DEVELOPING KNOWLEDGE BASED SYSTEM FOR DIAGNOSIS AND TREATMENT OF GASTRITIS DISEASE

A THESIS PRESENTED BY

YEDAMU YOHANNES

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Accepted by the Faculty of Informatics, St. Mary's University, in partial fulfillment of the requirements for the degree of Master of Science in Computer Science

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January 2023

DECLARATION

I, the undersigned, declare that this thesis work is my original work, has not been presented for a degree in this or any other universities, and all sources of materials used for the thesis work have been duly acknowledged.

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

_____________ Dr. Alemebante Mulu__________________________

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LIST OF ACRONYMS

AI: Artificial Intelligence

ES: Expert system

GUI: Graphical User Interface

HP: Helicobacter pylori

JPL: Java prolog Library

JDK: Java development kit

IDE: Integrated development Environment

KBS: Knowledge based system

KDD: Knowledge discovery in database

NSAID: Non-steroidal anti-inflammatory drugs

XML: Extensible markup language

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ABSTRACT

Gastritis is an inflammation of the stomach lining, which is fairly common and could have different causes. The gastritis diagnosis and treatment skill required by the physicians including clinical experience, good judgment, sense of humor, stress-tolerance, knowledge of available resources, problem solving ability and sense of anticipation. It is therefore important for individuals to have adequate knowledge of different types of gastritis disease to reduce the risk of the disease. Experts systems are rapidly growing technology and an active area of research in disease diagnosis and treatment. Expert systems use human expert knowledge to solve complex problems in many fields such as Health, science, engineering, business, and weather forecasting.

In an effort to address such problem, this study attempts to design and develop a user friendly GUI knowledge-based system that can provide advice for physicians and patients to facilitate the diagnosis and treatment of pneumonic patients. To this end, knowledge is acquired using both structured and unstructured interviews from domain experts which are selected using purposive sampling technique from Addis Ababa Bethel Referral Hospital. Relevant documents analysis method is also followed to capture explicit knowledge. Then, the acquired knowledge is modeled using decision tree that represents concepts and procedures involved in diagnosis and treatment of pneumonia and production rule is used to represent the domain knowledge. The knowledge-based system is developed using the integration of two programing languages with the interfacing library of JPL.

Knowledge is also extracted from domain experts and document analysis from gastritis treatment. Hence, the prototype of knowledge based system which provides gastritis patient diagnosis and treatment was developed using SWI-Prolog 8.2.3 and Java NetBeans IDE 8.2 with JDK 8 for integrating with graphical user interface respectively. The overall performance achieves 92.8% accuracy with an average system performance.

Keywords: Expert System, Knowledge based system, Types of Gastritis

Chapter One

1. Introduction

1.1. Background of the study

Gastritis is an inflammation of the stomach lining, which is fairly common and could have different causes. The gastritis diagnosis and treatment skill required by the physicians including clinical experience, good judgment, sense of humor, stress-tolerance, knowledge of available resources, problem solving ability and sense of anticipation. It is therefore important for individuals to have adequate knowledge of different types of gastritis disease to reduce the risk of the disease. Gastritis symptoms can mimic indigestion symptoms. Indigestion is pain or discomfort in the stomach associated with difficulty in digesting food. It may be a feeling of burning between your lower ribs. You may hear indigestion referred to by its medical term, dyspepsia. Your risk of developing gastritis goes up with age. Older adults have thinner stomach linings, decreased circulation and a slower metabolism of mucosal repair. Older adults are also more likely to be on medications such as nonsteroidal anti-inflammatory drugs (NSAIDs) that can cause gastritis. About two-thirds of the world's population is infected with H. pylori. Fortunately, it is less common in the United States. In the United States, H. pylori is found more often in older adults and lower socioeconomic groups. Gastritis is an inflammatory condition of gastric mucosa that displays changes related to etiology and the host response. It was identified in the 1800s as a result of autopsies. There may be similar morphological. images of gastritis based on different etiologies, and there may be more than one etiologic agent in a gastritis chart.

Gastritis was categorized as chronic and acute in 1947 for the first time. Then, chronic gastritis was categorized into two subgroups: namely, superficial and atrophic.

After Marshall and Warren demonstrated in 1983 that a bacteria called Campylobacter pylori caused gastritis, a tendency of an etiology-oriented denotation began. For this purpose, a group of gastropathologists prepared a classification in 1990 in Sydney for the first time to classify and rank gastritis. Within this period, the importance of the findings of gastritis, atrophy, and metaplasia in Correa’s chart in 1992 was realized, and these findings were included in the first classification. However, due to differences between observers in the rating of especially chronic gastritis and atrophy over time, the Sydney classification was reviewed, and a visual analog scale was prepared by preserving the basic principles. Despite all these efforts, inconsistencies, especially in the rating of atrophy, drew attention. Thus, the team that made the first Sydney classification put forward a metaplastic/nonmetaplastic atrophy rating in 2002.

Experts systems are rapidly growing technology and an active area of research in disease diagnosis and treatment. Expert systems use human expert knowledge to solve complex problems in many fields such as Health, science, engineering, business, and weather forecasting. Since there is shortage of experts in the domain area, we develop integrated data mining knowledge based system for diagnosing types of gastritis to improve the quality of decision made by general practitioners, to provide effective and efficient services to the patients.

In recent years, Knowledge Based System (KBS) and Expert System (ES) have become increasingly popular computer software approaches and are being used in a wide variety of application areas. Medicine is one of the areas in which knowledge based system has received much more attention. The attention is mainly because of the potential benefits that can be gained from using these technologies. Today knowledge based systems are essential tool in the area of medical domain particularly to over-come the shortage of human experts. There is a clear role for clinical knowledge based applications in the medical domain like diagnostic assistant systems, drug advisory system, protocol design, laboratory system, clinical workstations, image recognitions and interpretation for clinicians.

Knowledge base expert system is software that represents the knowledge. There are certain criteria of expert system which includes Rule-based expert system, Frame-based systems, Hybrid systems, Model-based systems, Real-time systems. The KBS is a computer program that uses artificial intelligence to solve problems within a specialized domain that requires human expertise. The typical applications of knowledge base system include classification, diagnosis, monitoring, designing, scheduling and planning for specialized tasks [1].

In this study, the researcher needs to develop a low-cost knowledge-based system using both procedural and declarative language incorporating the skills of medical experts. It can be implemented to help the patients in self-diagnosis and management of gastritis.

1.2. Statement of the problem

The gastritis diagnosis and treatment skill required by the physicians including clinical experience, good judgment, sense of humor, stress-tolerance, knowledge of available resources, problem solving ability and sense of anticipation. Diagnosing and treating patient accurately and efficiently is a challenging task. Particularly, many health care institutions are increasingly overcrowded and this leads to longer waiting time of patient and increase treatment delay. As a result it leads to miss- diagnosis and treatment of patient. If left untreated, gastritis can lead to serious problems, such as:

- Anemia: *H. pylori* can cause gastritis or stomach ulcers (sores in your stomach).that bleed, thereby lowering your red blood counts (called anemia).
- Pernicious anemia: Autoimmune gastritis can affect how your body absorbs vitamin B12. You're at risk of pernicious anemia when you don't get enough B12 to make healthy red blood cells.
- Peritonitis: Gastritis can worsen stomach ulcers. Ulcers that break through the stomach wall can spill stomach contents into the abdomen. This rupture can spread bacteria, causing a dangerous infection called bacterial transloction or peritonitis. It also can lead to a widespread inflammation called sepsis. Sepsis can be fatal.
- Stomach cancer: Gastritis caused by *H. pylori* and autoimmune disease can cause growths in the stomach lining. These growths increase your risk of stomach cancer.

