI are group of diseases that are spread from one person to another mostly through sexual contact. They represent a major health problem and are among the commonest causes of acute illness, and even death, in the world and have far reaching health, social and economical consequences. The World Health Organization WHO (2001) has estimated that there are approximately 340 million new cases of curable Sexual Transmitted Infections in the world per annum of which 65 million occur in sub Saharan Africa. According to the report, around half of the new STI cases per year are young people (most vulnerable group) under 25 and world wide new infections in young people occur at the rate of five per minute.

Ethiopia, a country in Sub-Saharan region, has little information on the incidence and prevalence of STI because of underreporting, lack of or weak surveillance. However, the problems of STI are generally believed to be similar to that of other developing countries. The national adult prevalence of HIV and Syphilis for 2005 is estimated at 3.5% and 2.7% respectively (MoH, 2006).
In all societies with over 30 cases of STI are mostly transmitted through sexual (vaginal and anal) intercourses. Transmission can occur also from mother to child and through blood and blood products, tissue/ organ transfer and occasionally through other non-sexual means.

Each new infection increases the risk of HIV transmission and carries the potential of other serious complications including fetal loss, still birth, infertility and so on. According to UNAIDS/WHO (1998), untreated STI greatly increases an individual risk of getting or passing on HIV to his /her sex partner. Fortunately, most STI--Gonorrhea, Chlamydia, Syphilis, Cancroids, Tricomoniasis and Bacterial vaginosis--can be cured with antibiotics if detected early. HIV infection is up to ten times more common in people with current or

prior STI, and the risk increases with number of STI episodes (UNAIDS/WHO, 1998). A person with STI will transmit or acquire HIV during a single sexual exposure. So making control of such cofactors, therefore, is vitally important in reducing HIV transmission.

Responding to this, the Federal Democratic Republic of Ethiopia (FDRE) has been undertaking several intervention activities since 1998. Of those activities, one is developing a strategy in view of the benefits of effective and timely treatment of STI cases, and the other is to provide STI diagnosis services to all people and special attention should be paid to the most vulnerable groups (FDRE, 1998). Accordingly, the Ministry of Health (MoH) has placed increasing emphasis on integrated systems especially at the rural primary health care level, by choosing a syndromic approach for patient management of STI (MoH, 2006).

1.2.2. Syndromic Approach

A syndrome is a group of symptoms that patients describe, combined with classic signs that medical persons observe during physical examination. A number of different organisms that cause STI give rise to a limited number of syndromes using the syndromic approach. Health staff can identify one of these syndromes and treat accordingly (MoH, 2006). The aim of syndromic approach is, in particular, to identify among vaginal discharge, urethral discharge, genital ulcer, lower abdominal pain, inguinal bubo or any other STI syndromes and to manage it accordingly. As such, a clinical or etiological diagnosis tries to identify just one causative agent, syndromic diagnosis leads to immediate treatment for all the most important causative agents (WHO, 2001). This is important because having more than one infection occurs frequently. What this means is that, if the necessary drugs are available and affordable, syndromic treatment can quickly render the patient non-infectious.

The use of syndromic approach to STI is strongly recommended in order to ensure adequate treatment at all levels of the health services (FHI, 2001). It

also delays the development of antimicrobial resistance, assists in more rational drug procurement for treatment of STI, and alleviates the lack of uniformity in STI diagnosis, case management, recording and reporting.

Despite the fact that most STI can be cured with antibiotics, and even health services are available not too far away for youth, young people have less access to them than adults do (UNAIDS/WHO, 1998). Because young people have reluctant to seek treatment for fear of being found out, the services are unwelcoming and unattractive, the situation frequently deters youth from accessing services, which in turn overlooks the second strategy formulated by FDRE mentioned above.

Therefore, efforts should be made to build a bridge that link between the youth and the effective management of STI to reduce the incidence of new STI among the young population.

1.3 Statements of the Problem

Concerning the unavailability of health services that they are too far away and too expensive, stigmatizing those who visit, and the difficulty of notifying and bringing sexual partner, are some of the factors that aggravate the prevention and control of STI case management in developing countries (WHO, 2001).

Despite, a significant portion of the population being made up of young people, they still remain under information poverty. Moreover, under the circumstances, the most important challenge in STI control is orienting services to reach the people who are most frequently exposed to infection and have the most opportunities to pass their infection on to other (FHI, 2001).

Besides syndromic approach which offered by professionals, control and management of STI in developing countries like Ethiopia so far is provided through a whole array of services and individuals usually not medically qualified, such as traditional healers, quacks, and street vendors, which in fact

worsen the intervention activity and prevention and reduction of HIV (MoH, 2006).

But according to the report of FHI (2001), the use of syndromic approach only have little impact on control of STI and reduction of HIV. For example, the management of STI in Tanzania reduced the incidence of HIV infection by 40%. But in Uganda, on the other hand, syndromic approach reduced neither most curable STI nor HIV transmission. These practices reveal that reducing high rate of STI requires a comprehensive strategy to control STI barriers.

Improving STI care by supplying health care facilities can address for the general population. However, it should be clear that other approach is needed to increase the coverage of STI reduction, especially for populations who are at high risk. Thus, rather than expecting solutions from other parties the participation of youth themselves to improve their own health is crucial(UNAIDS/WHO, 1998).

This research seeks to explore how to make STI diagnosis and management available for those who wish to check their STI status which provides effective diagnosis and treatment, awareness of risk/symptoms, encourage treatment compliance, partner management and improve health care seeking behavior with out the help of medical staff.

With an answer to this, the researcher looks experiment with an alternative way to comprehensive strategy of STI syndromic approach management which hopefully pleases the youth.

According to FHI (2001), comprehensive Strategy of STI includes effective diagnosis and treatment, improve health care seeking behavior, awareness of risk/symptoms, encourage treatment compliance, partner management and avoid reinfection. Of which the conventional syndromic approach has failed to provide awareness of risk/symptoms, encourage treatment compliance and effective partner management.

As Engelmore & Feigenbaum (1993a) indicate, the spectrum of applications of KBS technology is applied to diagnosis systems of all kinds which easily deduce faults and suggest corrective actions for a malfunctioning process. Medical diagnosis was one of the first knowledge areas to which KBS technology was applied.

This research, therefore, explores the Knowledge Base System in the applicability of a comprehensive strategy of STI syndromic approach as an alternative way managing STI.

1.4. Justification of the Study

Providing effective curative STI control services will enhance people's receptiveness to prevention messages and helps to achieve sustainable reductions in rates of the common curable STI. At the same time it will reinforce broader prevention behaviors that reduce risk, incidence and prevalence of both curable and incurable STI (WHO, 2001).

This work demonstrates the issue of discovering every possible means that will help in providing effective curative services for those who uses existing clinical services and who does not.

From such perspective, the proposed KBS in controlling STI will have the following benefits.

- ✓ Increasing awareness of risk for those who are unaware of their risk
- ✓ Improving health care seeking behavior as an alternative to consulting unqualified sources
- ✓ Enhancing effective STI management since many STI are not detected at health care facility and if detected, they may be treated incorrectly
- ✓ Easy partner management and prevention of reinfection
- ✓ Getting the service with much lower cost compared with paying an expert
- ✓ Availability of the KBS anytime and anywhere as needed

- ✓ Encouraging the youth (any person) to take early diagnosis and medication, and
- ✓ Addressing information poverty which can be overshadowed by the development of information and communication technology (ICT).

1.5. Objectives of the Study

1.5.1 General Objective

The general objective of the research is to discover an alternative approach for the management of STI to achieve sustainable reductions in rates of the common STI while reinforcing broader prevention behavior that reduce risk, incidence and prevalence of both curable and incurable STI.

1.5.2 Specific Objective

The research has the following as its specific objective:-

- to identify the challenges and opportunities associated with STI
- to review models and strategies for the development of KBS
- to represent knowledge using appropriate knowledge representation methods
- to design and develop a prototype knowledge based system that demonstrates the capacity of the system to give diagnosis in STI
- to test the reliability and performance of the prototype through feedback
- to report the result findings and
- to recommend suggestions for further work in the area.

1.6. Scope and Limitation of the Study

With in the field of information science, the central focus of this study is to experiment with designing and developing a prototype knowledge base system for the diagnosis and management of STI. To this end, SeTIKoBS (**Se**xual **T**ransmitted **I**nfections **Kno**wledge **B**ase **S**ystem) is built using knowledge

acquired from expertise in the area and supplemented by the information guideline which is outlined by the Ministry of Health, Ethiopia.

Non curable STI like HIV and Human papilloma virus, STI transmitted other than sexual (vaginal) intercourse such as mouth or anal intercourses and STI transmission during childbirth are beyond the scope of the research because even though non curable are parts of STI, it takes more time to demonstrate the experiment.

1.7. Methodology

For the purpose of undertaking the study proposed, literature review, data collection, knowledge representation, prototype testing and evaluation are employed. To understand the exact contribution of the work, various literatures are reviewed and analyzed. In customizing the strategy to STI management selected, unstructured interview was conducted to acquire knowledge from experts. Four STI experts are selected using purposeful sampling technique. These experts were selected primarily because: 1) all of them use the same guideline (syndromic approach) which is the base for this research and 2) if one is busy then the other experts can be involved without delay. Additional knowledge also acquired from the guideline for syndromic approach diagnosis of STI, published by MoH (2006), HARRISON'S Medical book (2001) and guideline of syndromic diagnosis of STI, published by World Health Organization (2001).

The knowledge acquired using the above methods then represented in the form of rule based system. This process is called knowledge representation. According to Aroyo (2006), it is a method of storing and processing Knowledge in computer. For this study, common knowledge representation method called production rule or simply rule is demonstrated to organize the knowledge. Using Prolog language, the details of building knowledge-base systems are illustrated. The choice of Prolog is due to three major features of the language: rule-based programming, built-in pattern matching, and backtracking

1.9. Organization of the Thesis

This thesis is structured in to seven chapters and the rest of the chapters are organized as follows. Chapter two discusses knowledge base system and applicability in the field of medicine. STI and the syndromic approach are also highlighted. For the purpose of undertaking the study proposed, the methodology part is illustrated in chapter three.

Chapter four deals with acquiring knowledge from domain expertise which illustrates the process of knowledge elicitation and modeling. The knowledge is represented using rule based structure which is explained in chapter five. In chapter six, knowledge application and SeTIKoBS performance measurements are explained. Finally, conclusion and recommendations for future research are illustrated in the last chapter.

CHAPTER TWO

2. Knowledge Base System and STI

Understanding the notion of Knowledge Based System/KBS/ requires conceptualizing its theory, definition and other explanation. Even though the spectrum of applications of KBS technology is wide, this chapter explores the applicability of KBS and its role in health. It also reviews briefly some highlights about STI.

2.1. Knowledge Based System and Expert System/ES/

Knowledge Based Systems are computer programs that are derived from a branch of computer science research called *Artificial Intelligence* (AI). AI's scientific goal is to understand intelligence by building computer programs that exhibit intelligent behavior. It is concerned with the concepts and methods of symbolic inference, or reasoning, by a computer, and how the knowledge used to make those inferences will be represented inside the machine (Engelmore & Feigenbaum, 1993b).

The term *intelligence* covers many cognitive skills, including the ability to solve problems, learn, and understand language; AI addresses all of those. But most progress to date in AI has been made in the area of problem solving -- concepts and methods for building programs that *reason* about problems rather than calculate a solution (Ignizio, 1991).

AI programs that achieve expert-level competence in solving problems in task areas by bringing to bear a body of knowledge about specific tasks are called *Knowledge Based* or *Expert Systems*. Frequently, however, the term expert systems is reserved for programs whose knowledge base contains the knowledge used by human experts, in contrast to knowledge gathered from textbooks or non-experts.

More often than not, the two terms, Expert Systems (ES) and Knowledge Based Systems (KBS), are used synonymously. Taken together, they represent the most widespread type of AI application (Engelmore & Feigenbaum, 1993a).

Thus, in this thesis no variation is made between the two terms as techniques used in KBS and ES are identical (Lucas, 2000); (Stefik, 1995). Therefore, the terms 'ES' and 'KBS' are used interchangeably throughout this thesis.

2.1.1. Definition

Numerous people have defined KBS from various perspectives. Some of these are:

"Knowledge-Based Systems focuses on systems that use knowledge-based techniques to support human decision-making, learning and action." (Coiera et al., 1994)
"[Expert Systems] simulate the process of human thinking by the application of knowledge and specific inferences." (Politecnico di Milano, nd).

"Expert System is a computer program designed to simulate the problem solving behavior of a human who is an expert in a narrow domain or discipline."(Expert Systems Development Group, nd)
The basic concepts reflected in the above definitions; KBS or ES is a computer program designed to simulate the problem solving behavior of a human to support human decision-making, learning and action.

2.1.2. Type of Expert Systems

An expert system can be one of the following five types: rule based, object oriented, logic based, induction based, and hybrid systems (Erikson, nd); (Darlingiton, nd); (Ignizio, 1991).

- A rule based expert system is an expert system that encodes its knowledge in the form of "IF.... THEN" rules. In rule based ES the pattern action model resembles human decision processes which means, the rules can easily be understood by programmers or experts that seems to mimic some human problem solving strategy. Furthermore, rules are independent of each other which encapsulate an important part of knowledge that can model a complex problem.
- In object oriented expert systems the fundamental concept is the 'object' which combines data structure and behavior in a single component.
- Induction based expert systems use rule induction which is one of the fastest means of extracting rule based knowledge from previous cases.
- Logic based expert system use simple true/false logic to evaluated data, or at a more sophisticated level, they are capable of performing at least some evaluation taking in to account real world uncertainties, using such methods as fuzzy logic.
- Hybrid expert systems employ a decision-analysis tool formed through the judicious combination of an expert system and some other methodology.

2.1.3. Tools for Building Expert Systems

An expert system tool or shell is a software development environment containing the basic components of expert systems. According to Russell and Norvig (1995), and Stefik (1995), each of the components is described in figure 2.1. below. However, the core components of expert systems are the knowledge base and the reasoning engine.

driven. **Backward chaining** starts with a list of goals and works backwards to see if there is data which will allow it to conclude any of these goals. An inference engine using backward chaining would search the inference rules until it finds one which has a *then* clause that matches a desired goal. If the *if* clause of that inference rule is not known to be true, then it is added to the list of goals.

- **Knowledge acquisition Facility** is a subsystem to help experts build knowledge bases. Collecting knowledge needed to solve problems and build the knowledge base continues to be the biggest bottleneck in building expert systems.
- **Explanation Facility** is a subsystem that explains the system's actions. The explanation can range from how the final or intermediate solutions were arrived at justifying the need for additional data.
- **User interface** refers to the means of communication with the user. It can make a critical difference in the perceived utility of a system regardless of the system's performance.
- **User** is a person (expert or otherwise) who uses the system for support. The end user usually sees an expert system through an interactive dialogue that proceeds in a dialogue involving questions by the system and answer input by the user.
- **Expert** is a domain expert who input the Knowledge into the system during the development and the knowledge acquisition processes described in the following section.

2.1.4. Advantages of Expert Systems

According to Ignizio (1991), use of Expert System,

- provides consistent answers for repetitive decisions, processes and tasks
- holds and maintains significant levels of information;
- encourages organizations to clarify the logic of their decision-making;
- help inexperienced users for diagnosis of different problems;
- never "forgets" to ask a question, as a human might;
- can work round the clock; and
- can be used by the user more frequently.

It also proves important in situations where experts in a particular area are scares, expensive, unavailable and/or for assisting in solving complex problems.

2.1.5. Application of Expert Systems

The KBS applications find their way into most areas of knowledge work. They are as varied as helping salespersons sell modular factory-built homes to helping NASA plan the maintenance of a space shuttle in preparation for its next flight. According to Engelmore & Feigenbaum (1993a), the spectrum of applications of expert systems technology to industrial and commercial problems is so wide as to defy easy characterization. But in general KBS applications tend to cluster into seven major classes.

Diagnosis Systems of All Kinds

This class comprises systems that deduce faults and suggest corrective actions for a malfunctioning process. Medical diagnosis was one of the first knowledge areas to which ES technology was. There are probably more diagnostic applications of ES than any other type.

Planning and Scheduling

Systems that fall into this class analyze a set of one or more potentially complex and interacting goals in order to determine a set of actions to achieve those goals. Examples involve airline scheduling of flights, personnel, and gates.

Configuration of Manufactured Objects

Configuration, whereby a solution to a problem is synthesized from a given set of elements related by a set of constraints, is historically one of the most important of expert system applications

Financial Decision Making

Insurance companies have used expert systems to assess the risk presented by the customer and to determine a price for the insurance. A typical application in the financial markets is in foreign exchange trading.

Knowledge Publishing

This is a relatively new, but also potentially explosive area. The primary function of the expert system is to deliver knowledge that is relevant to the user's problem, in the context of the user's problem.

Process Monitoring and Control

Systems falling in this class analyze real-time data from physical devices with the goal of noticing anomalies, predicting trends, and controlling for both optimality and failure correction. Examples of real-time systems that actively monitor processes can be found in the steel making and oil refining industries.

- *KBS Quality Assurance* - As many different forms of knowledge based system appear in clinical settings, there will be a need to ensure that they remain up to date, and consistent. Tools will be needed to assist with this task.