There are also the following major problems that affect the ineffective and inappropriate diagnosis and treatment of patients in health centers

- A physician uses one or two symptom but patients' health problem may need further investigation to identify problem.
- The knowledge, experience and skill of physicians may vary from one another thus for one health problem there might be a varied diagnosis and treatment
- Because of the overcrowded number of patients, the patient handling capacity of the health centers and related reason enforce them to miss-diagnosis and treatment of patients.

Therefore, designing a knowledge based system would reduce the repetition of task, the burden of human expert and waiting time of patient in the hospital. The knowledge based system will be used to assist human expert by providing the required knowledge at the right time for decision making. In this sense, building a sound knowledge based expert system that can Provide effective and efficient gastritis diagnosis and treatment service is paramount significant.

The research is expected to address the following questions:-

- What are the main symptoms and risk factors that can properly predict the types of gastritis disease?
- How to model and represent the acquired knowledge for developing the knowledge-based systems?
- How to design a user friendly knowledge-based system that is easily accessible by users?
- To what extent the prototype works in the diagnosis and treatment of Gastritis?

1.3. Motivation

Health problems touch every aspect of human life such as health condition, working environment, family life, social relations, economic and political activities of every endeavor. However, health care services are not efficient throughout the world as it is required to be. While the burden of chronic disease in sub-Saharan Africa is very high, the current density and distribution of the health workforce suggested that sub-Saharan Africa can't respond to the growing demand of chronic disease care. Ethiopia is one of the developing countries in sub- Sahara Africa. In Ethiopia the health problems are a hot issue for every stakeholder, to minimize the death of citizen by different chronic diseases. In the health domain the gap exists due to low patient handling capacity of health institutions and the growing demand of individuals who need response from the health sectors.

Therefore, designing an efficient knowledge based system for diagnosis and treatment of gastritis disease would help to minimize the above interrelated problems that are caused due to lack of potential human expert or lack of potential skills to solve the patient's health problem and; it is possible to contribute for stakeholders in the area.

1.4. Objective of the research

1.4.1. General Objective

The main objective of this study is to design and develop knowledge based system for diagnosis and treatment of gastritis disease.

1.4.2. Specific objectives

To achieve the general objective of the study, the following are specific objectives:

- To review the literature of different sources of information to understand the basic concepts, principle and technologies of knowledge based expert system.
- To extract the necessary knowledge from domain experts for diagnosis of gastritis disease
- To design and develop prototype knowledge based system using rule-based knowledge representation approach.
- To evaluate and validate the performance of the system.

1.5. Scope of the study

The scope of this study is on gastritis diseases diagnosis and treatment. The study will be limited to design a knowledge based system for the major sign and symptoms of gastritis, classification of gastritis diseases and based on the diagnosis result the system will treat the patient based on the knowledge patterns of experts.

1.6. Significance of the Study

Knowledge based system try to solve problems in a human expert like fashion by using stored knowledge elicited from domain expert. Therefore, the proposed knowledge based system has the following significance in the diagnosis and treatment of gastritis.

- Using the proposed knowledge base expert system, we can consolidate the different domain expert sources of information and use their expertise for solving the human health problem.
- The proposed system can be used as quick reference for general practitioner to diagnose the patient health problem with gastritis.
- Knowledge based system will be developed for the purpose of supporting or assisting decision makers. Therefore, the proposed research can be used to fill the gap of lack of human expert in the domain area.

1.7. Research Methodology

1.7.1. Research Design

Since the research topic needs several experiments and domain experts' opinion, the researcher will use quantitative research design. The researcher also collected the dataset for constructing knowledgebase from Bethel Hospital.

1.7.2. Literature review

The researcher will review different researches, articles and journal papers on gastritis disease and treatment, Knowledge base Systems, knowledge acquisition of knowledge based systems and different works on knowledge base systems to get conceptual understanding about the problem on the hand.

1.7.3. Methods of data collection

The researcher will use both interview and document analysis to acquire knowledge. The researcher will conduct the domain expert's interview with nurses and doctors who works for gastritis diseases Treatment at Bethel Referral Hospital. For this research, six health experts were selected purposively for interview about gastritis diagnosis and treatment depending on their professions, educational qualification level, and willingness.

1.7.4. Methods Knowledge Representation

Since the knowledge that the researcher will acquire from gastritis data set, literature review, domain experts interview in the form of rules and the knowledge that the researcher acquire from document analysis about diagnosis and treatment of gastritis disease are full of decision trees and procedures which are easy to convert to rules, the researcher forced to use rule-based knowledge representation method which is the most predominant knowledge representation methods to develop the Knowledge base.

1.7.5. Implementation tool

To represent rules in knowledge base and construct the prototype of gastritis disease advising Knowledge Based System, the researcher use SWI-Prolog. Java NetBeans IDE 8.2 with JDK-8u20 was employed to integrate prolog result and develop the GUI of the propose system.

1.7.6. Evaluation methods

The researcher also evaluate the KBS using system performance testing by preparing test cases and users' acceptance testing questionnaire which helps the researcher to make sure that whether the potential users would like to use the propose system frequently and whether the propose systems meets user requirements.

1.8. Organization of the paper

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

Chapter Two
Literature review and related work
2. Back ground of gastritis diseases

Gastritis represent a state of inflammation, irritation, or erosion of the stomach lining which may occur suddenly (acute) or gradually (chronic). Generally there is no universally accepted classification of gastritis and early classification was based mainly on the morphology, but recently pathogenic mechanisms have also been incorporated. The gastric mucosa is continuously exposed to many noxious factors, and Gastric protection aimed mainly to reduce or prevent the chemically induced acute hemorrhagic erosions which is exerted by compounds such as prostaglandins (PG) and SH derivatives without inhibiting acid secretion. Common causes of gastritis are excessive alcohol consumption or prolonged use of non-steroidal anti-inflammatory drugs (NSAIDs) such as aspirin or ibuprofen. It may also develop after major surgery, traumatic injury, burns, or severe infections. Chronic causes are infection with bacteria, primarily Helicobacter pylori (HP), chronic bile reflux, stress additionally certain autoimmune disorders can cause gastritis as well. The most common symptom is abdominal upset or pain, indigestion, abdominal bloating, nausea, vomiting and pernicious anemia. The current study here is focusing on the causes, clinical profile, inflammatory, immune response and autoimmune atrophic gastritis in affected individuals. Additional focuses are on different diagnostic tools for Helicobacter pylori infection (HP) and current therapeutic treatment [2].

Gastritis is also an inflammation of the stomach lining, which is fairly common and could have different causes. Many kind of agents may lead the stomach into an inflamed statement; in first place, it could be due to non-steroidal anti-inflammatory drugs (NSAID) such as aspirin, ibuprofen, naproxen, etc. which are used in different treatments to calm down some specific illness, e.g. rheumatoid arthritis; in second place, inflammation could be due to abrasive compounds (alcohol, acids and others) or unbalanced diets where the stomach is damaged by its own gastric acid; in third place, long-term physical and/or mental stress that result in the production of excessive amounts of stomach acid; in last place, the infection caused by a well-known microorganism, Helicobacter (H) pylori. When stomach inflammation is not treated, mainly in the latter case, the illness could end in a gastric ulcer or in the worst case, in gastric cancer. The signs and symptoms of gastritis depend on how long the problem has existed. If it occurs suddenly is called acute gastritis. In acute phase, superficial inflammation of the stomach causes the classic nausea and pain or discomfort in the upper abdomen. If it develops gradually is called chronic gastritis, and the symptoms might vary from those of acute, with a dull pain in the upper abdomen and a feeling of fullness and loss of appetite after a few bites of food. However, in some cases, people with chronic gastritis could not feel any of these symptoms. Another type is the reactive or chemical gastritis, which is defined as a foveolar elongation, tortuosity, and hyper cellularity of the gastric surface epithelium, together with edema, vasodilatation, congestion of gastric lamina propria, and a paucity of inflammatory cells. This type of gastritis has been thought to result from duodenogastric bile reflux or the use of NSAIDs [3].

2.1. Architecture of Knowledge base system

Architecture is a blue print that helps to represent the structure of an object or a system [4]. System architecture is the conceptual model that defines the structure, behavior and more views of that system. Moreover, architecture of a system helps to describe sets of conventions, rules, and standards that should be incorporated in the corresponding system. Similar to other systems, knowledge based system has its own architecture that describes the main components of it, the core functionalities that are carried out in the system and the basic tools that aid for development of knowledge-based systems.

The development of a KBS requires knowledge about both human reasoning and computer techniques which is known as knowledge engineering. Knowledge engineering is the process of working with experts to map their knowledge into a form suitable for a knowledge-based system to use [5]. Figure 2.1 shows the building blocks of knowledge based system architecture. The major components of the knowledge-based system in the process of knowledge engineering are the knowledge base, inference engine, explanation facility, user interface and also additional features can be added.

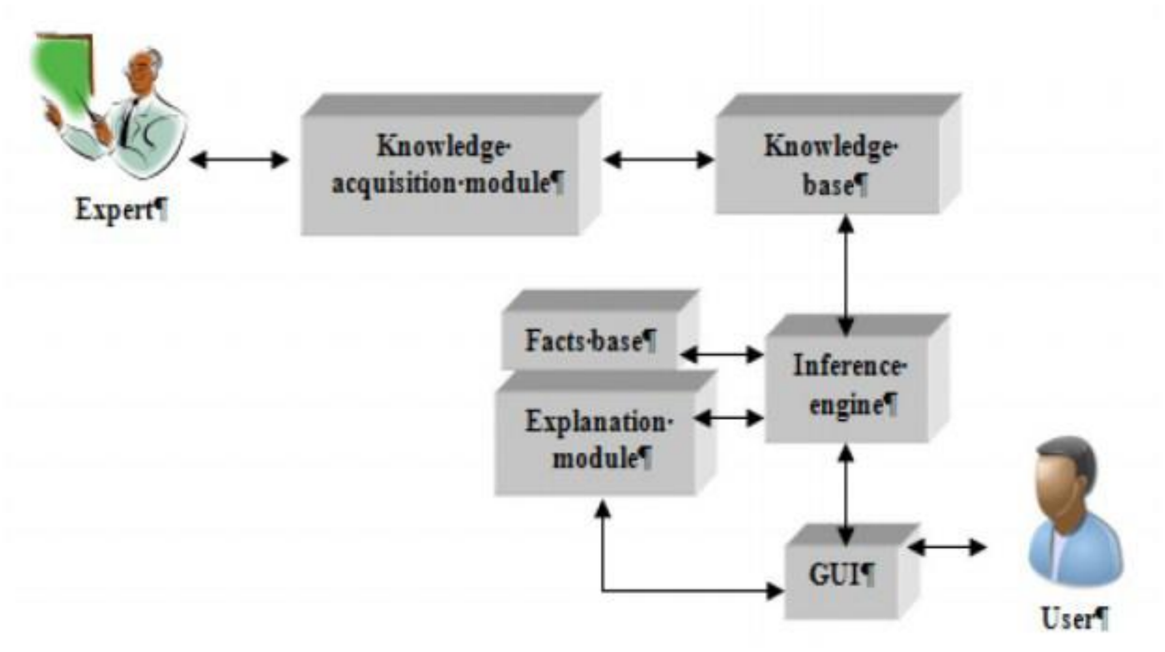

Figure 2.1 Architecture of Knowledge-Based System [5]

2.1.1. **Knowledge base**

The Knowledge Base(KB) is the heart of knowledge based systems, which represents the repository of knowledge for specific and narrow domain. It is a warehouse of the domain-specific knowledge captured from the human expert during knowledge acquisition [5]. Usually in any knowledge base there are many facts, rules, and meta knowledge. Facts are minimal elements of the knowledge which must be identified before anything else. The knowledge base is usually stored in terms of IF-THEN rules, where a given set of conditions will lead to a specified set of results. In the knowledge base, the working memory represents relevant data for the current problem being solved. Knowledge base works by taking questions and problems from users as an input and results in alternate solutions and answers through the inference mechanism [6].

The knowledge base contains both factual and heuristic knowledge [5]. Factual knowledge is a domain knowledge that is widely shared and usually found in books or published documents. Heuristic knowledge is the knowledge of good practice, good judgment and credible reasoning in the field. It is more experimental or judgmental knowledge of performance, rarely discussed andlargely distinctive. Before deciding on the structure of the knowledge base, the knowledge engineer should have a clear idea of different knowledge representation schemes and the suitability of each under different circumstances.

Generally, KB holds the knowledge which is useful for understanding, formulating and for solving problems. In this sense, the most important phase, in building knowledge based system, is the building of the knowledge base; this process is part of knowledge engineering which is an important field at present century.

2.1.2. The Human Element of Knowledge-Based System

Mainly there are three human elements or stakeholders involved throughout the development and use of knowledge-based systems. These are [7]:

Domain Expert: provides knowledge about task performance and has special knowledge, judgment, experience and methods to give advice and solve problems. The domain expert is generally a person who has worked in the domain area and understands its problem solving techniques, such as shortcuts, handling imprecise data, evaluating partial solutions, and all the other skills. The domain expert is primarily responsible for making clear these skills to the knowledge engineer [7].

Knowledge Engineer: is the AI language and representation expert involved in the overall development of the knowledge-based system. The knowledge engineer helps the domain expert to articulate the necessary knowledge and implements a knowledge base efficiently using appropriate software and hardware tools. The end user determines the major design constraints. The skills and needs of the user must be considered throughout the development. Unless the user is happy, the development effort is by large wasted. Therefore, the expert and knowledge engineer should give an emphasis for the user's need while designing a knowledge-based system [7].

User: individuals who are in need of consulting of knowledge based systems to perform their day -to-day activities mainly dealing with decision making. Such a people can be System analyst, system builders and supporting staff.

2.2. Knowledge Engineering process

Knowledge engineering is the process of acquiring knowledge from experts and building a knowledge-based system. A major goal of knowledge engineering is to help experts articulate what they know and document the knowledge in a reusable form. Knowledge engineering can be viewed from two perspectives, narrow and broad [8]. According to the narrow perspective, knowledge engineering deals with knowledge acquisition, representation, validation, inference, explanation and maintenance. On the other hand, the broader perspective deals with the entire process of developing and maintaining intelligent systems. For this research, the researcher gives more attention on knowledge acquisition, knowledge modeling, knowledge representation and evaluation of knowledge-based system.