Examples of such systems, according to Ignizio (1991), include the following:
INTERNIST: developed in 1970th which perform a diagnosis of the majority of diseases associated with the field of internal medicine.
MYCIN: developed in mid 1970th which provide assistance to physicians in the diagnosis and management of infections disease and the suggestion of suitable therapies.
PUFF: was developed in 1979 which provide to diagnose the presence as well as severity of lung disease.
Brain Tumors Diagnostic System (BTDS) is yet another expert system that provides assistance to a physician in the diagnosis of brain tumors.
Quick Medical Records (QMR) was designed to assist physicians in the diagnosis of illness based upon the patient's symptoms, examination finding, and laboratory tests.
Germ Wateher – checks for hospital acquired infection.
In our country, ExpART- –an ES that provide Anti Retroviral Therapy by Anteneh Worku in July 2004 and HIV Pre Test Counseling KBS —that assist in HIV Pre Test Counseling by Redeit Alemu in July 2006 are worth mentioned which was undertaken for partial fulfillment of the requirement of MScIS at Addis Ababa University (available at AAU Informatics Bibliography).

CHAPTER THREE

3. Research Design and Methodology

This section of the thesis describes the research design and methodology employed for the purpose of collecting required data in order to conduct experiment to achieve sustainable reductions in rates of the common STI.

3.1. Method of the Study

To discover an alternative approach for the diagnosis and management of STI, one should have pertinent and precise knowledge about STI. Koal (2006) stated that descriptive survey approach become particularly useful where one needs to understand some particular information which presents a complete description of a phenomenon with in its context.

Thus, the descriptive survey method is suitable to be employed in this investigation to understand the way how to manage and to asses the diagnosis session associated with STI. It is also thought appropriate to generate adequate information for the experiment to develop an alternative approach to diagnose and manage STI.

3.2. Data Source

For the purpose of collecting data for the study, primary and secondary sources of data are used. As primary sources, various experts in health including drug advisors, STI and HIV counselors and psychologists were interviewed to understand the dimension of STI. Of those, to acquire knowledge for the use of this research, only four STI experts are selected using purposeful sampling technique. These experts were selected primarily because: 1) all of them use the same guideline (syndromic approach) which is the base for this research and 2) if one is busy then the other experts can be involved without delay.

Besides, guideline for syndromic approach published by MoH Ethiopia (MoH, 2006), related documents, books and journals were assessed as secondary sources of data.

3.3. Sampling Procedures

The study was conducted in Federal Prison Administration Health Institutions. These Institutions are selected based on the following conditions:

i. Lots of STI cases are commonly seen in the prison because new prisoners are required to have medical check up before the join other prisoners. They are also encouraged to be diagnosed because it is free for the treatment in the prison than any other health institute.
ii. Easy access of STI expertise, patients and stand alone computer in examination rooms.
iii. Many people are available irrespective of sex or age which includes qualified STI expertise, military staff and high STI vulnerable groups.

These institutions are found in the following centers in different regions of the country. These are Prison General Hospital (Addis Ababa), Addis Ababa Prison Clinic (Addis Ababa), Zeway Prison Clinic (Oromya), Diredewa Prison Clinic (Diredewa), Shoarobit Prison Clinic (Amara) and Aleltu Prison Acadamy (Oromya). From these health institutions Prison General Hospital and Addis Ababa Prison Clinic are selected purposively. The reason why others clinics were not included was that they have small prisoners available in each prison compared with Addis Ababa prison clinic and each prison center is far away from Addis Ababa.

3.4. Phases of KBS Development

KBS development usually proceeds through several phases. The common phases are problem selection, knowledge acquisition, knowledge representation, and Knowledge application (Wentworth et al., 1995; Stuart et al., 1992).

- Problem selection: the most critical step in developing a KBS is identifying a suitable problem.
- Knowledge acquisition: after the problem has been selected, the knowledge acquisition phase of KBS development is carried out.
- Knowledge representation: the knowledge the expert uses to solve a problem must be represented in a fashion that can be used to code into the computer and then be available for decision making by the expert system. Common knowledge representation methods include rules, frames, and cases.
- Knowledge application: this includes testing and evaluation

Rule Based Reasoning

Expert systems whose knowledge is represented in rule form are called rule based systems which contains rules of the form IF condition THEN action. The condition portion of the rule is usually a premise and the action portion of the rule includes a conclusion. Knowledge representation clarifies how the acquired knowledge is represented in the rule based system (Coiera et al, 1994).

In this study, rule based reasoning method was employed for the purpose of knowledge representation because it is the most common way to represent the acquired knowledge and has got a lot of research interest in medicine over the last decades (Aroyo, 2006; Christer, 1991; Parsaye and Chignell, 1988). Moreover the piece of knowledge represented by the production rule is relevant to the line of reasoning being developed. If the IF part of the rule is satisfied; consequently, the THEN part can be concluded, or its problem-solving action taken.

Testing and Evaluation of Knowledge Based System

According to Anumba and Scott (2001), the evaluation of a knowledge-based system (KBS) is an important aspect of knowledge-based system development that is required to prove whether or not a system fulfils its original objectives. And it is defined as the "process of examining a KBS's ability to solve real world problems in a particular domain". The evaluation activity involves exploring the code, examining the reasoning processes and intermediate results, and asses the conclusions of the system which help to detect errors as early as possible in the development cycle. So in order to achieve the objective of the study each chapter of the development phase was revised with previously selected experts using semi structured interview. Some of the questions used for evaluation are appended in Annex one.

In the meantime, the built system code is evaluated with two purposively selected information science students to check the way of the system diagnosis and advice, the correctness of the reasoning techniques used and the quality of human-computer interaction.

3.5. Prototype Testing

From a philosophical viewpoint, experts are never 100 per cent accurate, as everything is prone to error (Parsaye and Chignell, 1988). Therefore, a KBS should not be expected to perform above this level. Anumba and Scott (2001) state, the best way to test the quality and efficiency of the system is to get it built, turn it over to suitable users, and respond to their feedback. This is a process of iterative prototyping, which ensures the completeness and soundness of a system.

Prototype Testing Techniques

Existing techniques for the evaluation of knowledge-based systems are considered, by Anumba and Scott (2001), to be few and primitive. These techniques can be split into two broad types, which are as follows:

1. *qualitative* – employing subjective comparisons of performance; and
2. *quantitative*–employing statistical techniques to compare KBS performance against either test cases or human experts.

Most developers employ the use of qualitative techniques such as the common process of running test cases through the proposed system and comparing the system's output with known results (Anumba and Scott, 2001; Moore and Miles, 1991). Quantitative techniques are rarely used and are considered inappropriate for the evaluation of a KBS (Moore and Miles, 1991). This is mainly because these approaches would not normally be used for the evaluation of human expertise.

Generally, KBS developers desire to assess their KBSs at a similar level to human experts, and therefore adopt qualitative techniques (Anumba and Scott, 2001; Moore and Miles, 1991). The most commonly employed qualitative techniques to evaluate KBSs are outlined below, Moore and Miles (1991):

- *Visual interaction.* This test allows the expert to make comments while interacting with the system, altering parameters as desired.
- *Predictive validation.* This test involves the use of historic test cases. The KBS is driven by past data to obtain a set of conclusions. These conclusions are compared with that of the historic case or with expert performance.
- *Black box testing.* Information is added to a piece of code and sections of, or the whole system. Results are predicted and are compared with the actual results of the system.

whether the case is curable or non curable STI, common or not common STI and also male or female. For each selected historical cases, ranking was set by the evaluator expert to check whether the system is consistent with that of the experts. Unstructured questionnaires were conducted, in conjunction with entering the cases into the system, to help ascertain the expert's views on specific aspects of the system's performance.

Confusion Matrix

Confusion Matrix displays the distribution of the records in terms of their actual classes and their predicted classes. It is statistical measures of the performance of a binary classification test which indicates the quality of the current model (Anumba and Scott, 2001). The confusion matrix defines four parameters. These parameters, as shown in table 3.1., are defined as :

1. **Sensitivity** (also called **recall rate** in some fields) measures the proportion of actual positives which are correctly identified as such (e.g. the percentage of sick people who are identified as having the condition);
2. **Specificity** measures the proportion of negatives which are correctly identified (e.g. the percentage of well people who are identified as not having the condition);
3. **Positive predictive value** (ratio of true positives to combined true and false positives), which is as much a statement about the proportion of actual positives in the population being tested as it is about the test; and
4. **Negative predictive value** ratio of true negative to combined true and false negative.

		Condition		
		Positive	***Negative***	
Test case	***Positive***	**True Positive**	**False Positive**	**Positive predictive value**
	Negative	**False Negative**	**True Negative**	**Negative predictive va**
		Sensitivity	**Specificity**	

Table 3.1. Confusion Matrix

3.6. Programming Tool

As a programming tool, Prolog language is used to demonstrate the potential of using expert systems for this experiment. The choice of Prolog is due to three major features of the language: rule-based programming, built-in pattern matching, and backtracking execution. The rule-based programming allows the program code to be written in a form which is more declarative than procedural. This is made possible by the built-in pattern matching and backtracking which automatically provide for the flow of control in the program. It is also available in Information Science department computer laboratory.

CHAPTER FOUR

4. Knowledge Acquisition

4.1. Conventional Vs Knowledge-based STI Diagnosis Syndromic Approaches

To achieve effective and efficient STI case management, patients should receive effective curative care and prevention education. This is accomplished by increasing awareness of risk, encouraging health care seeking behavior, effective STI detection and promotion of partner treatment (FHI, 2001).

However, the conventional ways of STI diagnosis, which exclude the comprehensive diagnosis approach, aren't knowledge-driven. This makes the STI diagnosis approaches insufficient to meet the current needs. For example, conventional ways do not provide any awareness even though most people with STI are a symptomatic or unaware of their risk.

In most of the health care facilities, as shown in figure 4.1.(a), the conventional approach of STI diagnosis starts with receiving patient request for allocation of Patient Card to STI expert. In most health care facilities, the patient pays money for the diagnosis to be provided by the expert. Then, based on the patient history, the expert prescribes the necessary medication. The expert may give counseling service like use of condom, partner management, use of drugs, STI complications and so on. But counseling service provided depends on many situations.

After all, the treatment used by the patient may fail because of lack of appropriate information, which leads the patient to drug resistance and other STI's complications. If the patient comes to visit again in one or another case, then he/she will start again from registration room which is tedious, expensive and time consuming.

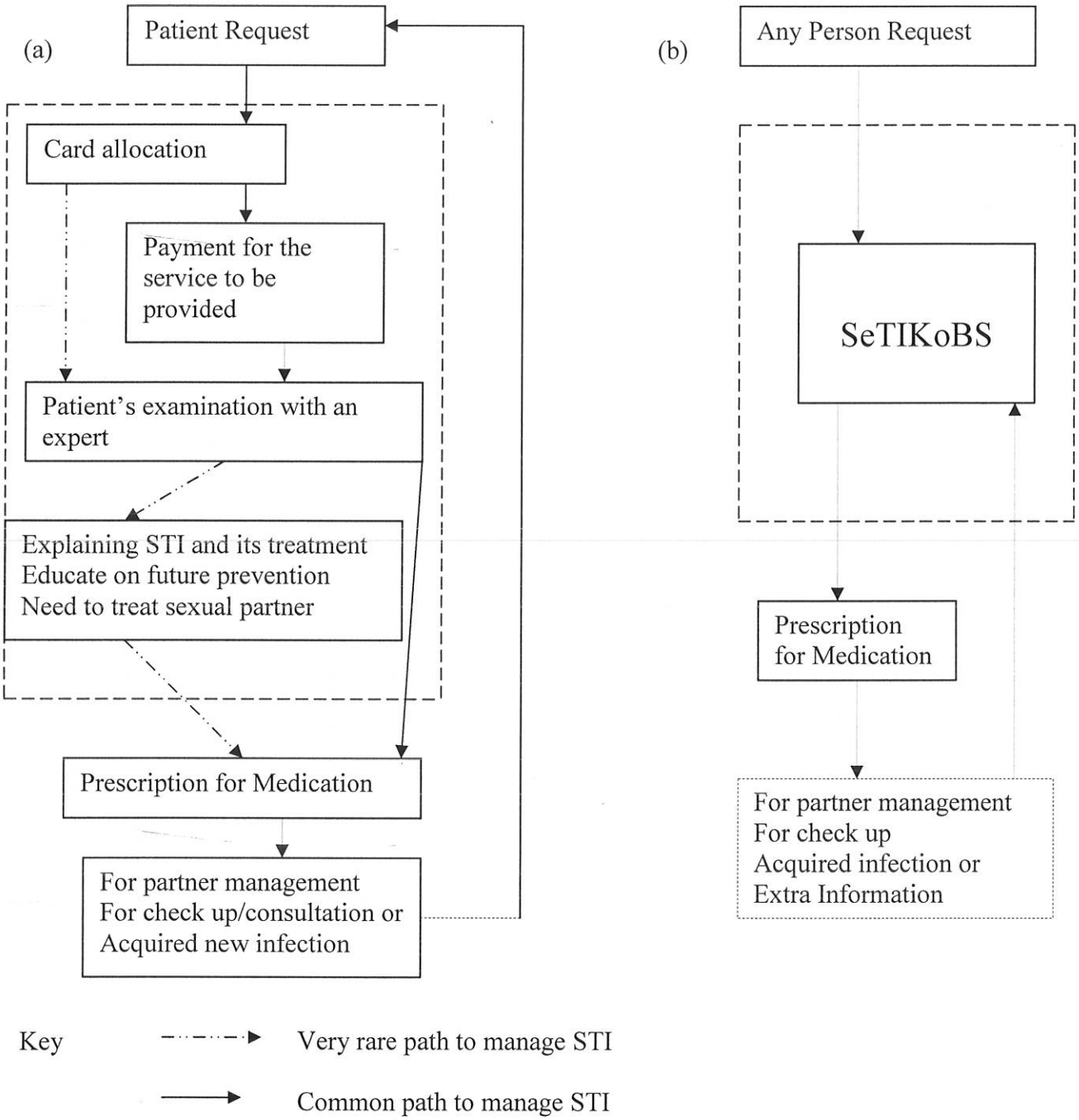

Figure 4.1. A comparison between (a) the conventional approach; and (b) the knowledge-based STI management syndromic approach.

The conventional approach involves complicated knowledge flow and a lot of paper work, and as such time is needed for the STI expert to manage the

patient. In the process, useful information may be missed due to human error. Since, experience and skill are types of tacit knowledge, it is difficult to make the knowledge of the expert shareable. It is interesting to note that the quality of patient diagnosis and management heavily rely on the know-how, experience and qualification of the expert. Moreover, the patient diagnosis and management of common STI can only be provided during the office hours. What this mean is that, when the patient wants to get consultation after the office hours, then he/she cannot be served immediately and the patient health may be affected. On the other hand, for the knowledge-based STI diagnosis approach, as shown in figure 4.1.(b), the processes of risk awareness and/or diagnosis of STI, from the time the person requested till he/she gets advice or medicine prescription is accomplished by The Knowledge-based system. According to the methodology adopted for this study, such system is developed at three stages, which include knowledge acquisition perspective, diagnosis representation perspective and performance measurement perspective. The knowledge acquisition perspective will be discussed in the remainder of this chapter. The other two perspectives will be illustrated on the next consecutive chapters. For the purpose of this study, this Knowledge-based system is named as **Se**xual **T**ransmitted **I**nfections **Kn**o**w**ledge **B**ase **S**ystem (SeTIKoBS).

4.2. Knowledge Acquisition for SeTIKoBS

Knowledge acquisition is the process of acquiring the knowledge from human experts or other sources e.g. books, manuals etc. It can be thought of as a model of the expertise of the best practitioners of the field (Brule, 1986). Aroyo (2006) suggests that clearly understanding the existing system and identifying the actual problem can help to design the right solution which ultimately alleviate the knowledge bottleneck in that field. In this research, various experts in the health system including drug advisors, HIV counselors and psychologists were involved to explore the dimension of STI. Of these, to acquire knowledge for the use of this research, only four STI experts are

selected using purposeful sampling technique. These experts were selected primarily because: 1) all of them use the same guideline (syndromic approach) which is the base for this research and 2) if one is busy then the other experts can be involved without delay. Table 4.1. presents the profiles of the domain experts that were identified in order to select the right expert in the domain area.

Level of Education	**Sex**	**Position**	**Work exp-erience**	**Reference Used**
Nurse 12+2	Fem-ale	Health Center STI focal person	21 year	MoH guideline
Medical Doctor	Fem-ale	Out Patient Clinic Examiner	4 year	MoH guideline
Internist	Male	Out Patient Clinic Examiner	19 year	MoH guideline but Differ in treatment.
STI specialist	Male	STI focal person (NGO)	25 year	MoH guideline + other Approach for complication

Table 4.1. Professional Profiles.

Discussions with the experts indicate that all experts generally undertake STI diagnosis using the guideline developed by MoH (2006) though some differ in treatment prescription. In addition to the experts, additional knowledge has been obtained from Internet, books, guidelines and manuals (Brounward et al., 2001; Dallabeta & Garbesa, 1998; Stuart et al., 1992). From the knowledge gathered and confirmation from the experts, the five most commonly encountered STI syndromes are urethral discharge, genital ulcer, vaginal discharge, lower abdominal pain in women and inguinal bubo. And of the 19

(nineteen) general risk/symptom assessment questions, through consultation with the experts, it was possible to come up with only eight (8) questions. These questions are presented in Table 4.2.

4.3. Conceptual Modeling

Conceptual modeling is a central activity in knowledge base system construction. According to Anteneh W. (2004), a knowledge model provides an implementation independent specification of knowledge in any application method. It is a representation of domain-specific knowledge in the manner in which the expert thinks" (Christer, 1991). Here, a flowchart is used to model the common STI syndromes. The advantage of using a flowchart modeling is easy to use and simplicity to suggest clear decision (MoH, 2006). Each flowchart consists of the following three steps.

a) The clinical problem: is what a patient complains of, (i.e. the patient's symptoms).
b) The decision that needs to be taken: this is the box, which requires further information.
c) The action to be carried out: each of the exit path leads to an action or do box. This is the box that instructs the patient what action to take.

The flowchart starts at the clinical problem box and works through step-by–step until it arrives at an exit box at the end of a branch. In the next part, the conceptual model for risk/symptom awareness questions and the flowchart for the common STI syndromes are discussed. During modeling of each flowchart, one of the four experts is involved in the building process.

4.3.1. Risk/Symptom Assessment

STI generally reflect risk behavior because most curable STI are usually of relatively short duration of symptoms or/and some of them are asymptomatic. So, delivering in increasing risk/symptom awareness is one of the program objectives in diminishing the pervasiveness of the disease. Table 4.2. shows the screening questions used in order to provide the best care for the patient and to understand the risk for certain infections. This is necessary for the system to talk about the patient's sexual behavior and to explain the risk/symptoms awareness (FHI, 2001).

No	Sexual Behavior Screening Questions	Response
1	Do you know any person he/she might have an STI?	Yes/No
2	Have you begun having any kind of sex yet?	Yes/No
3	Have you ever had any STI like genital ulcer, discharge, lower abdominal pain and inguinal swelling?	Yes/No
4	Have you ever injected your self ("shot up") with narcotic drugs?	Yes/No
5	Has your sex partner had any STI?	Yes/No
6	Have you recently developed urethral or vaginal discharge, genital sour (ulcer), lower abdominal pain or inguinal swelling?	Yes/No
7	Has any part of your body been sexually exposed to an STI?	Yes/No
8	Would you like to be tested for STI today?	Yes/NO

Table 4.2. Eight STI Risk Assessment Questions

These series of questions are asked to whoever triggers the system. They can enable to determine the client's risk exposure and also used as a gate to enter the system as shown in figure 4.7. If the client responds an affirmative answer then the system will provide appropriate explanation, diagnosis and plausible solution for specific problem, as needed. These problems include five most commonly encountered STI syndromes: inguinal bubo, genital ulcer, urethral discharge, vaginal discharge and lower abdominal pain in women.

4.3.2. Inguinal Bubo Syndrome (Swollen Glands)

Inguinal bubo is a painful swelling of the lymph nodes in the inguinal (groin) region. The common sexually transmitted pathogens that are associated with inguinal bubo include C. trachomatis, H. ducreyi and C. granulomatis both in men and women (MoH, 2006). A bubo is usually painful, warm and tender when palpated. There may be one large mass or a collection of smaller painful swellings. The detail assessment of inguinal bubo is depicted in figure 4.2.

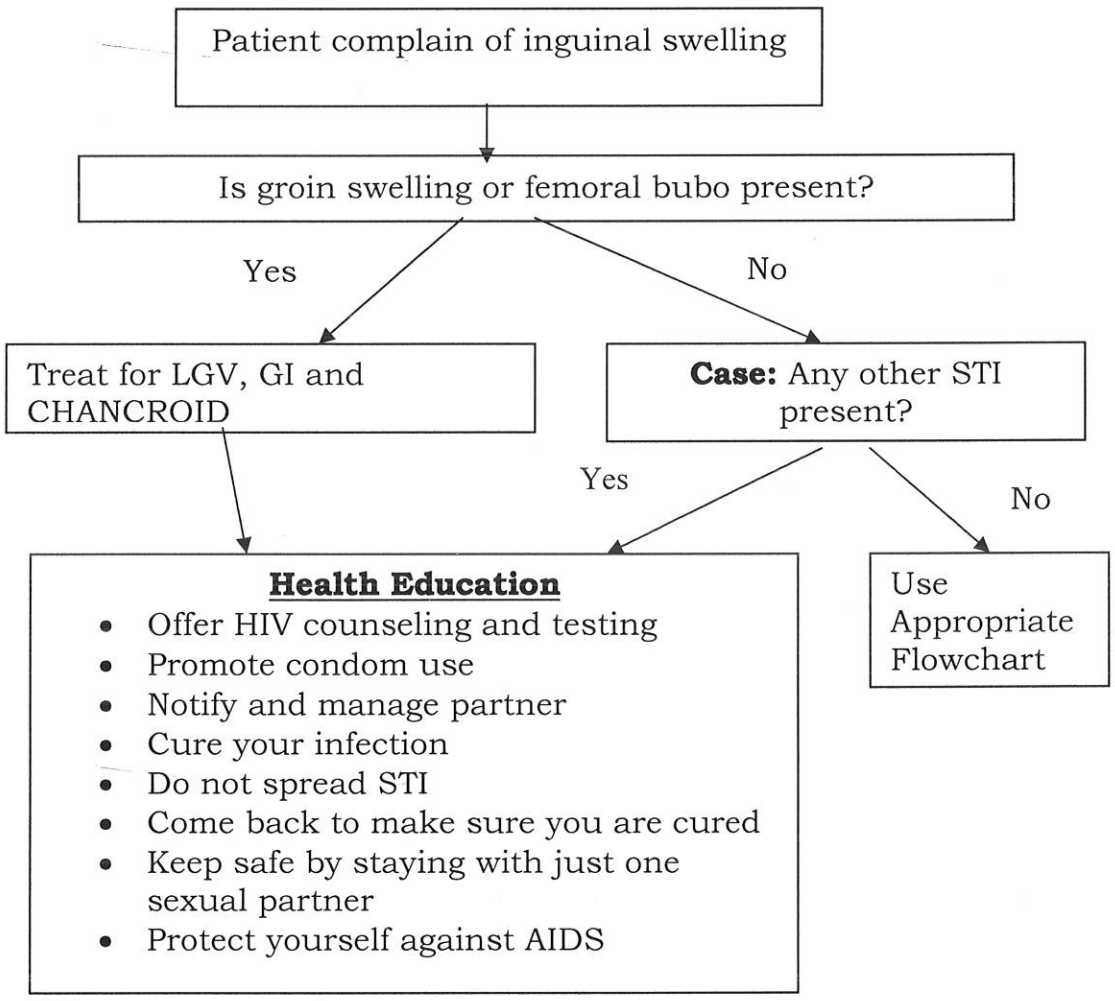

Figure 4.2. Flowchart for Inguinal Bubo

4.3.3. Genital Ulcer Syndrome

Genital ulcer is ulcerative lesion of the genitalia in men and women. The common types of lesions include primary syphilis, Genital herpes, Chancroid, Lymphogranuloma Venereum and Granuloma inguinale (MoH, 2006). Figure 4.3.illustrates the flowchart of Genital Ulcer syndrome.

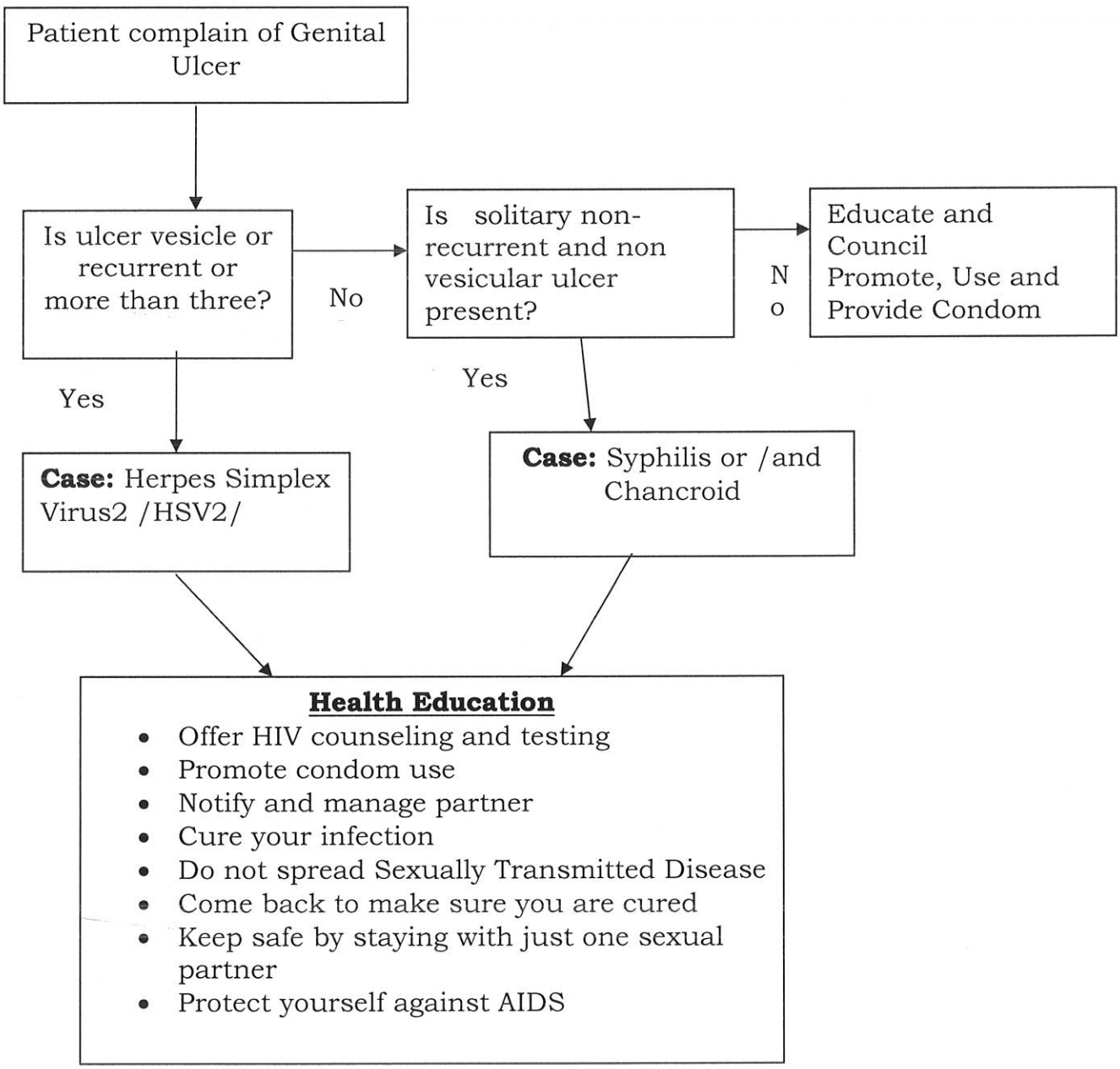

Figure 4.3. Flowchart for Genital Ulcer

4.3.4. Urethral Discharge Syndrome

Urethral discharge is abnormal discharge symptom from men's genital, mostly caused by Gonococcal and Chalmydial infections. Tricomonas vagenalis is also other cause for urethral discharge in male (MoH, 2006). Figure 4.4 demonstrate the flowchart of urethral discharge in male.

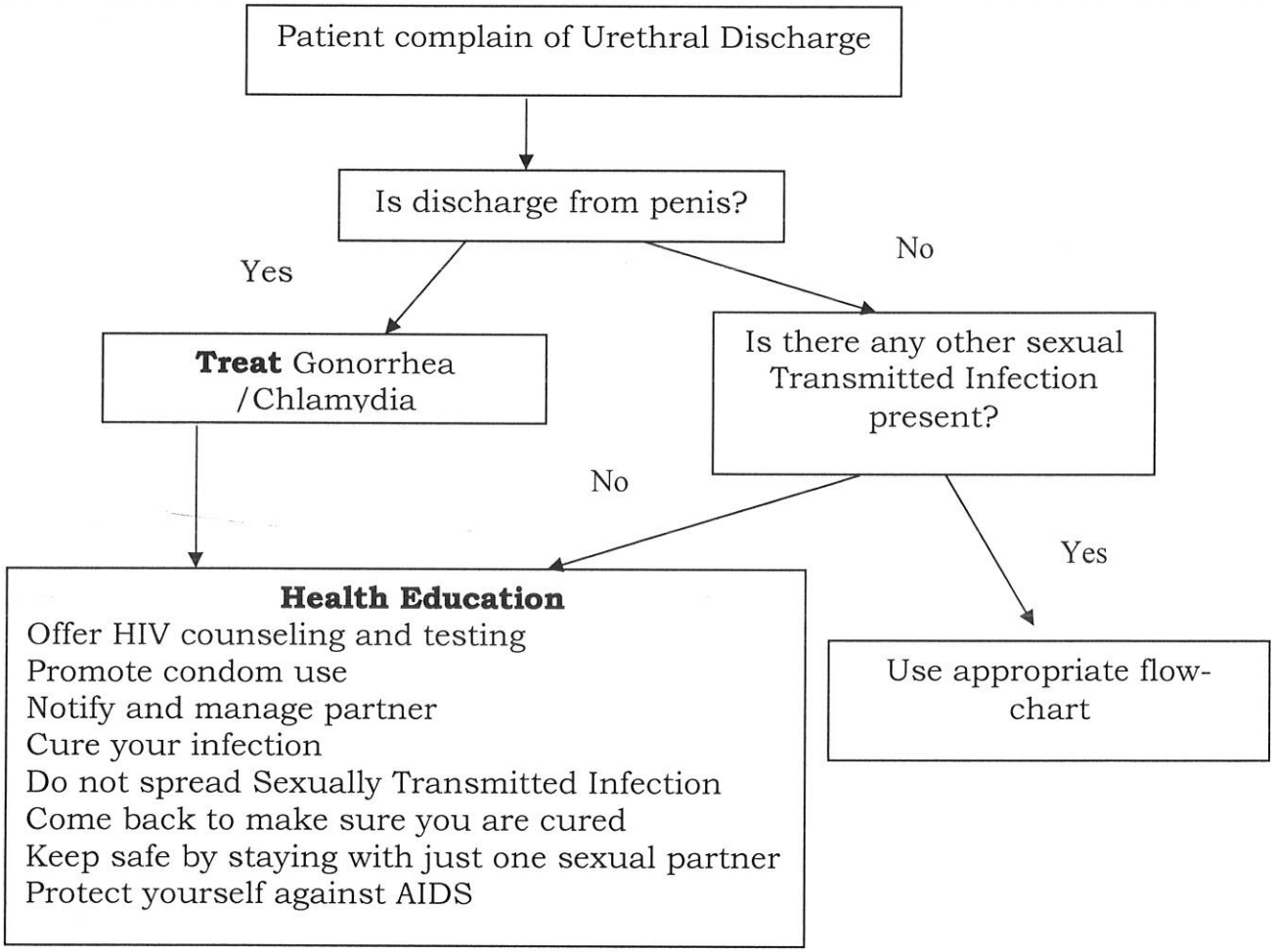

Figure 4.4. Flowchart for Urethral Discharge for Male

4.3.5. Vaginal Discharge Syndrome

According to Dallabeta (1998), the common causes of vaginal Discharge are

1. Neisserial gonorrhoeae
2. Chlamydia trachmatis
3. Trichomonas vaginalis
4. Gaardnerella vaginalis
5. Candida albicans.

The first two cause cervicitis (severe inflammation of the cervix) while the last three cause vaginitis (inflammation of the vagina). Many women have normally a small amount of vaginal discharge which is clear and odorless. It becomes abnormal if the woman notices a change in the amount, color or odor of the discharge. A patient can not differentiate between cervicitis and vaginal disorder. But often complains of vaginal discharge, which may represent either vaginal or cervical disorder. Figure 4.5 shows the flowchart for vaginal discharge syndrome.

4.3.6. Lower Abdominal Pain Syndrome

The term Pelvic Inflammatory Disease (PID) refers to infections of the female upper genital tract: the uterus, fallopian tubes, ovaries or pelvic cavity. It occurs as a result of infection going through the cervix. It can be caused by gonorrhea, chlamydia and some anaerobic bacteria. PID includes endometritis (inflammation of the mucous membrane of the womb), salpingitis (inflammation of the fallopian tube), tubo-ovarian abscess, oophoritis (inflammation of the ovary) and pelvic peritonitis (inflammation of the line membrane of the abdomen peritoneum). Women with PID usually have history of lower abdominal pain (Brounward et al., 2001). Figure 4.6 below shows the flowchart for lower abdominal pain syndromes.