2.2.1. Knowledge Acquisition

Knowledge can be gathered from different sources such as books, databases, images, maps, flow of diagrams, stories, sensors, and so on. There are usually two types of knowledge sources. These are documented (explicit) knowledge and undocumented (tacit) knowledge. Tacit knowledge is commonly deeply ingrained in human mind and organizations through experience. Explicit knowledge is relatively simple to express and capture in the form of books, tables, diagrams, and so on. Knowledge can be discovered and collected by using either the human senses or machines (e.g., scanners, cameras, pattern matchers, intelligent agents) [9].

The extraction of appropriate knowledge from experts and other sources are the essential aspects in the knowledge-based system development process. In fact, knowledge acquisition is performed during the whole knowledge-based system development process [9].

2.2.2. Methods of Acquiring Knowledge from Experts

Acquiring knowledge from experts is not a simple task. It involves knowledge identification, knowledge representation in an appropriate format, organizing the knowledge, and transferring the knowledge to a computer machine. Some of the reasons that increase to the difficulty of knowledge acquisition from experts and its transfer to a computer machine are stated below [9]:

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

2.3. Knowledge and its types

Knowledge is a set of facts designed for a special activity, procedures, and decision commonly articulated as rules. These types of knowledge may come from various sources like human mind, books, documents, sensors, computer files and so on.

Level of Knowledge

It is possible to symbolize knowledge at various levels. The two common are shallow and deep knowledge [9].

Shallow Knowledge is the representation of outermost level information that is used to address with very particular conditions. The shallow knowledge form represents the input and output relationship of a certain system. Intrinsically, it can be preferably represented in terms of IF THEN rules. Shallow representation is narrow. A collection of rules by itself may have limited meaning for the end-user. This may restrict the ability of the system to offer suitable justifications to the end-user. Shallow knowledge may also be inadequate in describing complex circumstances.

Deep Knowledge is the interior and causal structure of a certain system and comprises the relations between the system's elements. It can be applied to various tasks and various circumstances. It is also hard to automate this kind of knowledge. The system developer should have a complete intellectual ability of the main components and their relations.

Categories of Knowledge

Knowledge can be classified as declarative, procedural, or meta-knowledge [9].

Declarative knowledge is a descriptive representation of knowledge. It expresses facts like what things are. It is expressed in an actual statement, for instance, there is a positive relationship between cigarette smoking and cancer. Experts of the domain tell us about facts and relationships. This kind of knowledge is regarded as shallow information that domain experts can articulate. It is mainly essential in the early phase of knowledge acquisition.

Procedural knowledge conceives the way in which things function under various collections of conditions. Hence, it comprises successions in a gradual manner and how-to kinds of instructions; it may also comprise justifications. It includes automatic replies to inputs. It associates to the procedures used in the problem-solving process. For example: information about defining the problem, gathering of data, process of the solution, and criteria of evaluation.

Meta-knowledge is knowledge about knowledge. In knowledge-based systems, meta-knowledge is knowledge about the operation of knowledge-based systems (i.e., about their reasoning capabilities).

2.4. Overview of Knowledge-Base System

Knowledge-based systems (KBSs) are a branch of Artificial Intelligence, concerned with the design and implementation of programs that are capable of emulating human cognitive skills, such as observing, understanding, reasoning and learning, using knowledge of a given domain. Knowledge is the information about a specific domain, which includes information about both real world entities and the relationships between them. It is needed by a computer program to enable it to exhibit intelligent behavior with respect to a specific problem. KBSs capture the specific knowledge of a particular domain and imitate the problem solving strategies of human experts which simulate human reasoning. KBSs are a computer programs that use knowledge and inference procedures to solve difficult problems [10].

The KBS consists of a knowledge base, database and an inference engine for interpreting the database using the knowledge supplied in the knowledge base. All these different components interact together in simulating the problem solving process by an acknowledged expert of a domain has contributed the area when he would do by developing the "expert system", a program that could take a knowledge base of assertions and perform tasks of chemical analysis, medical diagnosis and airline scheduling.

2.4.1. Advantage of Knowledge-Based System

Knowledge-based systems are more useful in many situations than the traditional computer based information systems. Knowledge-based systems also offer several advantages over natural intelligent systems (humans). The main advantages of using a knowledge-based system are descried as follows [11]:

Permanent documentation of knowledge: A knowledge engineer extracts knowledge from domain experts and relevant documents for a certain problem domain and represents it using one of the knowledge representation techniques and transfers it into the knowledge base. This helps end-users to use the knowledge stored for a long-term from the documented knowledge in the knowledge base at any time.

Cheaper solution and easy availability of knowledge: It is assumed very huge, complicated and duplicating it into many copies, it is simple to use the knowledge in many places. This interrupts the dominations of domain experts and makes simple to acquire and utilize knowledge. On the contrary, educating new domain experts is inefficient and costly. Therefore, the aim of developing KBSs is to reduce cost, time, human expertise and medical error.

Dual advantages of effectiveness and efficiency: Since knowledge-based systems are Computer-based systems, they have efficiency-directed factors such as speed, accuracy, control, and permanent content storage. It is possible to make the knowledge-based system effective by integrating the knowledge element. They are more efficient than domain experts and attempts to become equally effective like domain experts.

Consistency and reliability: Since the knowledge element is integrated into the KBS and the capability to perform effectively, the trustworthiness of the system rises. Besides, dupery and errors can be stopped. Information can be accessible rapidly for making decision with appropriate justification. As the level and amount of knowledge rises, making right decision will rise and thereby reduce the threat of wrong decision.

Justification for better understanding: The reliability of the domain experts relies on the capability to explain their decisions. This can be offered by using the reasoning and justification component of the KBS to the end-users. If there is a well understanding of the decisions made by end-users of the system, then it increases the quality and trustworthiness of the system.

Self-learning and ease of updates: With the assistance of the inference engine of the system, the knowledge base always updates its knowledge from experience. The knowledge-based system can update its knowledge either using automatic machine learning or manually by the knowledge engineer. Such self-learning advances the adaptability and tractability of the system.

2.5. Rule-based System (Production rules)

Production rules are simple but powerful forms of knowledge representation providing the flexibility of combining declarative and procedural representation for using them in a unified form. A production rule has a set of antecedents and a set of consequents. The antecedents specify a set of conditions and the consequents a set of actions. The general format of the rule looks like the following [11].

If <conditions>, then <actions>

IF this condition occurs, THEN some action should occur. Rules are used for a simulation of the cognitive behavior of human experts. According to the authors rules represent a model of actual human behavior, not a neat formalism to represent knowledge in a computer. When the IF portion of a rule is satisfied by the facts stored in the context or fact established by a user input, the actions specified in the THEN portion are performed, and the rule is then said to be fired [9].

In AI, rules commonly divided in a form of knowledge and inference rules. Knowledge rules or declarative rules state all the facts and relationships about a problem. On the other hand, inference rules or procedural rules deals with how to solve a problem, for certain known facts. The knowledge engineer separates, the knowledge rules go to the knowledge base, whereas inference rules become part of the inference engine. The knowledge stored in rules can be schematically represented in the form of a network. However, a knowledge net representing the set of rules in a rule base should be complete with the proper connectivity of nodes in the net. Hence, drawing the knowledge net gives the knowledge engineer an opportunity to verify the knowledge base for possible inconsistencies and redundancies. The knowledge net represents the schematic diagram of the knowledge base [9].

The rules permit the generation of new knowledge in the form of facts that are not initially available but that can be deduced from other knowledge parts. The deduction procedure using facts and rules works; first, knowledge exists in the form of facts and rules. Next the new facts are added and finally combining the new facts with the existing facts and rules leads to the deduction of further facts [11].