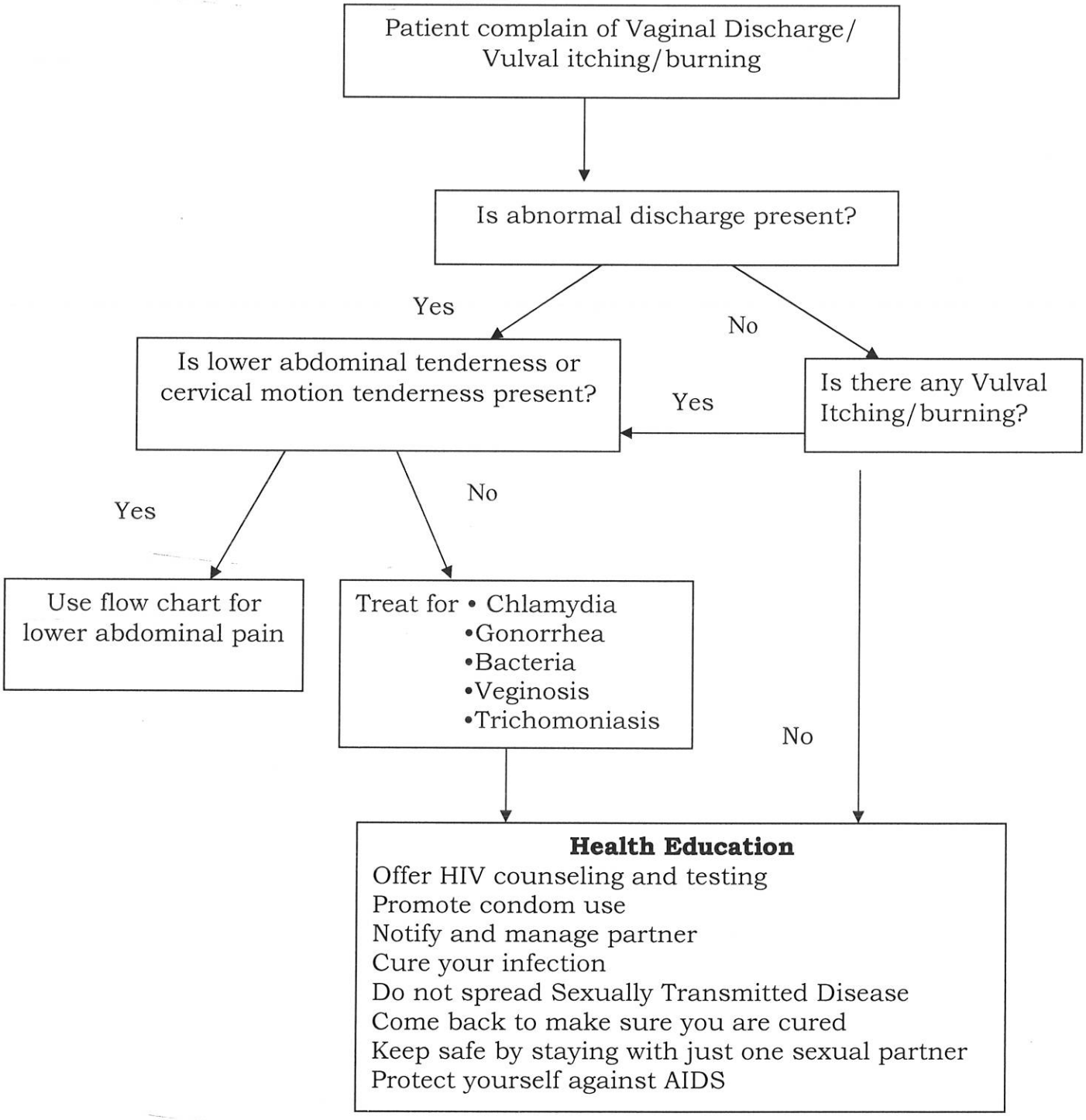

Figure 4.5. Flowchart for Vaginal Discharge for Female

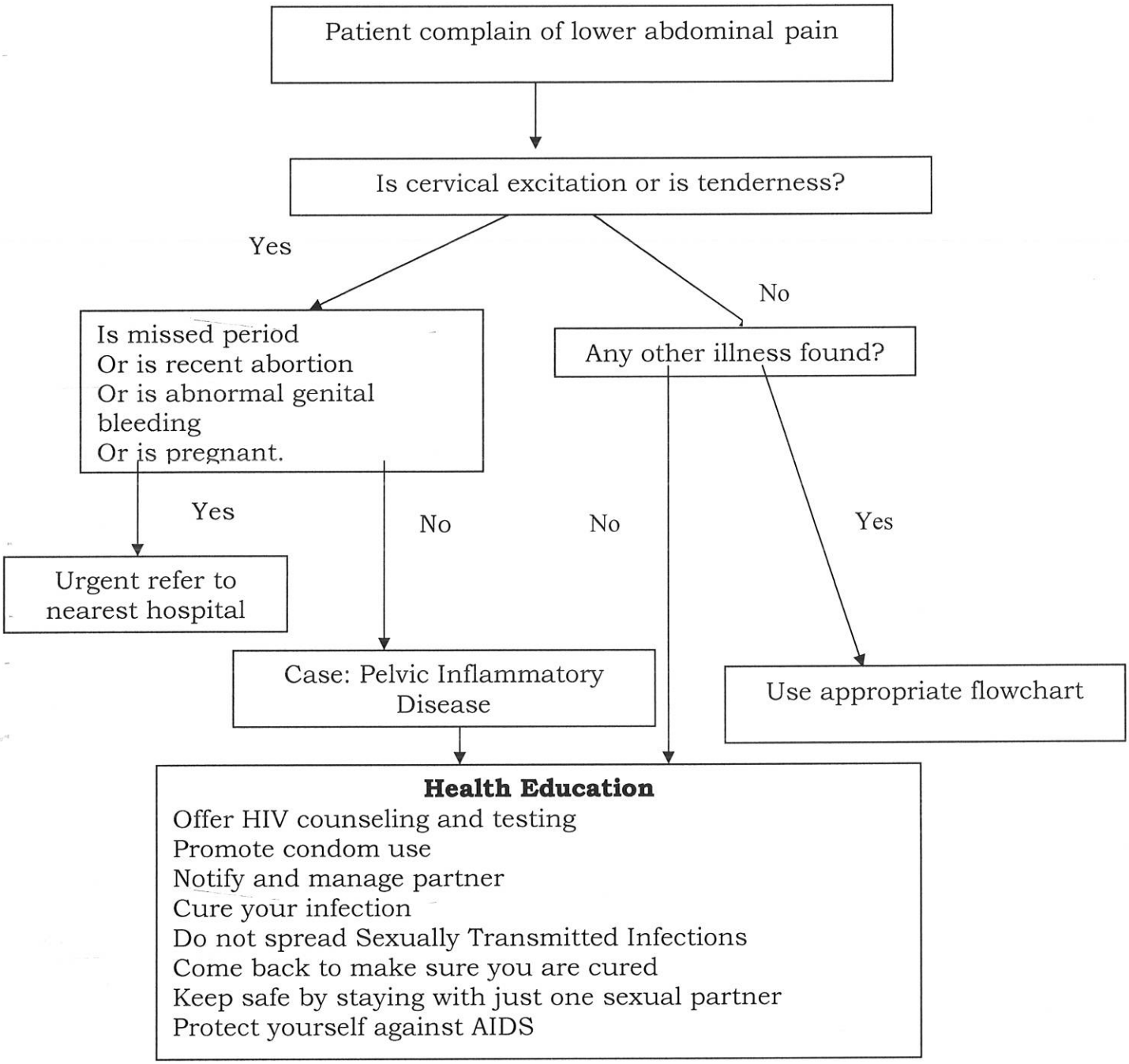

Figure 4.6. Flowchart for lower abdominal pain in Female

4.4. Evaluation of the Conceptual Model

After developing the conceptual model, per the methodology adopted for the development of SeTIKoBS, the models were evaluated with domain experts who helped in the knowledge development stages of SeTIKoBS. Unstructured interviews were employed for this purpose. The objectives for the evaluation carried out include the following:

- To check whether any knowledge has been missed during the knowledge acquisition phase of the system's development. In particular, to identify and amend any errors or aspects of SeTIKoBS which are confusing or misrepresented. This includes checking that the embedded knowledge is consistent with that of the experts.
- To refine some vague models which were not clear for the researcher. The intention here is splitting syndrome of the same type for those which have mutually exclusive symptoms or symptom which need different management.

From this perspective, the models are initially introduced to the experts when the diagnostic component could perform a small amount of tasks in a stable way. And slight modifications are applied in each model. For example, if a patient acquires more than one sexual transmitted infection syndromes at present then the system should advice the patient to use appropriate flowchart after diagnosing the first syndrome. After this, the researcher clarifies two major questions to check whether the knowledge was consistent with that of the experts. Each question is explored as follows.

1) Splitting causes of genital ulcer syndrome

In genital ulcer syndrome, there are two diagnostic cases. The first case is Herpes Simplex Virus2 which has symptoms of vesicular ulcer, recurrent ulcer or more than three ulcers present. And the second diagnostic cases are syphilis and chancroids which have symptoms of no vesicular ulcer, nonrecurrent or less than three ulcers present. Both cases are mutually exclusive and have no common symptom but they are treated in general as the causes for genital ulcer syndrome. In this case, all experts agreed to split genital ulcer syndrome into genital ulcer syndrome1 as Herpes Simplex Virus2 and genital ulcer syndrome2 as syphilis or chancroids.

Here Splitting is important to minimize treatment overload by dividing genital ulcer syndrome treatment into genital ulcer syndrome1 treatment and genital ulcer syndrome2 treatment.

2) Splitting symptoms of lower abdominal pain

In lower abdominal pain syndrome, there are two types of symptoms which need further classification for easy management. The first group symptoms include cervical excitation or lower abdominal tenderness which is treated in local health facilities and the second group symptoms include recent delivery, abortion, known pregnant or abnormal vaginal bleeding in which the treatment is urgent referral. Here the question is, what is the treatment of both symptoms if it appears in a single patient? In this case, all experts agreed to split the first group symptoms as PID (Pelvic Inflammatory Disease) and the second group symptoms as acute PID. And if a patient has any one of acute PID symptoms, then the management is urgent referral regardless of PID symptoms. Here splitting is important to emphasize for patients who needs urgent management.

After this discussion, the models are generalized as depicted in figure 4.7., which represents the wide-ranging paths that indicate the logical view for the diagnosis and management of common STI using syndromic approach.

Taken together, in this chapter, the transformation process of acquiring required knowledge from human experts or other sources for the purpose of building SeTIKoBS has been discussed. In the next chapter, the method used to encode the knowledge acquired for use by SeTIKoBS (i.e., the knowledge representation perspective) will be illustrated.

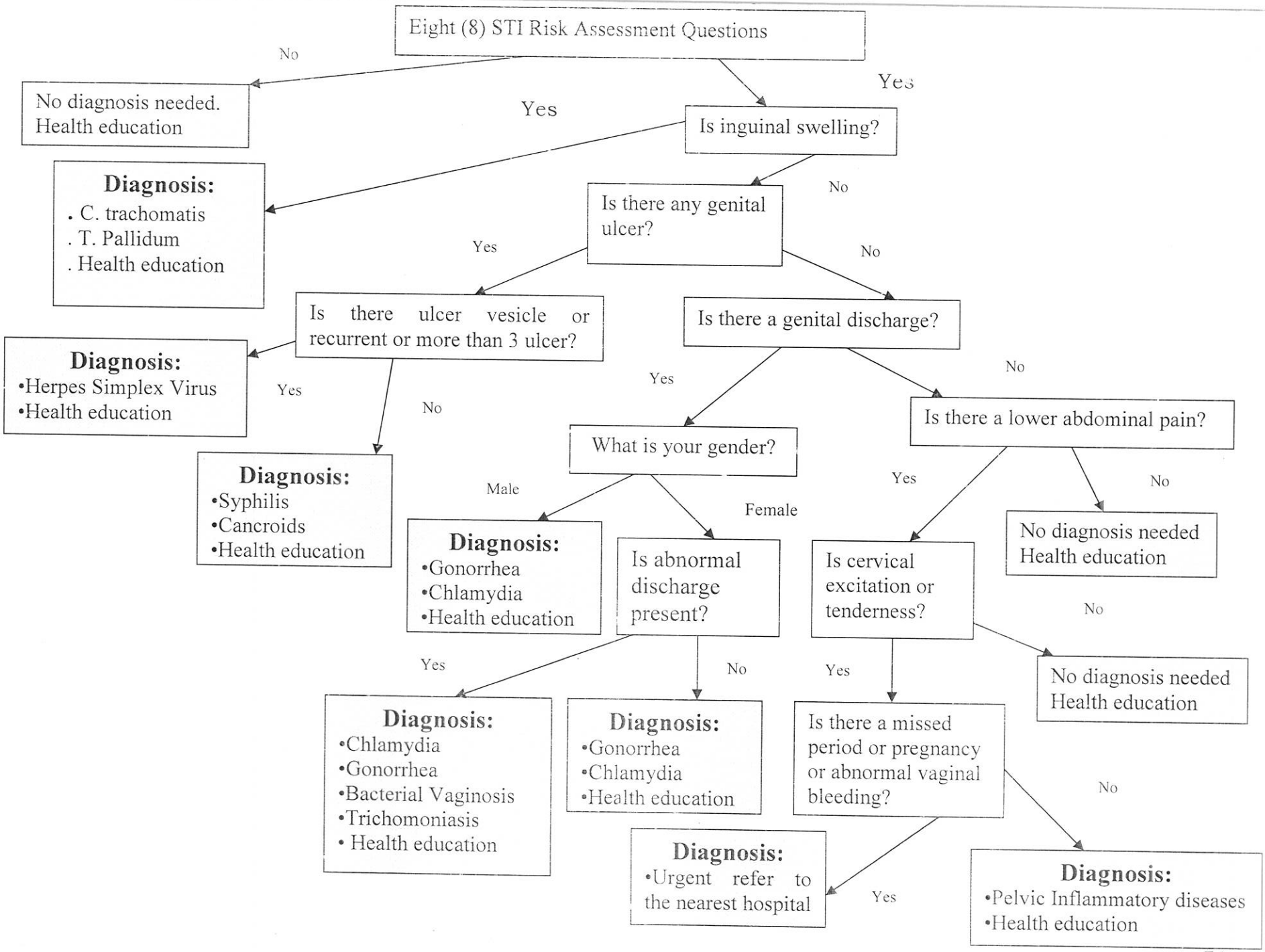

Figure 4.7. Logical View for Syndromic Diagnosis of STI

CHAPTER FIVE

5. Knowledge Representation

5.1. Introduction

In the knowledge acquisition phase, we have discussed: how knowledge is elicited and the procedure of structuring that elicited knowledge from the experts. The corresponding knowledge model has also been developed using the top-down approach of hierarchical structure. The model developed is used as a general outline to design the knowledge base. In this chapter SeTIKoBS knowledge representation perspective will be discussed.

Knowledge representation is a method used to encode the knowledge for use by the expert system or it is putting the knowledge into rules or cases or patterns in the knowledge representation process (Rich & Knight, 1991). According to Aroyo (2006), it is a method of storing and processing knowledge in computer. Common knowledge representation methods include rules, frames, and cases. In this study, the widely applied representation called production rule or simply rule is used to organize the knowledge acquired. Rule-based system is chosen as a knowledge representation language because 1) it has advantages of naturalness of expression, modularity and restricted syntax (Brule, 1986) and 2) Production rules are one of the most popular and widely used knowledge representation languages in medicine (Ignizio, 1991).

A rule consists of an IF part and a THEN part (also called a *condition* and an *action*). The IF part lists a set of conditions in some logical combination; consequently, the THEN part can be concluded, or its problem-solving action taken. Expert systems whose knowledge is represented in rule form are called *rule-based systems* (Waterman, 1986). Currently, it is the most common form of expert system in medicine because the rules are made up of separate modules that can be rearranged, replaced, combined, or interchanged easily and it has naturalness of expression (Waterman, 1986; Brule, 1986).

As stated in the literature part, (see for example, Engelmore & Feigenbaum, 1993b; Coiera, 1994) structure of a rule based expert system consists of

- Knowledge-base; which stores knowledge in the form of a set of IF-THEN rules which makes it a rule based expert system;
- Inference engine; a general problem-solving knowledge or method which contains the interpreter and the scheduler;
- Explanation facility; which relates to the ability of the system to reason with rules and data which are not precisely known, and to explain the reasoning process that it used to reach a recommendation; and
- User interface; which relates to the portion of the code which creates an easy way of using the system.

As a shell, Prolog shell provides the above mentioned rule-based ES features which are suited for developing SeTIKoBS. While three of the structural components of a rule-based expert system are discussed in the remainder of this chapter, the user interface will be dealt with in the next chapter.

5.2. Knowledge-base for SeTIKoBS

SeTIKoBS knowledge-base is the collection of much of the problem solving knowledge in sexual transmitted infections using syndromic approach which contains rules of the form IF condition THEN action. Knowledge representation clarifies how the acquired knowledge is represented in the rule based system. The following account presents the way acquired knowledge is represented in SeTIKoBS as rule-based expert system that helps to build a production system in which rules encode expert knowledge (Coiera et al., 1994).

5.2.1. IF-THEN Rules

IF-THEN rules are the most common ways to represent knowledge. Premises or condition are put under the IF clause and conclusions are put under the THEN clauses. The following shows an IF-THEN rule based system in diagnosing patients using sexual transmitted infections syndromic approach by the common symptoms in the knowledge-base.

Rule 1:

If you are free of the risk assessments of STI questions indicated in Table 3.2.

Then You are not infected with Sexually Transmitted Infections.

Else You are suspected as infected with Sexually Transmitted Infections.

Rule 2:

If you are suspected as infected with Sexually Transmitted Infections and

If you have ulcer in your genital area and

If your ulcer is recurrent and more than 3 vesicular:

Then your case is Herpes Simplex Virus2

Else your case is Syphilis or Cancroids

Rule 3:

If you are suspected as infected with Sexually Transmitted Infections and

If you have abnormal genital discharge different from semen and

If you are male

Then your case is Gonorrhea or Chlamydia or both.

Else If you are female and

If abnormal discharge present

Then your case is Gonorrhea or Chlamydia or Tricomonasis or

Bacterial vaginosis or any of combination.

Rule 4:

If you are suspected as infected with Sexually Transmitted Infections and

If you have lower abdominal pain and

If cervical excitation is tenderness and

If you suffer in missed period, recent abortion, known pregnancy,

abnormal vagina bleeding or recent delivery

Then Refer to hospital (urgent)

Else your case is Pelvic inflammatory disease

Rule 5:

If you are suspected as infected with Sexually Transmitted Infections and

If you have lower abdominal pain and

If you do not suffered with cervical excitation or tenderness

Then your case is out of the domain

Rule 6:

If you are suspected as infected with Sexually Transmitted Infections and

If you have inguinal bubo

Then your case is Lympho Granuloma Venerelium or Chancroid.