Some of the advantages of rule-based knowledge representation include the following [11].

- **Declarative Nature:** Rule based representation method represents the knowledge of the world declaratively in the form of rules and facts.

- **Homogeneity:** Rule based representation has uniform syntax. Hence, the meaning and interpretation of each rule can be easily analyzed.

- **Simplicity:** Rule based representation has simple syntax. It uses English like human languages to write rules. Therefore, both technical and nontechnical persons can easily understand the rules. As a result, domain experts can often understand the rules without an explicit translation of them.

- **Independence:** In rule based representation, a new rule can be added without affecting the existing rules. Each rule is an independent piece of knowledge about the domain.
- **Modularity:** A rule based system exhibits a high degree of modularity. Each rule represents an independent piece of knowledge. Therefore, it is possible to add new rules without affecting already existing rules of the knowledge base.
- **Separation of Knowledge from Use and Control:** In rule based representation method, there is a clear separation between the knowledge about the domain (facts) and the control (how the knowledge is to be used to solve the problems). In other

words, the same inference engine can be used with different rule bases and a rule base can be used with different inference engines.

2.6. Knowledge-Base System Development Tools

All projects are usually implemented in a high-level language. These high-level languages need some novel features, such as facilities for experimentation with large chunks of knowledge, tentative modifications, planning and reasoning strategies. In addition, these languages need powerful abstraction mechanisms with which other higher-level constructs can be built so as to make programming flexible and easy. Current KBS frameworks have been built using a number of languages, of which LISP and PROLOG are very popular among AI researchers [12]. There are a number of tools that are more specific and can also be useful like Java Expert System Shell (JESS), CLIPS (C Language Integrated Production System), GURU and Vidwan to develop KBS [13].

Knowledge-based system programming tools provide a range of facilities for representing knowledge and reasoning with knowledge. A KBS tool is a set of software package designed to assist the development of knowledge-based systems [13]. It supplies an inference engine alongside frameworks for entering facts and facilities for building a user interface. A KBS programmer is then only required to input facts and information into the knowledge base and to specify permitted inferences for the inference engine, in order to construct a knowledge-based system. These tools are powerful programming environments originally intended for use in knowledge-based systems development. The current trends suggest that KBS tools have to become more general-purpose in order to compete with other software development environments [14].

Prolog is a logic programming general-purpose fifth generation (AI) language. It has a purely logical subset, called "pure Prolog", as well as a number of extra logical features [13]. Prolog and other logic-based languages support a declarative programming style. Declarative programming is constructing a program in terms of high-level descriptions of a problem's constraints, rather than procedural programming style, writing programs as a sequence of instructions for performing an algorithm. This mode of programming essentially tells the computer "what is true" and "what needs to be done" rather than "how to do it". An interpreter executes the program by systematically making inferences from logic specifications. The idea of using the first-order predicate calculus to express specifications for problem solving is one of the central contributions Prolog has made to computer science particularly in artificial intelligence. The benefits of using first-order predicate calculus for a programming language include a clean and elegant syntax and well-defined semantics [15].

Prolog has been as popular as Lisp for AI work. Prolog shares most of Lisp's advantages in terms of flexibility and conciseness. The idea behind logic programming is that the programmer should state the relationships that describe a problem and its solution. These relationships act as constraints on the algorithms that can solve the problem, but the system itself is responsible for the details of the algorithm. It is gaining an increasing acceptance among AI researchers because of its elegance, simplicity and sound mathematical basis [16].

The SWI-Prolog, a modern ISO-compliant portable Prolog compiler, has flexibility, portability, availability and possibility of integration with other software. It offers a bi-directional programming interface to and from ANSI C language allowing for easy integration with other code. It provides a built-in XML/RDF parser, suitable for direct XML processing and applications in the field of Semantic Web [16].

2.7. Knowledge Modeling

Models are applied to express the important characteristics of real-time systems to understand in a simple way by dividing them into small parts. Models are more related with problem domain they represent [17]. Real-time systems are huge objects comprising of interconnected elements doing in complications as teamwork. Models assist individuals to weigh-up and know such complications by supporting them to explore every specific area of the system. Models are applied in the construction process of systems to draw the architecture of the system and to simplify the exchange of information between several individuals in the group at various levels of abstraction. Individuals have several understandings of the system and models can assist them to know these understandings in a coordinated way.

According to Schreiber et al. [18], the modeling process builds conceptual models of knowledge-intensive activities. During the knowledge acquisition process, the knowledge engineer will attempt to understand both the tacit and explicit form of knowledge and then use visual tools to make an exchange of views between domain experts and end-users. This exchange of views produces concepts and understandings with regard to how the acquired knowledge is applied, how judgments are made, and so on. And the knowledge engineer should build the knowledge model from the acquired exchange of views with domain experts and end-users. This helps the knowledge engineer to transfer the knowledge model into functional computer-machine programs.

2.8. Knowledge Representation

Knowledge representation concerned with how knowledge can be represented symbolically and manipulated in an automated way by reasoning. It is a methodology by which a suitable structure is selected to represent a given knowledge component in such a way that operations like storage, retrieval, inference, and reasoning are facilitated without disturbing the required characteristics of the knowledge components. With knowledge representation, real-world knowledge is used for problem solving and reasoning [17].

Therefore, the manner in which the knowledge is stored is important. The knowledge must be stored in a way that makes it possible for AI to search it, and infer new knowledge from it. The primary goal of knowledge representation is to enable an intelligent program with a knowledge base to make intelligent decisions about its environment [18]. A good knowledge representation strategy acts as a medium to achieve computation efficiency, human expression and basis for reasoning. It is a knowledge structure that enables easy operations on the knowledge it possesses [17].

2.9. Knowledge Verification, Validation, Usability and Usefulness

There are four types of evaluations to be conducted on KBS. These are verification, validation, usability and usefulness.

Verification is the rightness of the developed KBS to be evaluated. It can be conducted entirely on the formal model or on the computable model whose syntax is clearly stated for their rightness to be evaluated. It assures whether the knowledge on the formal model or on the computable model does not comprise syntactical faults. This means it assures the coordination between several elements of the KBS. A verified KBS denotes the acquired knowledge from domain experts and secondary sources rightly.

Validation is checking the knowledge base of the KBS for semantic faults that may occur during the KBS development. A validated KBS comprises the correct knowledge to perform like the domain expert in the domain area. Thus, validation searches for faults in the KBS behavior when it attempts to find a solution for a certain domain problem.

Usability is an association between the KBS and the end-user. This means whether the end-user is satisfied when he/she interacts with the KBS. Therefore, it must be evaluated before installing the KBS to the end-user.

Usefulness refers the association among the new KBS, the end-users, and the company that owns the product. The usefulness view can be noticed when the new KBS accomplishes its job. It is not possible to evaluate the new KBS if it is not functional.

Performance measures: Barry [14] noticed, Precision, Recall, and Accuracy are the common parameters used for measuring the performance of a certain classifier. These parameters are defined in terms of the instances that are relevant and the instances that are correctly classified (or retrieved). The following table 2.1 shows the confusion matrix which can be used to calculate P, R and Accuracy of the classifier.