Rule 7:

If you are suspected as infected with Sexually Transmitted Infections and

If you have no discharge and

If you have no ulcer and

If you have no lower abdominal pain

Then your case is out of the domain.

These rules are some of the lists included here as representatives in SeTIKoBS knowledge-base. The action part of the system comprises the output which is caused by the fired rule. For example, if the syndrome is inguinal bubo then the corresponding treatment and health education is indicated as:

a) Treatment

The treatment of inguinal bubo syndrome is ciprofloxacin 500 bid for 03 days. PLUS doxycycline 100 mg po bid for 14 days or erythromycin 500mg qid for 14 days if the patient is contraindicated to doxycyclin.

b) Health education

The action part of health education is 'Please take your treatment properly, otherwise you will develop STI complication, search and get HIV counseling and testing, use condom and provide for others, please notify and manage your partner(s) otherwise, you will not cure even though you take the given medication. Return and check after completion of treatment to check whether you improve or not.'

However, in Prolog the syntax is really THEN IF, and the normal Right Hand Side and Left Hand Side appear on opposite sides. That is,

conclusion:-
first_premise,
second_premise,
...

So this is a bit confusing since the rule-base system use a normal IF THEN format. For example, to identify a particular syndrome in SeTIKoBS using the normal IF THEN format, one would state;

IF symptom is abnormal urethral discharge and

IF gender is male

THEN syndrome is urethral discharge.

The implementation of the same rule in Prolog would be:

Syndrome(urethral_discharge):-

symptom(abnormal_urethral_discharge),

gender(male).

The following rules distinguish between two types of genital discharge syndrome. They are clauses of the predicate **syndrome/1**:

syndrome(genital_ulcer1) :-

do_you_have(vesiclarUlcer_recurrent_moreThan3Ulcer),

diagnose(herpes_Simplex_Virus),treatment(herpes_Simplex_Virus).

syndrome(genital_ulcer2) :-

do_you_have(nonVesiclarUlcer_nonRecurrent_lessThan3Ulcer),

diagnose(syphilis/chancroids),treatment(syphilis/chancroids).

In order for these rules to succeed in distinguishing the two syndromes, we would have to store facts about a particular syndrome that need identification in the program.

For example, if we added the following facts to the program

do_you_have(abnormal_urethral_discharge), gender(male).

then the following query could be used to identify the syndrome:

?- syndrome(X).

X = uretheral discharge.

5.2.2. A Simple Shell

An expert system shell is an expert system with an empty knowledge-base, i.e. an inference engine, user interface module, explanation module, knowledge

base (rule) editor etc. For example, EMYCIN is the shell of MYCIN[1]. It is important to start with a shell with a suitable control strategy (Simon, 2007). SeTIKoBS has two distinct control strategy parts: the knowledge base, which contains the specific information about syndrome identification; and the predicates which control the user interface.

By separating the two parts, a shell can be created which can be used with any knowledge-base. The minimal change needed to break the two parts into two modules is a high level predicate which starts the diagnosing process.

Since in general it is not known what is being diagnosed, the shell will seek to solve a generic predicate called **top_goal**. Each knowledge base will have to have a **top_goal** which calls the goal to be satisfied. For example:

top_goal(X):- syndrome(X).

This is now the first predicate in the knowledge base about syndromes. The shell has a predicate called **solve**, which does some housekeeping and then solves for the **top_goal**.

It looks like:

```
solve:-
abolish(known, 3),
top_goal(X),
write('The syndrome is '), write(X), nl.

solve:-
write('Well! Come back when necessary.'), nl.
```

[1] MYCIN: developed in mid 1970th which provide assistance to physicians in the diagnosis and management of infectious disease and the suggestion of suitable therapies.

The built-in **abolish** predicate is used to remove any previous **known**s from the system when a new consultation is started. This allows the user to call **solve** multiple times in a single session.

The **abolish** predicate is a built-in predicate which removes previous **known**s for a new consultations, and ensure that **known** is defined to the system so no error condition is raised the first time it is referenced.

To summarize this, as indicated in figure 5.1., the predicates of SeTIKoBS have been divided into two modules; namely: The Native predicate and the Supporting predicate.

The Native predicates, the predicates which are in the shell, are:

go – starts the conversation with SeTIKoBS;

solve - starts the diagnosis;

ask - poses simple questions to the users and remembers the answers;

menuask - presents the user with a menu of choices;

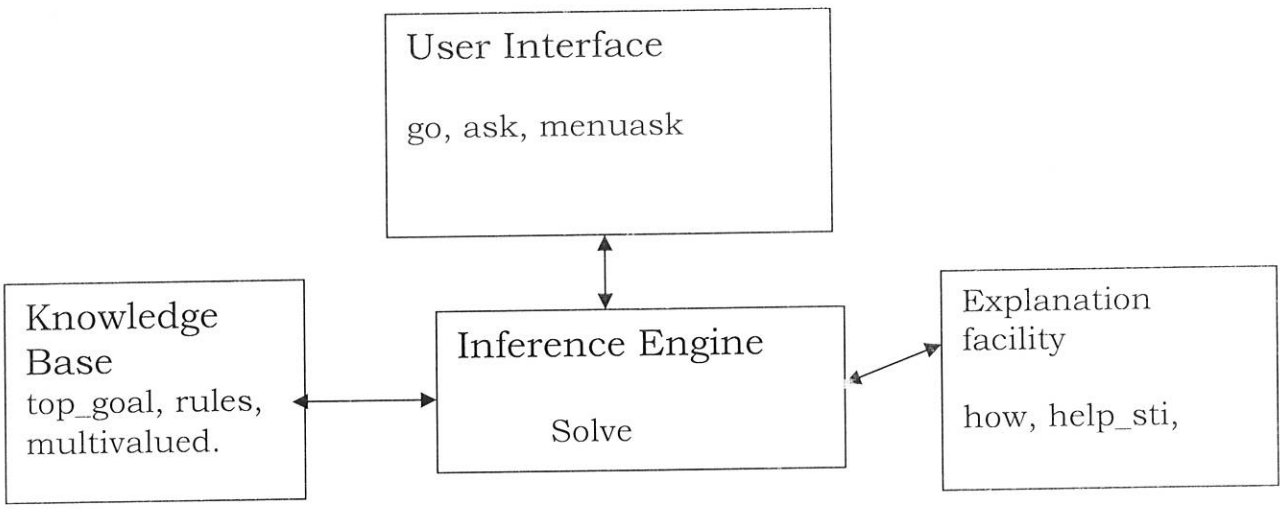

Figure 5.1. Major predicates of SeTIKoBS Prolog shell

The supporting predicates for the above three predicates which are in the knowledge base are:

top_goal - specifies the top goal in the knowledge base;

rules- represent the knowledge in the knowledge base. For example **syndrome, diagnose, risk assessment** etc.

multivalued - defines attributes which have multiple values.

5.3. Inference Engine

Inference Engine is a general problem-solving knowledge or method which the interpreter analyzes, and it processes the rules and the scheduler determines which rule to look at next. There are two type of reasoning employed: i) data-driven reasoning, or forward chaining, which involves chaining of IF-THEN rules to form a line of reasoning that starts from a set of conditions and moves toward some conclusion.

ii) The other type of reasoning is goal-driven reasoning or backward chaining, which is an efficient way to solve problems that can be modeled as "structured selection" problems (Russell and Norvig, 1995). That is, the aim of the system based on this type of reasoning is to pick the best choice "finding_goal" from many enumerated possibilities. For example, diagnostic systems can fit this model, since the aim of the system is to pick the correct diagnosis (Engelmore & Feigenbaum, 1993a).

SeTIKoBS Goals

Possible goals are derived by combining the five syndromes and the risk assessment questions stated in the knowledge acquisition part. We come up with these goals by counting the syndromes which are identified in the previous chapter and the outcomes of the risk assessment questions. Based on these, SeTIKoBS goals include the following:

Goal1: inguinal_bubo

Goal2: genital_ulcer1

Goal3: genital_ulcer2

Goal4: urethral discharge

Goal5: vaginal_discharge

Goal6: lower_abdomenal_pain1

Goal7: lower_abdomenal_pain2

Goal8: not_indicated_here

Goal9:nothing_is_detected

Goal10:no_syndrome.

Prolog has a built-in backward chaining inference engine. This engine is used to derive conclusions using simple backward chaining. Each rule has a goal and a number of sub-goals, and the Prolog inference engine either proves or disproves each goal.

Goal-Driven Reasoning

The knowledge gathered is structured in rules which describe how each of the possibilities might be selected. The rule breaks the problem into sub-problems. For example, the following top level rule is in a system which identifies a syndrome.

IF

symptom is genital ulcer

THEN

syndrome is genital ulcer.

The system would try all of the rules which gave information satisfying the goal of identifying the syndrome. Each would trigger sub-goals. In the case of these

rule, the sub-goals of determining the ulcer would be pursued. The following rule is one that satisfies the genital ulcer type sub-goal:

syndrom(genital_ulcer1) :-

do_you_have(vesiclarUlcer; or recurrent or moreThan3Ulcer),

diagnose(herpes_Simplex_Virus),treatment(herpes_Simplex_Virus).

syndrom(genital_ulcer2) :-

do_you_have(nonVesiclarUlcer;_nonRecurrent_lessThan3Ulcer),

diagnose(syphilis/ chancroids),treatment(syphilis/ chancroids).

The sub-goals of determining nonVesiclarUlcer,_nonRecurrent_ _lessThan3Ulcer would be satisfied by asking the user. By having the lowest level sub-goal satisfied or denied by the user, the system effectively carries on a dialog with the user. And the user sees the system asking questions and responding to answers as it attempts to find the rule which correctly identifies the diagnosis.

5.4. Explanation Facility in Expert Systems

Though an expert system consists primarily of a knowledge base and an inference engine, a couple of other features are integrated like reasoning with uncertainty and explanation to answer questions. For instance

WHY do you want to know this fact? (i.e. where is the reasoning going?)

HOW did you deduce this fact? (i.e. how did we get here?).

Such explanation facilities are useful for instilling confidence in users of the expert system.

Often times in structured selection problems, the final answer is not known with complete certainty. The expert's rules might be vague, and the user might be unsure of answers to questions. This can be easily seen in medical diagnostic systems where the expert is not able to be definite about the

relationship between symptoms and diseases. In fact, the doctor might offer multiple possible diagnoses.

For expert systems to work in the real world, they must also be able to deal with uncertainty. One of the simplest schemes is to associate a numeric value with each piece of information in the system. The numeric value represents the certainty with which the information is known. The most common scheme for dealing with uncertainty is to assign a certainty factor to each piece of information in the system. The inference engine automatically updates and maintains the certainty factors as the inference proceeds. In such cases, it is easy to modify it to add the code for explanations. Using such theories to attach confidence measures to facts and to rules does not seem to be the way humans' reason with uncertainty.

When we use native Prolog, we don't have access to the inference engine. But this problem is easily solved by simply writing a Prolog inference engine in Prolog. Then, having written the inference engine, we can modify it to handle explanations. For example, the processing of **why** questions in Prolog can be handled using get_user predicate as follows:

```
get_user(X,Hist):-
repeat,
read(X),
process_ans(X, Hist), !.

process_ans(why,Hist):-
write(Hist), !, fail.

process_ans(X, _).
```

Notice that the Hist (history) is a list of goals. So by passing this history along to the **ask** predicates, the **ask** predicates can now respond to **why** questions.

The dialog with the user would look like:

?-diagnose

do_you_have: inguinal_swelling? why.

[do_you_have(inguinal_swelling), syndrom(inguinal_bubo)]

do_you_have: inguinal_swelling?

We can further use **how and whynot** questions using native Prolog which determine why an expected result was reached and was not reached. And it is easier just to rederive the answer.

But the problem is, as could be seen from the above, in the why explanation method, the explanation facility is not user friendly and most medical terms are vague. So it is difficult to explain the why questions with such short definitions. Therefore, a new mechanism is necessary to use explanation as a more practical means of handling uncertainty rather than assigning a numeric value or providing vague explanation method for users. This is because, to achieve the ultimate goal of SeTIKoBS, a user friendly explanation facility is crucial for successful STI syndrome consultation and management.

As a result, the system developed uses "how" and "help_sti" explanation facility to manage STI certainty and explanation of the given syndrome. The "how" explanation facility is used for clarifying of how the diagnosing mechanism is reached to the given syndrome and the "help_sti" explanation facility illustrate the general information about STI' including the diagnosed syndrome. In addition to this, the built-in Prolog command "help" is used as a Prolog help explanation facility for the purpose of showing the specific part of Prolog manual.

5.5. Review with Domain Experts

After representing the rules and facts using rule-based reasoning, the represented rules are discussed with the experts who were involved in the knowledge acquisition phase. The rules and the explanation facilities were

considered straight forward, so there was no objection from the experts. But the three no_type cases expressed in SeTIKoBS goal portion, namely no_syndrome, nothing_is_detected and not_indicated_here, were the major issues discussed with the experts. Actually there is no no_type of syndrome in practice but to make the Knowledge base complete these syndromes are incorporated with the system.

The no_type syndrome declaration is also helpful in defining the corresponding counseling activity. For example, the no_syndrome session will provide advice like 'Well! Come back any time as necessary.' and the not_indecated_here syndrome suggests 'your disease is beyond this system. Please contact the nearest health service if you have any problem. '

In short, the brief descriptions of no_type syndromes are as follows: no_syndrome represent a person who refuses to undertake the diagnosis session. The not_indecated_here syndrome diagnoses a patient who has STI syndrome but not indicated here. And the nothing_is_detected syndrome fired from the system when a person enters to STI diagnosis session either by saying yes to the risk exposure questions or voluntarily trigger the session but no indication or positive answer is detected by the system for every askable symptoms. The no_type syndromes are the effects of appling iterative demonstration on the system developed so that to complete the system, they are drawn as types of syndromes.

After we refined the completeness of the system, we then discussed the consistency of each syndrome. In addition to the contribution of the experts, the effect of the review done on the system made the experts considered the knowledge represented in the knowledge base were consistent with their own knowledge. In the meantime, the built SeTIKoBS code is evaluated with two information science students to check the way of the system diagnosis and advice, the correctness of the reasoning techniques used and the quality of

human-computer interaction. So, we gained valuable information that enable to enhance the quality of the system.

In general, the objective of this chapter is to use knowledge representation technique in SeTIKoBS development, i.e. the rule based system. The rule base of this system is a collection of IF-THEN rules that represents the knowledge acquired from experts in the syntax of the prolog shell, which clarifies how the acquired knowledge is represented in the rule based system. Here most of the features or structures of a rule based expert system were discussed. The next chapter will illustrate the user interface and the performance perspective of this system.

CHAPTER SIX

6. Knowledge Application and Performance Measurement

In the knowledge representation phase, we demonstrated how knowledge is modeled with the top-down approach of hierarchical structure using flowchart. The model developed is used as a general outline to design the knowledge-base which clarifies how the acquired knowledge is represented in the rule based system.

The following discussion covers the user interface aspect, which are the application of rule-based structure and the performance measurement perspective of SeTIKoBS.

6.1. User Interface

The system developed with the Prolog shell has used a command driven, dialog type user interface. Increasingly these days menus are being used to make interfaces easier to understand and work with. Using this Prolog built_in interface, users can interact with the system. Up on initiation, the Prolog interface welcomes the user to SWI-Prolog (Multi-threaded, Version 5.4.5) and provide "1? -" at the end. This indicates the successful start-up of the system.

To start the diagnosis, the user should write "**go**.", which is a top level command loop, and press the Enter key. The "**go**" predicate gives the user a quick command. At the prompt, a welcome message and the use of the system corresponding with system menus are displayed in the dialogue, as indicated in figure 6.1. After reading a command, **do** is called to execute the command.

The **go** predicate recognizes seven commands:

- **load** - Load any knowledge base;
- **dx (**abbreviation of diagnosis**)**- Consult the knowledge-base by satisfying the top goal of the knowledge-base;
- **how**-Used for explanation facility of the given diagnosis;
- **help_sti**-Provide general information about STI;
- **help**-Offer Prolog help window;
- **quit**-Exit from the diagnosis; and
- **halt** is used to stop Prolog shell.

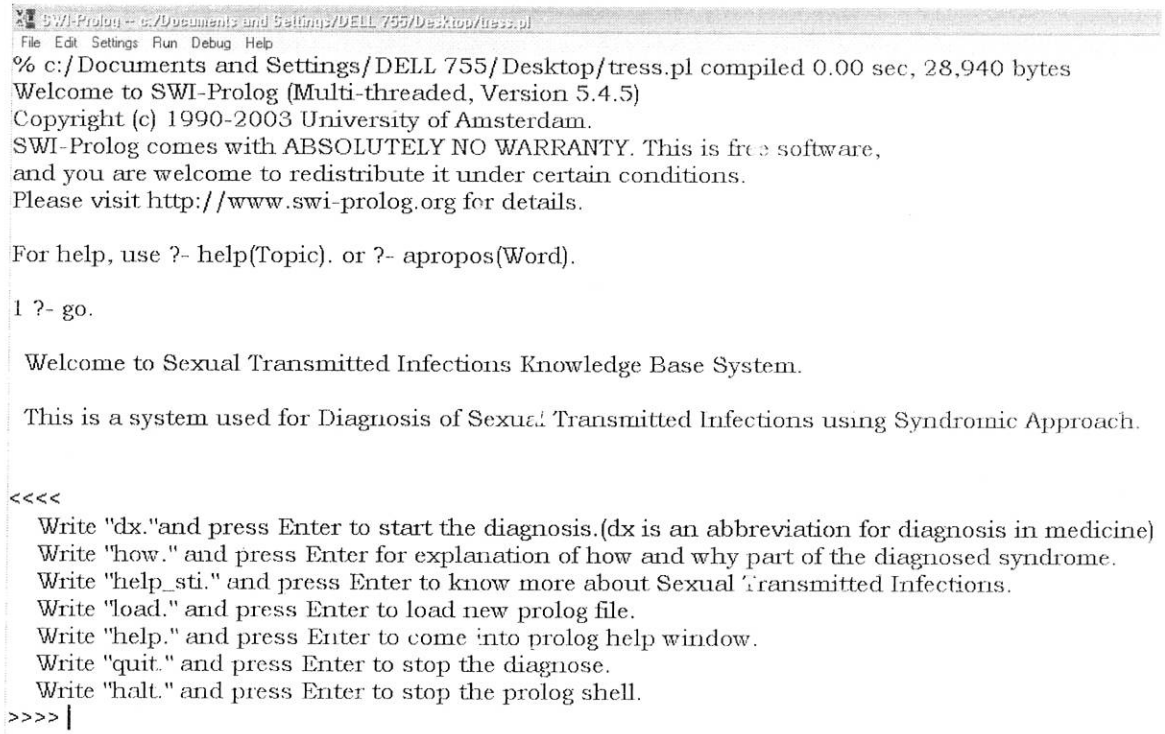

Figure 6.1. Screen shot of the menu page.

The diagnosis starts if the user selects the "dx." command. The first message during diagnosis session is asking the seven risk assessment questions. And

the system ask the user, as described in figure 6.2., whether there is at least one " yes" answer in the risk assessment evaluation.

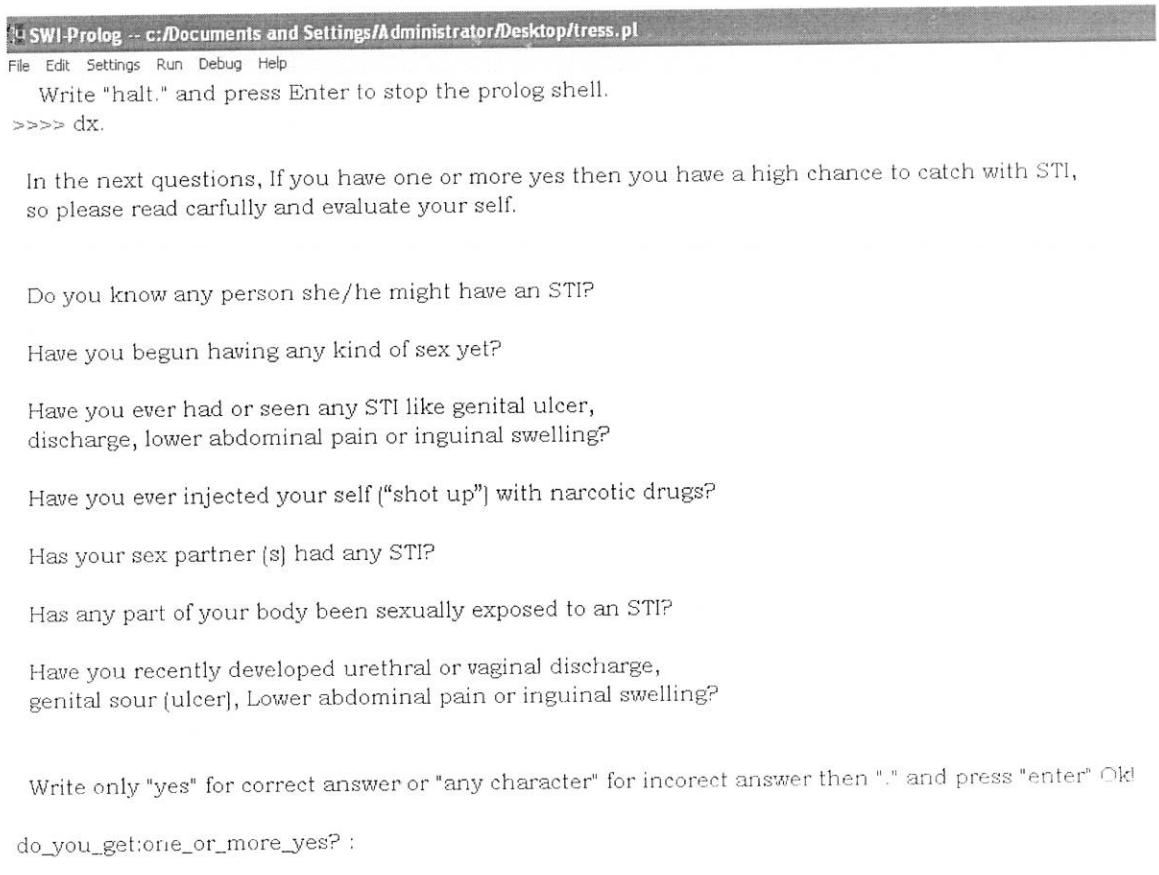

Figure 6.2. Risk assessment questions.

If the answer is "no", then the system asks permission whether the user continue the diagnosis system or not. If the user refuses to continue the diagnosis session, see figure 6.3., then the system displays a message, gives health education and the session ends.

```
Write only "yes" for correct answer or "any character" for incorect answer then "." and press "enter'

do_you_get:one_or_more_yes? : no.
do_you_like_to:test_for_sti-now? : no.


Well! come back any time when necessary.

        Health Education.

   search and get HIV counselling and Testing.

   use condom and provide for others.

   Please notify for your partner(s),If any.

   Return and check after sometime

        THANK YOU.

The syndrome is:  no_syndrome

<<<<
   Write "dx."and press Enter to start the diagnosis.(dx is an abbreviation for diagnosis in medicine
   Write "how." and press Enter for explanation of how and why part of the diagnosed syndrome.
   Write "help_sti " and press Enter to know more about Sexual Transmitted Infections
```

Figure 6.3. Diagnosing users who refuse to get the diagnosis session.

But if the answer is "yes" in the risk assessment evaluation, then the system can directly introduce the diagnosis session. At this point, the query to **top_goal** starts the program and the user is responsible for determining whether some of the attribute-values are true. The dialogue in figure 6.4. shows how the system diagnoses a specific syndrome. The predicate **ask** provides this function. The **ask** predicate has to determine from the user whether or not a given attribute-value pair is true. The program needs to be modified to specify which attributes are askable. This is easily done by making rules for those attributes which call **ask**.

For example,

do_you_have(X):-ask(do_you_have,X).

gender(X):- ask(gender,X).

are askable attributes.

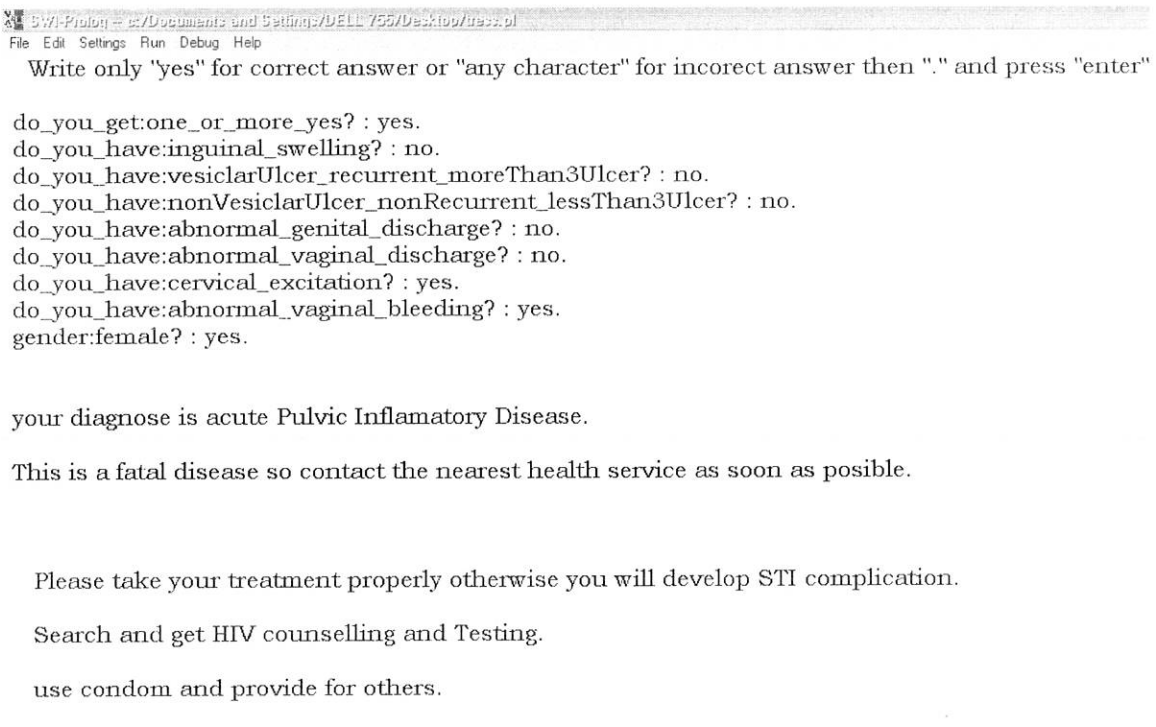

Figure 6.4. Diagnosing user who involves in diagnosis session.

The simplest version of **ask** prompts the user with the requested attribute and value and seeks confirmation or denial of the proposed information.

In addition to this, the predicate **known/3** is used to remember the user's answers to questions, and the predicate **multivalued** are letting the attributes be multi-valued. This might make sense for some attributes such as **gender** which take more than a single value. The full code is annexed in annex two.

6.2. Performance & Evaluation Test

The performance and evaluation of knowledge-based system is an important aspect of knowledge-based system development that is required to prove whether or not a system fulfils its original objectives and to provide high quality counseling and diagnosis to the users (Anumba & Scott, 2001).

As indicated in the methodology part, (Anumba and Scott, 2001), the performance measurment techniques can be split into two broad types, these are:

1. *Qualitative* – employing subjective comparisons of performance; and
2. *Quantitative*–employing statistical techniques to compare KBS performance against either test cases or human experts.

For the purpose of this study, both qualitative techniques and quantitative techniques are employed for evaluation and performance measurement.
The commonly applied qualitative techniques to evaluate KBS are outlined below (Moore and Miles, 1991; Anumba & Scott, 2001):

- *Visual interaction.* This test allows the expert to make comments while interacting with the system, altering parameters as desired.
- *Predictive validation.* This test involves the use of historic test cases. The KBS is driven by past data to obtain a set of conclusions. These conclusions are compared with that of the historic case or with expert performance.
- *Black box testing.* Information is added to a piece of code and sections of, or the whole system. Results are predicted and are compared with the actual results of the system.

These lists are not exhaustive but highlight the main techniques considered useful for the evaluation of a knowledge-based system (Moore and Miles, 1991). For this research, visual interaction and predictive validation techniques are employed to test SeTIKoBS performance. Black box or other qualitative testing techniques were not selected because visual interaction and predictive validation techniques are the commonest types of KBS performance testing (Moore and Miles, 1991); and For the time being, both selected cases are enough to test the built prototype KBS.

6.2.1. Visual Interaction

This test allows the user to make comments while interacting with the system. So the technique was applied as a first test to assess the performance of the system from the user perspective. In this regard, SeTIKoBS prototype effectiveness test was operated in selected health institutions. For this experiment the users were classified into two different groups. The first group, using random sampling technique, 12 (twelve) medical persons (junior and senior nurses) are selected from a total of 38 nurses. Of the twelve selected medical persons, using purposive sampling technique, ten experts were used as system evaluators and the other two experts, who currently posted in STI clinic, were assigned to help the second group. The second group includes nine patients and voluntary SeTIKoBS users. This group was selected and evaluated by the two experts mentioned above. Then, the prototype developed was deployed in five available standalone computers in the selected health institutions and after full explanation about SeTIKoBS, the system was evaluated. The analysis of SeTIKoBS user's performance test, the major problems of the system encountered during evaluation process and their plausible solutions are discussed as follows.

No	Syndrome Name	Gender	Correctly diagnosed	Incorrectly diagnosed
1	Inguinal bubo	1M, 2F	1	2
2	Urethral discharge	2Male	1	1
3	Genital_ulcer1	1Male	1	0
4	Lower_abdomenal_pain1	1Female	1	0
5	No Syndrome	1M, 1F	2	0
Total			6	3

Table 6.1. Patient profile for SeTIKoBS users performance test.

Analysis

From the data shown in table 6.1., of the total nine patients, six were diagnosed correctly as STI syndrome cases. And the other three were diagnosed incorrectly as STI syndrome case but it does not indicate the quality of the given model (Moore and Miles, 1991). So for better understanding, as indicated in the methodology part, we used confusion matrix.

Confusion Matrix

Confusion Matrix displays the distribution of the records in terms of their actual classes and their predicted classes. It indicates the quality of the current model (Anumba and Scott, 2001). So, to understand the given data, as indicated in the methodology part, the confusion matrix defines four parameters. These parameters, as depicted in table 6.2., are defined as :

- **Sensitivity** (also called **recall rate** in some fields) measures the proportion of actual positives which are correctly identified as such (e.g. the percentage of sick people who are identified as having the condition);
- **Specificity** measures the proportion of negatives which are correctly identified (e.g. the percentage of well people who are identified as not having the condition);
- **Positive predictive value** (ratio of true positives to combined true and false positives), which is as much a statement about the proportion of actual positives in the population being tested as it is about the test; and
- **Negative predictive value** ratio of true negative to combined true and false negative.

The matrix presented below, shown in table 6.2., indicates that: out of the total 7 instances which have a class " Positive ", 4 are correctly diagnosed, whereas, 3 of the instances are misdiagnosed. Likewise, out of 2 class "Negative" instances, 2 are diagnosed correctly and nothing is incorrectly diagnosed.

		Patients with STI Syndrome		
		Positive	***Negative***	
SeTIKoBS test	***Positive***	**True Positive = 4**	**False Positive = 3**	**Positive predictive value** = TP / (TP + FP) = 4 / (4 + 3) ≡ **57.14%**
	Negative	**False Negative = 0**	**True Negative = 2**	**Negative predictive value** = TN / (TN + FN) 2 / (2 + 0) ≡ **100%**
		Sensitivity = TP / (TP + FN) = 4/ (4+0) = 4/ 4 ≡ **100%**	**Specificity** = TN / (FP + TN) = 2 / (3 + 2) = 2 / 5 ≡ **40%**	

Table 6.2. Confusion Matrix for SeTIKoBS users performance experment.

Hence with almost equal numbers of false positives and false negatives, a positive SeTIKoBS test is in itself poor at confirming STI syndromes (PPV = 57.14%) and further investigations must be undertaken, it will though pickup 100% of all STI syndromes (the sensitivity). In the mean time, as an STI test, a negative result is very good at reassuring that a patient does not have STI (NPV = 100%) but at this initial diagnosis SeTIKoBS correctly identifies 40% of those who do not have STI (the specificity). A specificity of **40%** means that the test recognizes some healthy people as healthy. So, further investigations were undertaken to ensure high STI syndromes confirming rate and to recognize all health people as healthy. After we discussed with the experts mentioned above, the problems encountered were organized and integrated into four major classes. These are:

1. Misdiagnosing Syndromes.
2. Include new syndromes in SeTIKoBS.
3. Not diagnosing combined syndromes and
4. Make the language easy of use.

Each case is discussed below together with its solution.

1. Misdiagnosing Syndromes

As we see from the confusion matrix, out of the seven patients who are diagnosed STI syndromes, excluding no syndrome which investigates the healthy person, 42.85% of the cases are misdiagnosed. As the experts indicated, the cause of misdiagnosis is due to lack of facts that additionally differentiate the syndrome from other specific diseases.

For example, in the case of inguinal bubo syndrome, one fact is swelling of the nodes in groin region. Even though this symptom is an indicator for the given syndrome, there are other cases like infection on the lower extremities or in the perineum (body part of lower of pelvis) which produce swelling of the inguinal lymph nodes, but strictly speaking this regional enlargement should not be regarded as inguinal bubo. Besides, the same is true for urethral discharge syndrome. In this case, male semen is considered as abnormal urethral discharge.

In both cases, therefore, there should be other additional fact(s) which differentiate a syndrome from another infection or misleading information. From this perspective, SeTIKoBS is reengineered by applying additional facts to syndromes which distinguish syndromes from other diseases using the knowledge of STI experts. For instance, painful swelling of groin lymph node is a unique feature of inguinal bubo syndrome. And to discriminate semen from other discharge, it is enough to add a fact that describe about semen to the

knowledge base. Figure 6.5 and 6.6 shows the revised rule added to the rule for Inguinal bubo and Urethral discharge syndrome respectively.