Table 2.1 Metrics for performance evaluation

	Predicted Class		
Actual Class		**Class=YES**	**Class=NO**
	Class=YES	TP	FP
	Class=NO	FN	TN

- The **precision** (P) is the proportion of the classified information which is relevant, as calculated using the equation:

  P = TP/ (TP +FP)

- The **recall** (R) is the proportion of the classified relevant information versus all relevant information, as calculated using the equation:

  R = TP/ (TP +FN)

- The **F-measure** is the harmonic mean of precision and recall, as calculated using the equation:

  F = 2 * P * R/ (P + R)

- The **accuracy** (AC) is the fraction of the total number of predictions that were correct, as calculated using the equation:

  AC = (TP +TN)/ (TP + FP + TN +FN)

2.10. Review of Related Works

Medical expert systems have met a pretty interest within the academic areas. The following related literatures are on medical expert systems for diagnosis and treatment of different approaches.

Solomon [19] developed a self-learning KBS for diagnosis and treatment of diabetes. This study was acquired tacit and explicit knowledge. Thus, the tacit knowledge was acquired using both structured and unstructured interviews from domain experts which were selected using purposive sampling technique from Black Lion Hospital Diabetes Center and relevant documents analysis method was also followed to capture explicit knowledge. Then, the acquired knowledge was modeled using decision tree that represents concepts and procedures involved in diagnosis and treatment of diabetes and production rules are used to represent the domain knowledge. The overall total performance of the prototype system was 84.2%.

Another research on Expert System was for Mouth Problems in Infants and Children [20] was done. This system was developed to ask the user to answer the questions about the symptoms of the patient and end up with the diagnosis. Then this expert system shows the user some information about the disease and some advices telling him/her how to deal with the baby. SL5 Object expert system language was used to design and implement this expert system.

Guesh [21] developed a prototype KBS for blood transfusion. This study was conducted using rule-based representation technique to solve the problem of existence of knowledge gap among the domain experts on which blood type to transfuse for patients in need of urgent or non-urgent transfusion. Accordingly, tacit knowledge was acquired using both interview and observation techniques and secondary sources using document analysis technique. The acquired knowledge was modeled using hierarchal knowledge representation method. Then, the knowledge is represented using production rule and the prototype system was developed using SWI-Prolog editor tool. The prototype system registered 82.5% performance after extensively tested and evaluated.

Solomon [22] developed the potential for applying KBS for diagnosis of acute respiratory tract infections. The research was conducted using rule-based representation technique to find solution for the problem of preserving domain expert’s knowledge tract infections. Therefore, to solve such problem knowledge about the diagnosis of acute respiratory tract infections was acquired from domain experts and secondary sources. Then, the acquired knowledge was modeled using decision trees and represented in the form of production rules. Prolog programming language has been used to implement the prototype system. In this study, he recommended for further study to develop an expert system for diagnosis of respiratory infections.

Generally, several studies have been developed using rule-based representation technique to reason out the solution of a particular problem. But, the developed KBSs were not used automatic knowledge extraction from datasets for diagnosis of gastritis disease and the system was not with smart user interface fundamentally .Thus, in this study an attempt is made to design a prototype KBS by integrating prolog and Java net beans for diagnosis and treatment of gastritis that is effective and efficient in decision making.

CHAPTER THREE
METHODOLOGY

This chapter describes the details of the methodology used to develop knowledge based system for diagnosis and treatment of gastritis disease that would help to minimize problems that are caused due to lack of potential human expert or lack of potential skills to solve the patient's health problem.

A research methodology is an arrangement of condition for collocation and analysis of data in a manner that aims to address the research problem. This section provides interesting features for knowledge acquisition, data understanding, data preparation, data preprocessing, knowledge modeling and representation of the Bethel referral hospital gastritis dataset emphasizing its ability to accurately diagnosis of type of gastritis. Domain experts are interviewed to select appropriate attribute, transforming continues data in to nominal and how to discretize for knowledge mining.

3. Research design and approaches

The study follows knowledge engineering approach for coming up with the knowledge based system for diagnosis and treatment of gastritis. Knowledge engineering is the process of acquiring knowledge from experts and building a knowledge-based system. A major goal of knowledge engineering is to help experts articulate what they know and document the knowledge in a reusable form. Knowledge engineering can be viewed from two perspectives, narrow and broad. According to the narrow perspective, knowledge engineering deals with knowledge acquisition, representation, validation, inference, explanation and maintenance. On the other hand, the broader perspective deals with the entire process of developing (from the very beginning of knowledge election up to evaluation of the prototype system) and maintaining intelligent systems. For this research, the researcher gives more attention on knowledge acquisition, knowledge modeling, knowledge representation and evaluation of knowledge-based system.

3.1.1. Knowledge Acquisition

Knowledge acquisition is the process of eliciting, structuring and organizing knowledge from human experts, books, documents, and sensors [23]. On the other hand, it refers computer files and transferring to the knowledge base using knowledge representation techniques used in knowledge-based system; namely, logic, production rules, semantic nets, frames and cases. The acquired knowledge may be specific to the problem domain and the problem solving procedures, or it may be general knowledge (e.g., knowledge about business), meta-knowledge (knowledge about knowledge). In this field, many professionals have disclosed a common understanding that knowledge acquisition is a very difficult task to carry out [23].

The acquisition of knowledge is the most important and decisive phase in building knowledge-based systems. However, it is an extremely hard and capable of making an error task that knowledge engineer does while developing a knowledge-based system. One of the major difficulties during knowledge acquisition is to elicit and explicitly identify the human expert knowledge, and capture a knowledge relevant to the intended application. As a result of the challenges and difficulties confronted in the transfer of expertise knowledge, knowledge acquisition has been depicted as the obstruction of knowledge based systems development [9].

In this study, the knowledge required to build a knowledge-based system was elicited from both tacit and explicit sources of knowledge. Tacit knowledge is collected from four experts in the domain area from Bethel Referral Hospital (that are working as - Internist, Pediatrics, and Nurse) by using structured and unstructured interview. These experts are essentially taking part during the study and asked to verify the rightness of the acquired knowledge. Moreover, explicit source of knowledge has been collected from the internet, manuals, research papers and journal articles, etc.

3.2. Knowledge of Gastritis

Gastritis refers to a group of diseases characterized by inflammation of the gastric mucosa. Histologic examination of gastric mucosal biopsies is necessary to establish a diagnosis of gastritis. In clinical practice, the role of the pathologist who evaluates a gastric biopsy for gastritis is to find the cause of gastritis because that will provide direct targets toward which therapeutic measures can be directed. An etiologic classification of gastritis is presented at the end of this section. Comprehensive reviews of gastritis have been published. The goal of this article is to present a practical approach to the diagnosis of the most common types of gastritis encountered in a large practice of gastrointestinal pathology. The reader will be presented several cases representative of typical forms of gastritis; for each case, the reader will be prompted through a series of questions to examine the histologic features of the mucosa, leading to a pattern of answers and to a final diagnosis[24].

3.2.1. Types of Gastritis

Helicobacter pylori infection is the most common cause of chronic gastritis. Other forms of infectious gastritis include the following: Helicobacter heilmannii–associated gastritis; granulomatous gastritis associated with gastric infections in mycobacteriosis, syphilis, histoplasmosis, mucormycosis, South American blastomycosis, anisakiasis or anisakidosis;

chronic gastritis associated with parasitic infections; and viral infections, such as cytomegalovirus and herpesvirus infection [24].

Non-infectious gastritis is associated with autoimmune gastritis; reactive or chemical gastropathy, usually related to chronic bile reflux or nonsteroidal anti-inflammatory drug (NSAID) intake; uremic gastropathy; non-infectious granulomatous gastritis; lymphocytic gastritis, including gastritis associated with celiac disease; eosinophilic gastritis; radiation injury to the stomach; graft-versus-host disease; ischemic gastritis; and gastritis secondary to chemotherapy.

Many cases of gastritis are of undetermined cause and present as chronic, inactive gastritis with various degrees of severity.

ATROPHIC GASTRITIS

Several publications, including those reporting the Sydney system and the updated Houston classification of gastritis, have proposed criteria for the evaluation of atrophic gastritis. Inter observer variability is significant, especially in the evaluation of antral atrophy. Recent advances that appear to decrease the inter observer variation in the assessment of gastric atrophy have been reported. Atrophy is more accurately assessed after resolution of severe inflammation of the mucosa; therefore, if there is H pylori gastritis, the infection should be eradicated before atrophy is definitively evaluated. When marked inflammation is present, a diagnosis of indefinite for atrophy may be offered, especially if there is no intestinal metaplasia [24].

The recommended definition of atrophy is the loss of appropriate glands, and atrophy can be scored according to the degree of severity as mild, moderate, or severe. In this definition, intestinal metaplasia represents a form of atrophy described as metaplastic atrophy (or gastric glandular atrophy with intestinal metaplasia).

AUTOIMMUNE ATROPHIC GASTRITIS

This form of gastritis is caused by antiparietal cell and anti-intrinsic factor antibodies and presents as a chronic gastritis with oxyntic cell injury, and glandular atrophy essentially restricted to the oxyntic mucosa of the gastric body and fundus. The histologic changes vary in different phases of the disease. During the early phase, there is multifocal infiltration of the lamina propria by mononuclear cells and eosinophils and focal T-cell lymphocyte infiltration of oxyntic glands with glandular destruction. Focal mucous neck cell hyperplasia (pseudopyloric metaplasia), and hypertrophic changes of parietal cells are also observed [24].

During the florid phase, there is increased lymphocytic inflammation, oxyntic gland atrophy, and focal intestinal metaplasia. The end stage is characterized by diffuse involvement of the gastric body and fundus by chronic atrophic gastritis associated with multifocal intestinal metaplasia. In contrast to the gastric body, the antrum is spared. Recently, a distinct form of autoimmune gastritis, characterized by atrophic pangastritis, was reported in a small group of patients with systemic autoimmune disorders.

Autoimmune gastritis is a relatively rare disease but represents the most frequent cause of pernicious anemia in temperate climates. The risk of gastric adenocarcinoma was reported to be at least 2.9 times higher in patients with pernicious anemia than in the general population, and there is also an increased risk of gastric carcinoid tumors.

LYMPHOCYTIC GASTRITIS

Lymphocytic gastritis is a type of chronic gastritis characterized by marked infiltration of the gastric surface and foveolar epithelium by T lymphocytes and by chronic inflammation in the lamina propria. A diagnosis can be rendered when 30 or more lymphocytes per 100 consecutive epithelial cells are observed, and the counts are recommended in biopsies from the gastric corpus. The endoscopic pattern is, in some cases, described as varioliform gastritis. The cause of lymphocytic gastritis is usually unknown, but some cases are seen in patients with glutensensitive enteropathy/celiac disease and in Me´ne´trier disease [24].

Smaller numbers of intraepithelial lymphocytes can also be seen in H pylori gastritis, but the diagnosis of lymphocytic gastritis should be reserved for cases with marked intraepithelial lymphocytosis in the absence of active H pylori gastritis. Lymphocytic gastritis can be observed in children but is usually detected in late adulthood, with average age of diagnosis of 50 years.

CHRONIC, REACTIVE (CHEMICAL) GASTROPATHY

Chronic reactive gastropathy (also know as chemical gastropathy) is very common in current clinical practice.

The mucosal changes are usually more prominent in the prepyloric region, but they may extend to involve the oxyntic mucosa. The usual underlying causes include chronic bile reflux and long-term NSAID intake. The histopathologic features include mucosal edema, congestion, fibromuscular hyperplasia in the lamina propria, and foveolar hyperplasia with a corkscrew appearance in the most severe forms. The foveolar epithelium characteristically shows reactive nuclear features and reduction of mucin. The epithelial changes occur with little background chronic inflammation. However, if there is erosion of the mucosa, superficial neutrophils may be present [24].

3.2.2. Criteria for diagnosis of Gastritis

The domain experts have concept of sign and symptoms to start investigation of Gastritis disease. During the process of knowledge gathering, domain experts explained that they use patient’s medical history, physical examination, and test results [24].

Examination of the biopsy material results in the following pattern of answers:

1. Are there features of chronic gastritis? There is minimal chronic gastritis.

2. Are there neutrophils in the mucosa? No.

3. Is there Helicobacter? No. Examination of H&E stains does not reveal H pylori bacterial forms.

4. Is there atrophy? No. There is no atrophy or intestinal metaplasia.

5. What is the topography of lesions? The chronic gastritis involves, at minimum, the gastric antrum.

6. Are additional special features seen? Yes. There are diagnostic special features, including foveolar hyperplasia with a corkscrew appearance of the foveolae. The foveolar epithelium shows reactive cytologic features, including reduced cytoplasmic mucin. The lamina propria shows congestion and smooth muscle hyperplasia, with prominent muscularization of the most superficial mucosa.

7. Are special stains recommended? No ancillary tests are performed.

Diagnosis. Gastric antral mucosa with features consistent with reactive gastropathy. No H pylori organisms are identified.

Examination of the biopsy material results in the following pattern of answers:

1. Are there features of chronic gastritis? Yes. The sample of gastric mucosa reveals mucosal erosion with granulation tissue and associated chronic and acute inflammation.

2. Are there neutrophils in the mucosa? Yes. There are superficial neutrophils in the mucosa, but they are limited to the area of mucosal erosion.

3. Is there Helicobacter? No. Examination with H&E stain does not reveal such bacterial forms.

4. Is there atrophy? No. There is no atrophy or intestinal metaplasia.

5. What is the topography of lesions? Away from the areas of erosion, there is no evidence of gastritis; therefore, the location of the biopsy is not contributory in this case.

6. Are additional special features seen? Yes. There are special features including enlarged cells, arousing suspicion of cytomegalovirus inclusions in the granulation tissue.

7. Are special stains recommended? Yes. Immunohistochemical stain for cytomegalovirus reveals rare but characteristic viral inclusions (not shown).

Diagnosis. Gastric antral mucosa with erosion and cytomegalovirus inclusions, consistent with cytomegalovirusassociated gastritis.

Examination of the biopsy material results in the following pattern of answers:

1. Are there features of chronic gastritis? Yes.

2. Are there neutrophils in the mucosa? Yes. There are neutrophils in the mucosa; therefore, there is a component of active gastritis.

3. Is there Helicobacter? No. Examination with H&E stains do not reveal H pylori bacterial forms. Immunohistochemical stain is performed.

4. Is there atrophy? If the biopsy is from gastric oxyntic mucosa then there is atrophy, however, if the specimen is from the antrum, it may represent chronic gastritis without atrophy. There is no intestinal metaplasia.

5. Are special stains recommended? Yes. Immunohistochemical stains for synaptophysin and gastrin are performed.

Immunohistochemical stains for synaptophysin (Figure 4, B), show a linear pattern of synaptophysin-positive positive cells, whereas the gastrin stain is negative. Because gastrin is negative, the biopsy is not from the gastric antrum (G cells are characteristically located in the antrum and pylorus), and therefore, it can be established that the biopsy is of oxyntic mucosa with reduced oxyntic glandular profiles, establishing a diagnosis of atrophy. The linear arrays of synaptophysin-positive cells represent enterochromaffin- like cell hyperplasia. Enterochromaffinlike cell hyperplasia occurs in response to hypergastrinemia that results from hypochlorhydria associated with gastric oxyntic cell atrophy.