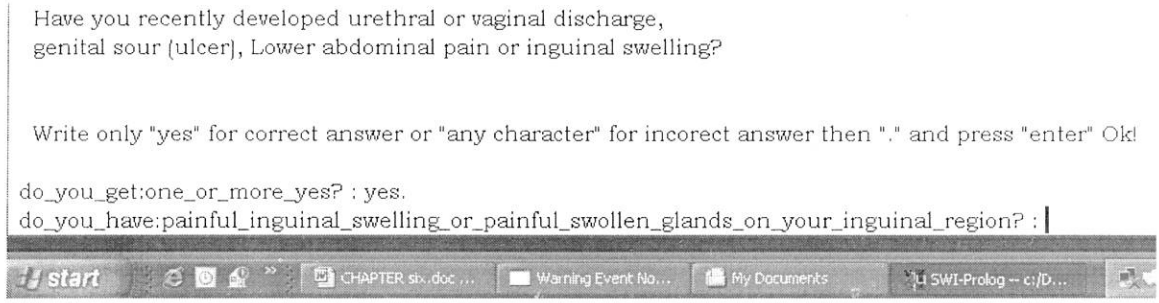

Figure 6.5. Rule added for Inguinal bubo syndrome.

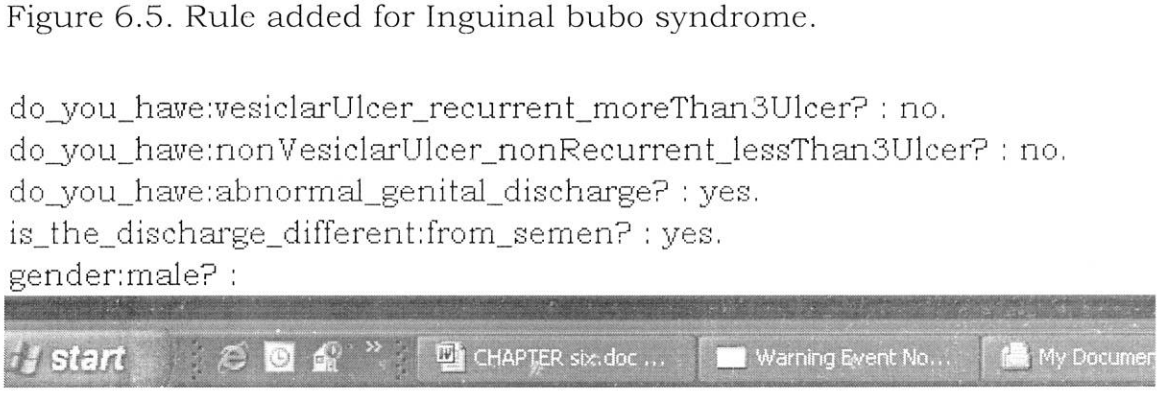

Figure 6.6. Rule added for Urethral discharge syndrome .

Using such methods it is possible to modify the rules and facts which help to make a syndrome distinct from another syndrome or any other disease. So by building up such facts, it can intensify the knowledge base to mitigate misdiagnosis.

2. Include new syndromes in SeTIKoBS

This system, as a prototype, can diagnose the most frequently seen syndromes in health facilities. But some health personnel suggest adding a new syndrome to the system whose believe is that the syndrome scrotal swelling is as important as that of the syndromes built. So building a new syndrome is the second question.

Actually SeTIKoBS provides advice for this type of question as:

"Your disease is beyond the capability of this system.

Please contact to the nearest health service if you have any problem."

And it provides "health education on risk reduction."

But building a new syndrome is as simple as that of modifying the definitions of syndromes which were undertaken above. To add a new syndrome, simply define the rules syndrome(Y), diagnose (G), treatment(Y), the corresponding health education and the explanation facility using health_education /0 and how_why(Y) respectively. Here the variables Y and G are the arguments which indicate the syndrome name and the diagnose(is) which cause that syndrome respectively. The /0 is a rule with no argument.

Then the next issue is adding the facts to the specific rules and concatenates, if necessary, to the related ask, menuask and multivalued. By adding these definitions to prolog source file, it is possible to upgrade SeTIKoBS simply, the code added to the main code is attached in annex three.

3. Not diagnosing combined syndromes

This complaint is raised from both the staff and the patient. In the conventional approach, what the experts do to solve such kind of problem is primarily to diagnose the first STI symptom complained by the patient and if there is another complaint then continue treatment of the patient until no STI symptom arises. The same is true in SeTIKoBS. Normally, once the user enters into the system, it provides menu in the user interface and unless otherwise the user uses halt or quit choice, the system can diagnose any number of syndromes using "dx" command. But not prescribing the same drug two times for combined syndromes is still the bottleneck.

4. Make the language easy to use

It is known that medical terms are vague and unclear for non medical staff. So making the terms clear in meaning or intention is the fourth question which is raised from patients. To address such problems, alternative terms were used as an option of lightening the vagueness and unclearness of the word. For example, to clarify 'inguinal bubo', the askable question which is displayed to the user is:

do_you_have:
painful_inguinal_swelling_or_swollen_glands_on_your_groin_region?:

According to the experts, one way of simplifying the phrase 'inguinal swelling' is defining inguinal swelling in other term like swollen gland in groin region or abscess between thighs and abdomen. Another possibility is using the how command in the user interface menu which helps the user by defining and exploring the given syndrome in more comfortable way.

After fixing the necessary modification to the developed SeTIKoBS, predictive validation test is involved using historical test cases.

6.2.2. Evaluation Using Test Cases

This test involves the use of historic test cases. The KBS is driven by past data to obtain a set of conclusions. As indicated in the methodology part, these conclusions are compared with that of the historic case or with expert performance. Evaluation using test cases (also referred to as predictive validation) is conducted mainly by the researcher and, at times, with experts present. The main aim of predictive validation is to test SeTIKoBS ability to diagnose STI syndromes. Using rough estimation, twenty-five historical test cases were selected from STI archives which used to compare the diagnosis of the past with that of the system and the experts. These cases were selected by

the expert evaluators using random sampling technique so that no bias would be introduced into the evaluation process.

Of these historical test cases, by stratifying the cases first and then using random sampling, one from each category is selected to use at various stages of the system development to detect errors and check that the knowledge within the system is consistent with that of the experts.

The test cases used to evaluate SeTIKoBS ability to manage STI syndromic approach are new ones which have not been used in the early stages of the system's development. Initially, the researcher entered a number of random cases from the expert's case files into SeTIKoBS. The cases were selected from STI department archives randomly. And the system generally dealt with the cases very well. Second, test cases were entered into the system by the expert evaluators. Four test cases randomly chosen by the experts, one for each expert and one from each case, were used for evaluate during this phase. These cases are briefly described below. Unstructured questionnaires were conducted, in conjunction with entering the cases into the system, to help ascertain the expert's views on specific aspects of the system's performance.

Case 1

Background: This case describes a 35 year old female patient complaining of abnormal vaginal bleeding duration of 4 hours, cervical excitation, loss of appetite, abdominal cramp and fever.

Summary of results: The system modeled the case well, although the expert would have preferred the patient to refer as urgent as possible. He commented that if a patient has recent vaginal bleeding and cervical excitation then no time should be wasted. She must have been referred to the nearest hospital as soon as possible though he believes that it was probably necessary for the patient to secure intravenous fluid for resuscitation depending on the patient's

condition. The exact interventions in the patient's history indicate the treatments as secure intravenous fluid and referral to Gandy Hospital (one of the hospitals in Addis Ababa specializing in Obstetrics and Gynecology). The system also implied intravenous fluid treatment as required with urgent refer.

The risk assessment factors are well represented within SeTIKoBS. The system doesn't consider other problems except the two symptoms which cause the system to decide on the given problem. The explanation facility and remedial advice given by the system were considered reasonable by the expert evaluator. In contrast, the expert forgot the risk assessment questions and advised to manage partner for STI case. He agreed that the system came up with the correct solution to the problem and gave the system an overall rating of 82 out of 100.

Case 2

Background: A 25 year old male patient complained of ulcer in the genital area. The ulcers were two in number and they are not recurrent.

Summary of results: The expert was impressed with the diagnosis provided by SeTIKoBS, particularly excluding Herpes Simplex Virus2 (HSV2) treatment which reduces risk of over treatment and save time for patients. According to the expert, using the conventional way, the expert diagnoses this problem as genital ulcer syndrome including HSV2. But the system diagnosed the syndrome as genital ulcer2 which exclude HSV2 because this ulcer has mutually exclusive symptoms with other ulcer causes.

The evaluator agreed fully with all the risk assessment questions and advice given by SeTIKoBS. With the amount of information required for this case, including explanation facility, she considered the system to exceed her capabilities in efficiency because in addition to the diagnosis process, this system has the ability to trace asymptomatic infections. The evaluator was

exceptionally pleased with how she was guided through the case, rating the system at 95 out of 100.

Case 3

Background: The case was a simple urethral discharge and burning sensation during urination which was reported by 19 year old patient. There was no other history.

Summary of results: Both the system and the expert diagnosed urethral discharge syndrome but they differ in the way they came up with the conclusion. In addition to urethral discharge, the expert considered burning sensation as one symptom to differentiate the diagnosis from other cases. But the system did not consider burning sensation as a symptom, rather it checked the discharge whether it is different from semen. As it was specified that burning sensation during urination is possible, not all causative agents which cause urethral discharge syndrome have burning sensation symptoms.

The risk assessment, treatment and health education were well represented in the system. Furthermore, the remedial treatment and health education recommended by the system were consistent with that of the expert. The expert considered that the system's risk assessment questions have more useful information and the health education was complete. The expert overall system rating was 85 out of 100.

Case 4

Background: In this case, a 24 year old female patient complained of flat or small nipple like tissue on the genital area.

Summary of results: Although the expert diagnosed this case as genital wart syndrome, he found it difficult to understand the system's diagnosis. Because SeTIKoBS diagnose was rather an advice like "Your disease is beyond this

system. Please contact to the nearest health service if you have such problem. And then provide education on risk reduction." This was absolutely different from the expert diagnoses.

On the other hand, the name of this syndrome given by the system was "not indicated here" which caused a little confusion during this evaluation. The main reason for this confusion is because SeTIKoBS diagnosed only the commonest type of STI. And genital wart syndrome is not common and as such is beyond the scope of this system.

But the expert believed that, the risk assessment and health education part were well represented in the system. The evaluator finally did not specify an overall rating of the system for this session.

Discussion

In general, these evaluations are used to assess SeTIKoBS performance for the task for which it is designed. When the experts are asked how well SeTIKoBS performed, the task for which it was designed, an average rating of 87.3 percent was given. The percentages used in the evaluation processes are based on the ratings given by expert's who evaluate that specific case. So the evaluation of SeTIKoBS can be considered a success because it has demonstrated that the system has coped well with the test cases, and the risk assessment and health education generated by SeTIKoBS are considered to be of a high standard.

It is also noteworthy that, as evident from the test cases, the system is able to provide (in some situations) more accurate results than that arrived at using conventional methods. In addition, the experts have also visualized how future extensions of the system will significantly improve their existing STI syndromic approach management. However, the main difficulties encountered in the evaluation were with the expert evaluators not having enough time for the

testing. This was mainly due to their busy schedule and frequent interruption of power.

CHAPTER SEVEN

7. Conclusion and Recommendations

The previous perspectives have brought to light some issues of importance in the design of Sexual Transmitted Infections Knowledge Base System. This chapter illustrates the conclusions drawn from this work and the recommendations for future work in the area.

7.1. Conclusion

Sexual Transmitted Infections (STI) are groups of diseases that are spread from one person to another mostly through sexual contact. They are among the common causes of acute illness, and even death, in the world. In order to mitigate STI, there are three approaches: namely etiological, clinical and syndromic. Ethiopia's Ministry of Health has chosen syndromic approach to manage STI. But evidences indicate that in some other developing countries this approach has little impact on STI management. In addition to this, a significant portion of the population, especially young people, still remain under information poverty about STI.

The main aim of this research work is to provide an alternative way to make comprehensive strategy of STI syndromic approach management available for those who wish this diagnosis and management, which is also hopefully suitable to the youth.

So, by integrating the knowledge-based and AI technologies, a **Se**xual **T**ransmitted **I**nfections **Kno**wledge **B**ase **S**ystem (SeTIKoBS) prototype is proposed. To build this system, required knowledge is acquired from experts and written documentations in the area. The acquired knowledge is structured in the form of hierarchy and rules are employed in order to represent the knowledge. Using the Prolog built-in interface, users can interact with the system. Moreover, the system incorporates an explanation facility.

To assess SeTIKoBS performance for the task of which it is designed, two evaluation techniques are used and an average rating of 87.3 percent was given by evaluators.

In general SeTIKoBS, as an alternative approach for the management of STI, gained advantages from all STI management approaches and reduced some drawbacks from syndromic approach. The demonstrated system minimized risk of over treatment, which is the advantage of etiological approach and the bottleneck for syndromic approach. Besides, as that of clinical approach, SeTIKoBS saved patient's diagnosis time. So these advantages granted one of the research objectives which improved upon achievement of sustainable reductions in rates of the common STI.

Moreover, by using the risk assessment questions and providing easy partner management, the system developed has the ability to trace asymptomatic infections which reinforces broader prevention behaviors that reduce risk, incidence and prevalence of both curable and incurable STI.

7.2. Recommendations

The following recommendations may be put forward to further enhance the functionality of SeTIKoBS in terms of developing the prototype into a fully matured operation system

- The Knowledge Base should be expanded through the involvement of large panel of experts, and a thorough extraction of applicable rules from WHO standard texts for the system to be of practical use world wide.
- The scope could be enlarged by way of including all syndromes, currently on diagnosis use, integrating follow up rules, and managing complications of STI and treatments.
- SeTIKoBS uses static learning. But to incorporate all needed rules in a given domain and to process incomplete and imprecise data, a self-learning system should be developed.
- Cost-Benefit Analysis should be done to objectively illustrate the worth of the Knowledge Based System.
- A database system should be designed in order to fetch, store and update data as desired.
- A way should be explored on how to integrate SeTIKoBS with currently existing health information systems.

Bibliography

- Alison Cawsey. (1998). The Essence of Artificial Intelligence. Prentice Hall, New York.
- Anonymous. Dictionary of Computing, 1986, New York: Oxford University Press.
- Anteneh Worku (2004). KBS in antiretroviral therapy, unpublished thesis for MSc in Information Science, AAU.
- Anumba C.J., Scott D. (2001).Performance evaluation of a knowledge-based system for subsidence management, Journal: Structural Survey, Volume: 19, Number: 5, pp: 222-232, MCB UP Ltd.
- Aroyo, L.(2006). Knowledge Base Systems lecture note.
  Internet address: www.win.tue.nl/
- Bishop, Peter. Fifth Generation Computers Concepts, Implementations & Uses, 1986, Chichester, England: Ellis Horwood Ltd.
- Brounward, Faud, Kasper, Hauser, Longo, Jameson.(2001).Principle of Internal Medicine.15th Edition.
- Brule, James F. (1986). Artificial Intelligence: Theory, Logic and Application, Blue Ridge Summit, PA: TAB Books.
- Christer, C. (1991). Expert systems as conceptual framework and management support system for strategic management. International Journal of Information Resource Management.
- Coiera, E. et al., 1994. The Rcle of Knowledge Base System in clinical practice.
  Internet Address: www.coiera.com/paper/munich/workshop/htm
- Cork Constraint competition center, 2003. University college cork.
  Internet address: http://www.4c.ucc.ie
- Dallabeta G, Garbesa. (1998). Syndromic Approach to STI Management. Sex transm Info:74:s1-s11
- Darlingiton, K. Basic Expert systems.

Internet Address: www.besnsg.org.uk/itin08/darling.htm

- Donald Gillies.(1996).Artificial Intelligence & Scientific Method. Oxford University Press, London.
- Edwards, Alex and Connell, N.A.D. Expert Systems in Accounting, 1989, Herfordshire, UK: Prentice Hall International (UK) Ltd.
- Efraim Turban, (1992). Expert System and Applied Artificial Intelligence. New York: Macmillan Inc.
- Englimore R.S and Feigenbaum E., (1993a) Expert systems and Artificial Intelligence WTEC Hyper- librarian.
  Internet Address: www.wtec.org/loyala/kb/cl-sl.htm
- Engelmore R.S and Feigenbaum E., (1993b) ADVANCED RESEARCH IN KNOWLEDGE-BASED SYSTEMS: INVENTING THE NEXT GENERATION
  Internet address: http://www.wtec.org/loyola/kb/c1_s5.htm
- Erikson, H., Introduction to expert systems. Linkoping university, SEWEDEN
  Internet address: www.ida.liu.se/2TDDB6/Slides/Lecture.pdf
- Expert System. Available at http://en.wikipedia.org/wiki/ExpertSystem.
- Expert System Developing Group. Pennsylvania college of Agricultural Science
  Internet Address: www.cas.psu.edu/expsystm.htm.
- Family Health International (FHI)(June 2001).Manual on HIV/AIDS Prevention and Care Department. Virginia 22201, U.S.A.
- FDRE, 1998. Policy on HIV/AIDS of the FEDERAL Democratic republic of Ethiopia. Addis Ababa.
- Forsyth, Richard, Expert Systems: Principles and Case Studies, 1984, London: Chapman and Hall Computing.
- Giarratano, J. and Riley (1998). Expert systems: principles and programming 3rd Ed. California: PWS publishing company.
- Harmon, Paul and King, David. Expert Systems: Artificial Intelligence in Business. 1985, New York: Wiley.
- Ignizio, James P. (1991).Introduction to Expert System: The Development and

Implementation of rule based expert system.

- Johonnes J.B 2004. To know or not to know: a moral reflection on information poverty. JIS, Pretoria, South Africa.
- Kamran Parsaye & Mark Chignell,(1988). Expert Systems for experts. Wiley, New York.
- Liebowitz, Jay, Introduction to Expert Systems, 1988, Santa Cruz, CA: Mitchell Publishing, Inc.
- Lucas, P. (2000). Expert Systems. In The encyclopedia of Life Support Systems of UNESCO.
- Michaelsen, Robert H.; Michie, Donald and Boulanger, Albert. "The Technology of Expert Systems" Byte; April 1985; 10(4): pp. 303-312.
- Ministry of Health (MOH), Ethiopia, 2006. Syndromic Management of Sexual Transmitted Disease –Reference manual. Addis Ababa.
- Moore, C.J., Miles, J.C. (1991), "The importance of detailed evaluation for KBS implementation in the engineering industry", Computing Systems in Engineering, Vol. 2 No.4, pp.365-78.
- Parsaye, K., Chignell, M. (1988), *Expert Systems for Experts*, John Wiley and Sons, Inc., New York, NY.
- Politecnico di Milano, ME.MO:ME.thods and MO.dels for the Territory. Helpdesk, release 1.2.
  Internet Address: www.geomemo.org
- Rediet Alemu (2006). KBS in pretest voluntary counseling, unpublished thesis for MSc in Information Science, AAU.
- Rich, Elaine and Knight, Kevin. Artificial Intelligence Second Edition. 1991, New York: McGraw-Hill.
- Russell, S. and Norvig, P., 1995. Artificial intelligence- A modern approach. Prenti Feigenbaum E., ce Hall.
- Simon L. Kendal (2007). An introduction to Knowledge Engineering. Springer, London.

- Stefic M. 1995. Introduction to knowledge Base System. San Francisco, CA: Morgan Kaufmann publishers, Inc.
- Stuart C. Shapiro, Wiley, (1992).
  Internet address: http://www.jfsoma.com/pubs/jkbooks/index/html
- Stuart J. Russel and Peter Norvig(1995). Artificial Intelligence. A Modern Approach, 2nd ed. Pearson Education Inc.
- UNAIDS/WHO, 1998. Joint United Nations Program on HIV/AIDS. Press Release, Geneva.
- Waterman, Donald A. (1986) *A Guide to Expert Systems*, Reading, MA: Addison-Wesley.
- Wentworth, A. J.,Kanus, R., &Aougab, H. (1995). Verification Validation and Evaluation of Expert System.
  Internet Address: www.fhwa.dot,gov/aard/tfvve.htm
- World Health Organization (WHO)(2001). Global prevalence and incidence of curable STI. Geneva.

Annex One

The following are some of the questions used to monitor the progress of a system:

- Is the knowledge representation scheme adequate or does it needs to be extended or modified?
- Is the system coming up with the right answers and for the right reasons?
- Is the embedded knowledge consistent with the experts?
- Is it easy for users to interact with the system?
- What facilities and capabilities do the users need?

The above questions indicate that, as the system is being constantly revised, by incorporating feedback from users and expert collaborators, the KBS evolves.

Annex Two

```
%This is a system used for Diagnosis of Sexual Transmitted Infection using
Syndromic Approach.
%to start the diagnosis write "go" then "." and press "enter". Ok!%
do_you_come(to_visit_us)
%.....Diagnosis starts.....
go :-
greeting,
repeat,nl,
write('<<<< Please enter the given choice below.'),nl,
write('  Write "dx."and press Enter to start the diagnosis.(dx is an abbreviation for
diagnosis in medicine)'), nl,
write('  Write "how." and press Enter for explanation of how and why part of the
diagnosed syndrome.'), nl,
write('  Write "help_sti." and press Enter to know more about Sexual Transmitted
Infections.'), nl,
write('  Write "load." and press Enter to load new prolog file.'), nl,
write('  Write "help." and press Enter to come into prolog help window.'),nl,
write('  Write "quit." and press Enter to stop the diagnose.'), nl,
write('  Write "halt." and press Enter to stop the prolog shell.'), nl,
write('>>>> '),
read(X),
do(X),
X == quit.

greeting :-nl,
write('  Welcome to Sexual Transmitted Infections Knowledge Base System.'),nl,nl,
write('  This is a system used for Diagnosis of Sexual Transmitted Infections using
Syndromic Approach.'),nl,nl.
```

```
do(dx) :- solve,!.
do(load) :- load_kb,!.
do(how):-how_whyy,!.
do(help_sti):-help_sti,!.
do(help):-help,!.
do(halt):-halt,!.
do(quit).

do(X) :-nl,fail.

solve :-
abolish(known, 3),
top_goal(X),nl,nl,
write('The syndrome is: '), write(X),write('.'), nl, nl.

solve :-nl,nl,
write('Well! come back any time when necessary.'),syndrome(no_syndrome),nl,
write('The syndrome is: '), write(' no_syndrome'), nl.

how_whyy:-nl,write('Choose any one of the syndrome you like to clarify. ok!'),nl,
            howy(Pl).

how_why(no_syndrome):-nl,
write('                          No syndrome '),nl,nl,
write('This indicate nothing about your Sexual Transmitted Infection(STI) status so
please understand what STI means. '),nl,
write('STI are group of diseases that are spread from one person to another mostly
through sexual contact.'),nl,
...
write('  When we come to your question, the syndrome is no because'),nl,nl,
write('    1. You have no yes in risk assessment evaluation questions and '),nl,
```

```
write('    2. You are not volunteer to test for sti now.'),nl,!.

how_why(inguinal_bubo):-nl,
write('                              Inguinal Bubo Syndrome (Swollen Glands)'),nl,nl,
write('Inguinal bubo is defined as a painful swelling of the lymph nodes in the
inguinal (groin) region. The common '),nl,
...
write('When we come to your question, the syndrome is inguinal_bubo
because:'),nl,nl,
write('    1. You have at least one yes in risk assessment evaluation questions
and'),nl,nl,
write('    2. You have inguinal swelling or swollen glands on your inguinal
region'),nl.


help_sti:-nl,
write('                              Some Facts About Sexual Transmitted Infections
(STI).'),nl,nl,
write('STI are group of diseases that are spread from one person to another mostly
through sexual contact.'),nl,
write('They represent a major health problem and are among the commonest causes
of acute illness, and even death,'),nl,
write(' in the world and have far ...
  ... increasing and has rendered some low cost regimens ineffective. STI can place a
heavy financial burden on '),nl,
write('  families, communities and health services Dallabetta (1998).'),nl.
load_kb :-nl,
write('Enter file name only with the extention ".pl".Please do not add the
extention".pl". : '),
read(F),
reconsult(F).
```

```
top_goal(X):-nl,risk_assessment,
write(' Write only "yes" for correct answer or "any character" for incorect answer
then "." and press "enter" Ok!'),nl,nl,
do_you_get(one_or_more_yes),syndrom(X),nl.
top_goal(X):- do_you_like_to(test_for_sti-now),syndrom(X),nl.
syndrome(no_syndrome):-education_on_risk_reduction.
syndrom(inguinal_bubo) :-
        do_you_have(inguinal_swelling_or_swollen_glands_on_your_groin_region),
        is_the_swelling(painful),
       diagnose(lgv/chancroid),treatment(lgv/chancroid).
syndrom(genital_ulcer1) :-
        do_you_have(vesiclarUlcer_recurrent_moreThan3Ulcer),
       diagnose(herpes_Simplex_Virus),treatment(herpes_Simplex_Virus).
syndrom(genital_ulcer2) :-
       do_you_have(nonVesiclarUlcer_nonRecurrent_lessThan3Ulcer),
       diagnose(syphilis/chancroids),treatment(syphilis/chancroids).
syndrom(urethral_discharge) :-
       do_you_have(abnormal_genital_discharge),gender(male),
       is_the_discharge(different_from_semen),
        diagnose(gonorrhea/chlamydia),treatment(gonorrhea/chlamydia).
syndrom(vaginal_discharge) :-
       do_you_have(abnormal_vaginal_discharge),gender(female),
        diagnose(gonorrhea/chlamydia/bacterial_Vaginosis/trichomoniasis),
       treatment(gonorrhea/chlamydia/bacterial_Vaginosis/trichomoniasis).
syndrom(lower_abdomenal_pain1):-
       do_you_have(cervical_excitation),additional,gender(female),
       diagnose(acuit_PID),treatment(acuit_PID).
syndrom(lower_abdomenal_pain1):-
       do_you_have(abdomenal_tenderness),additional,gender(female),
       diagnose(acuit_PID),treatment(acuit_PID).
```

```
syndrom(lower_abdomenal_pain2):-
        additional2,gender(female),
        diagnose(pid),treatment(pid).
syndrom(not_indicated_here):-
        do_you_have(sti_symptoms_butnot_indicated_here),diagnose(no_sti).
syndrom(nothing_is_detected):-nl,nl,
write('     Thank You for visiting STI system diagnosis using syndromic
approach.Please help others to check their status.'),nl, write(' In addition to
this:'),nl,diagnose(not_sti).
additional:-do_you_have(abnormal_vaginal_bleeding);
        do_you_have(recent_delivery_abortion);do_you_have(pregnancy).
additional2:- do_you_have(cervical_excitation);
do_you_have(abdomenal_tenderness).
diagnose(lgv/chancroid):-nl,nl,
                        write('your diagnose is either Lympho_Granuloma_Venerelium or
Chancroid or both.'),nl,nl,
                        write('if the nodes are fluctuant then aspirate through healthy
skin.'),nl,nl,
                        health_education.
diagnose(herpes_Simplex_Virus):-nl,nl,
                        write('your diagnose is herpes_Simplex_Virus.'),nl,nl,
                        write('If the ulcer doesnot improve after 10 days then'),nl,
                        write('go to the nearest health service and contact them.'),nl,nl,
                        health_education.
diagnose(syphilis/chancroids):-nl,nl,
                        write('your diagnose is syphilis/chancroids or both.'),nl,nl,
                        write('If the ulcer doesnot improve after 10 days then.'),nl,
                        write('go to the nearest health service and contact them.'),nl,nl,
                        health_education.
diagnose(gonorrhea/chlamydia):- nl,nl,
                        write('your diagnose is gonorrhea/chlamydia.'),nl,nl,
```

```
                write('please review if symptom persists.'),nl,nl,
                health_education.
diagnose(gonorrhea/chlamydia/bacterial_Vaginosis/trichomoniasis):-nl,nl,
                write('your diagnose is one of this or a combination of any of those
                .'),nl,nl,
                write('gonorrhea/chlamydia/bacterial_Vaginosis/trichomoniasis.'),nl,nl,
                health_education.
diagnose(acuit_PID):-nl,nl,
                write('your diagnose is acute Pulvic Inflamatory Disease.'),nl,nl,
                write('This is a fatal disease so contact the nearest health service as
soon as posible.'),nl,nl,
                health_education.
diagnose(pid):-  nl,nl,
                write('your diagnose is Pulvic Inflamatory Disease.'),nl,nl,
                write('review your health condition after three(3) day'),nl,
                write('and if not respond you are at risk so contact the nearest health
service.'),nl,nl,
                health_education.
diagnose(no_sti):-nl,nl,
                write('your disease is beyond this system'),nl,nl,
                write('please contact to the nearest health service if you have any
problem. '),
                education_on_risk_reduction.
diagnose(not_sti):-nl,
                education_on_risk_reduction.
treatment(lgv/chancroid):-nl,
                write('          TREATMENT                '),nl,
                write('ciprofloxacin 500 bid for 03 days.  PLUS'),nl,
                write('doxycycline 100 mg po bid for 14 days  or'),nl,
                write('erythromycine 500mg qid for 14 days if the patient is
contraindicated to doxycyclin'),nl,nl.
```

```
treatment(herpes_Simplex_Virus):-nl,
        write('          TREATMENT          '),nl,
        write('Acyclovire 200mg five times per day for 10 days.  OR'),nl,
        write('Acyclovire 400mg tid for 10 days.'),nl,nl.
treatment(syphilis/chancroids):-nl,
        write('          TREATMENT          '),nl,
        write('Benzathine penicillin 2.4 M. units IM stat.  OR'),nl,
        write('doxycycline 100 mg po bid for 14 days for penicillin allergy
PLUS'),nl,
        write('ciprofloxacin 500 bid for 03 days.    OR'),nl,
        write('erythromycine 500mg qid for 07 days if the patient is
contraindicated to doxycyclin'),nl,nl.
treatment(gonorrhea/chlamydia):-
        write('          TREATMENT          '),nl,
        write('ciprofloxacin 500 tablet mg po stat or spectinomycin 2gm IM stat
PLUS'),nl,
        write('doxycycline 100 mg po bid for 07 days   or'),nl,
        write('erythromycine 500mg qid for 07 days if the patient is
contraindicated to doxycyclin'),nl,nl.
treatment(gonorrhea/chlamydia/bacterial_Vaginosis/trichomoniasis):-nl,
        write('          TREATMENT          '),nl,
        write('ciprofloxacin 500 tablet mg po stat or spectinomycin 2gm IM stat
PLUS'),nl,
        write('doxycycline 100 mg po bid for 07 days   or'),nl,
        write('erythromycine 500mg qid for 07 days if the patient is
contraindicated to doxycyclin'),nl,
        write('PLUS  metrendazole 500mg bid for 07 days.'),nl,nl.
treatment(pid):-nl,
        write('          TREATMENT          '),nl,
        write('ciprofloxacin 500 tablet mg po stat or spectinomycin 2gm IM stat
PLUS'),nl,
```

```
        write('doxycycline 100 mg po bid for 14 days   or'),nl,
        write('erythromycine 500mg qid for 14 days if the patient is
contraindicated to doxycyclin'),nl,
        write('PLUS  metrendazole 500mg bid for 14 days.'),nl,nl.

treatment(acuit_PID):-nl,
        write('          TREATMENT                '),nl,
        write('Before referal, setup an IV line and resuscitate the patient if
required '),nl,nl.
health_education:-nl,nl,
   write('  Please take your treatment properly otherwise you will develop STI
complication.'),nl,nl,
   write('  Search and get HIV counselling and Testing.'),nl,nl,
   write('  use condom and provide for others.' ),nl,nl,
   write('  please notify and manage your partner(s).If not you will not cure
eventhough '),nl,
   write('  you take the given medication.'),nl,nl,
   write('  Return and check after completion of treatment to check wether you
improve or not.'),nl,nl,
   write('  For further information, use help_sti from the menu choices.'),nl,nl,
   write('          THANK YOU.'),nl,nl.
education_on_risk_reduction:-nl,nl,nl,
   write('          Health Education.'),nl,nl,
   ... help_sti from the menu choices.'),nl,nl,
   write('          THANK YOU.'),nl,nl.
risk_assessment:-
write('  In the next questions, If you have one or more yes then you have a high
chance to catch with STI,'),nl,
write('  so please read carfully and evaluate your self.'),nl,nl,nl,
...
write('  Has any part of your body been sexually exposed to an STI?'),nl,nl,
```

```
write(' Have you recently developed urethral or vaginal discharge,'),nl,
write(' genital sour (ulcer), Lower abdominal pain or inguinal swelling?'),nl,nl,nl.
do_you_try(X):- ask(do_you_try,X).
do_you_have(X):-ask(do_you_have,X).
do_you_get(X):-ask(do_you_get,X).
do_you_like_to(X):-ask(do_you_like_to,X).
is_the_discharge(X):-ask(is_the_discharge,X).
is_the_swelling(X):-ask(is_the_swelling,X).
gender(X):- ask(gender,X).
multivalued(gender).
multivalued(do_you_have).
multivalued(howy).
multivalued(do).
ask(A,V):-
write(A:V), % ask user
write('? : '),
read(Y), % get the answer
asserta(known(Y, A, V)), % remember it
Y == yes. % succeed or fail
ask(A, V):-
known(yes, A, V), % succeed if true
!. % stop looking
ask(A, V):-
known(_, A, V), % fail if false
!, fail.
ask(A, V):-
not(multivalued(A)),
known(yes, A, V2),
V \== V2,
!, fail.
howy(Pl) :- menuask(howy,Pl,[inguinal_bubo,no_syndrome]).
```

```
                contraindicated to doxycyclin'),nl,
                write('In addition, paracitamol and scrotal support is mandatory
                '),nl.
health_education:-nl,
    write('          Health Education.'),nl,
    write(' Please take your treatment properly otherwise you will develop STI
    complication.'),nl,
    write(' Search and get HIV counselling and Testing.'),nl,
    write(' use condom and provide for others.' ),nl,
    write(' please notify and manage your partner(s).If not you will not cure
    eventhough '),
    write(' you take the given medication.'),nl,
    write(' Return and check after completion of treatment to check wether you
    improve or not.'),nl,
    write(' For further information, use how or help_sti from the menu
  choices.'),nl,
    write('          THANK YOU.'),nl,nl.
do_you_have(X):-ask(do_you_have,X).
does_your_testis_have_no(X):- ask(does_your_testis_have_no,X).
```

```
how_why(scrotal_swelling):-nl,

write('          Scrotal Swelling Syndrome (Swollen scrotum)'),nl,nl,

write(' Scrotal Swelling is defined as a painful swelling of the Scrotum region. The
common '),nl,

write('sexually transmitted pathogens that are associated with Scrotal Swelling
include N.gonorrhoeae or C. trachomatis. '),nl,

write('If you have scrotal swelling suspected of non STI origin like'),nl,

write('testicular torsion, trauma and inguinal hernia ,they may require '),nl,

write('urgent referral for proper surgical evaluation and management. '),nl.

write('When we come to your question, the syndrome is scrotal swelling
because:'),nl,nl,

write('   1. You have yes in risk assessment evaluation questions and'),nl,nl,

write('   2. You have scrotal swelling or swollen scrotum on your scrotal region'),n

write('your testis have no (rotated or elevated or history of trauma.'),nl,

write('and your gender is male').
```