6. Are additional special features seen? No.

7. Is immunohistochemical stain for H pylori positive? No.

Diagnosis. Gastric oxyntic mucosa with chronic active gastritis and glandular atrophy, severe. No intestinal metaplasia is identified. No Helicobacter organisms are identified.

Note: These features are most suggestive of autoimmune gastritis.

Examination of the biopsy material results in the following pattern of answers:

1. Are there features of chronic gastritis? Yes. There are large numbers of intraepithelial lymphocytes.

2. Are there neutrophils in the mucosa? No.

3. Is there Helicobacter? No. Examination with H&E is performed.

4. Is there atrophy? No. There is no glandular atrophy and no intestinal metaplasia.

5. What is the topography of lesions? The chronic gastritis involves, at minimum, the gastric antrum.

6. Are additional special features seen? Yes. The specific features in this biopsy include a characteristic intraepithelial lymphocytosis. Immunohistochemical stain for CD3 is positive, highlighting a population of T lymphocytes in the mucosa and, typically, many intraepithelial lymphocytes.

7. Are special stains recommended? Yes. Immunohistochemical stain for H pylori, which is negative.

Diagnosis: Chronic gastritis with increased intraepithelial T lymphocytes. No Helicobacter organisms are identified.

Note: These features are consistent with lymphocytic gastritis–associated with celiac disease.

3.2.3. Treatment of Gastritis

Treatment regimes differ from antibiotics (in H. pylori gastritis) to vitamin supplementation (in autoimmune metaplastic atrophic gastritis), to immunomodulatory therapy (in autoimmune enteropathy), to dietary modifications (in eosinophilic gastritis) [24].

- H. pylori-associated gastritis: A triple-therapy comprising Clarithromycin/proton-pump inhibitor/amoxicillin for 14-21 days is considered the first line of treatment. Clarithromycin is preferred over metronidazole/proton-pump inhibitor/amoxicillin because the recurrence rates when clarithromycin is used are far less compared to a triple-therapy using metronidazole.

However, in areas where clarithromycin resistance is known, metronidazole should be used.

Quadruple bismuth containing therapy would be of benefit, particularly if metronidazole is used.

- After two eradication failures, H. pylori culture and tests for antibiotic resistance should be considered.
- Autoimmune gastritis: Substitution of deficient iron and vitamin B12 (parenteral 1000 μg or oral 1000-2000 μg). Monitor Iron and folate levels, and eradicate any co-infection with H. pylori. Endoscopic surveillance for cancer risk and gastric neuroendocrine tumours (NET) is required.
- Other forms of treatment in gastritis include cessation of alcohol, smoking, and anti-inflammatory drugs, avoiding spicy food, managing stress, immunomodulatory therapy in autoimmune enteropathy, and dietary modification in eosinophilic gastritis.

Medical Therapy

The goal of therapy for peptic ulcer disease is to relieve symptoms, heal craters, prevent recurrences, and prevent complications. Medical therapy should include treatment with drugs, and attempt to accomplish the following: 1) reduce gastric acidity by mechanisms that inhibit or neutralize acid secretion, 2) coat ulcer craters to prevent acid and pepsin from penetrating to the ulcer base, 3) provide a prostaglandin analog, 4) remove environmental factors such as NSAIDs and smoking, and 5) reduce emotional stress (in a subset of patients).

Antacids neutralize gastric acid and are more effective than placebo in healin g gastric and duodenal ulcers. However, antacids have to be taken in relatively large doses 1 and 3 hours after meals and at bedtime, and may cause side effects. The major side effect of magnesium-containing antacids is diarrhea caused by magnesium hydroxide [24].

Surgical Therapy

Over the past few decades in the United States, we have witnessed a declining need for surgery to treat peptic ulcer disease. This decline may be explained primarily by the widespread use of H2 receptor antagonists, and now more recently, proton pump inhibitors. Complications such as gastrointestinal hemorrhage, perforation, or gastric outlet obstruction remain the major indications for surgical intervention.

The most common reason for surgical intervention for benign gastric ulcers is failure of the ulcer to completely heal after an adequate trial of medical or endoscopic therapy. Patients are usually given a 6-month trial of antisecretory agents prior to surgical consultation. The major concern regarding non-healed ulcers is the high risk of underlying malignancies.

Due to the benign nature of duodenal ulcers, physicians can monitor the patients' response to medical regimens by following their symptoms. When patients with duodenal ulcers require surgery, it is usually one of three procedures: vagotomy, vagotomy with antrectomy, or subtotal gastrectomy. Vagotomy alone (without gastric resection) may involve truncal vagotomy with drainage, selective vagotomy with drainage, or proximal gastric vagotomy alone (without a drainage procedure).

Endoscopic Therapy

Endoscopy is the preferred procedure for the diagnosis and treatment of an upper gastrointestinal hemorrhage because of the low complication rate and accuracy. Stigmata on ulcers may be seen during endoscopic procedures, and are important prognostic indicators.

Primary Treatment of H. pylori Infection

In the United States, the recommended primary therapies for H. pylori infection include: a PPI, clarithromycin, and amoxicillin, or metronidazole (clarithromycin-based triple therapy) for 14 days or a PPI or H2RA, bismuth, metronidazole, and tetracycline (bismuth quadruple therapy) for 10–14 days [24].

Sequential therapy consisting of a PPI and amoxicillin for 5 days followed by a PPI, clarithromycin, and tinidazole for an additional 5 days may provide an alternative to clarithromycin-based triple or bismuth quadruple therapy but requires validation within the United States before it can be recommended as a first-line therapy. The first course of therapy offers the greatest likelihood of eradicating H. pylori infection. Subsequent treatment trials particularly if the same antibiotics are utilized or if the patient has been previously exposed to any antibiotics contained in the treatment regimen, are less likely to achieve a successful outcome.

The most important predictors for treatment of failure following anti- H. pylori therapy include poor compliance and antibiotic resistance. There is limited evidence to suggest that smoking, alcohol consumption, and diet may also adversely affect the likelihood of successful eradication.

It is critical for clinicians to stress the importance of taking the medications as prescribed to minimize the likelihood of treatment failure and development of antibiotic resistance.

Patients should also be informed of the most commonly reported treatment-related side effects.

3.3. Conceptual Modeling for Gastritis diagnoosis

Conceptual modeling is extensively acknowledged as the critical stage of knowledge acquisition. Models are applied to acquire the important characteristics of problem domains by decomposing them into more controllable parts that are simple to know and to use. Models are very related with the domain they denote. A “model is a simplification of reality” [25]. Models support individuals to increase in value and know such complexity by allowing them to investigate each specific area of the system successively. Models are applied in systems development tasks to depict the designs of the system and to simplify communication between disparate individuals in the group at disparate levels of abstraction. Individuals have disparate opinions of the system and models can aid them know these opinions in a combined way.

In the Clinical Diagnosis, a decision needs to be made whether the gastritis disease is suspected or not. The input knowledge role consists of data about the patient case such as, Nausea, Vomiting, blood pressure, anorexia, fatigue, weight loos, belching, abdominal bloating, malaise and smoking. The following figure 3.1 shows Decision tree for gastritis disease from discussion of domain expert:

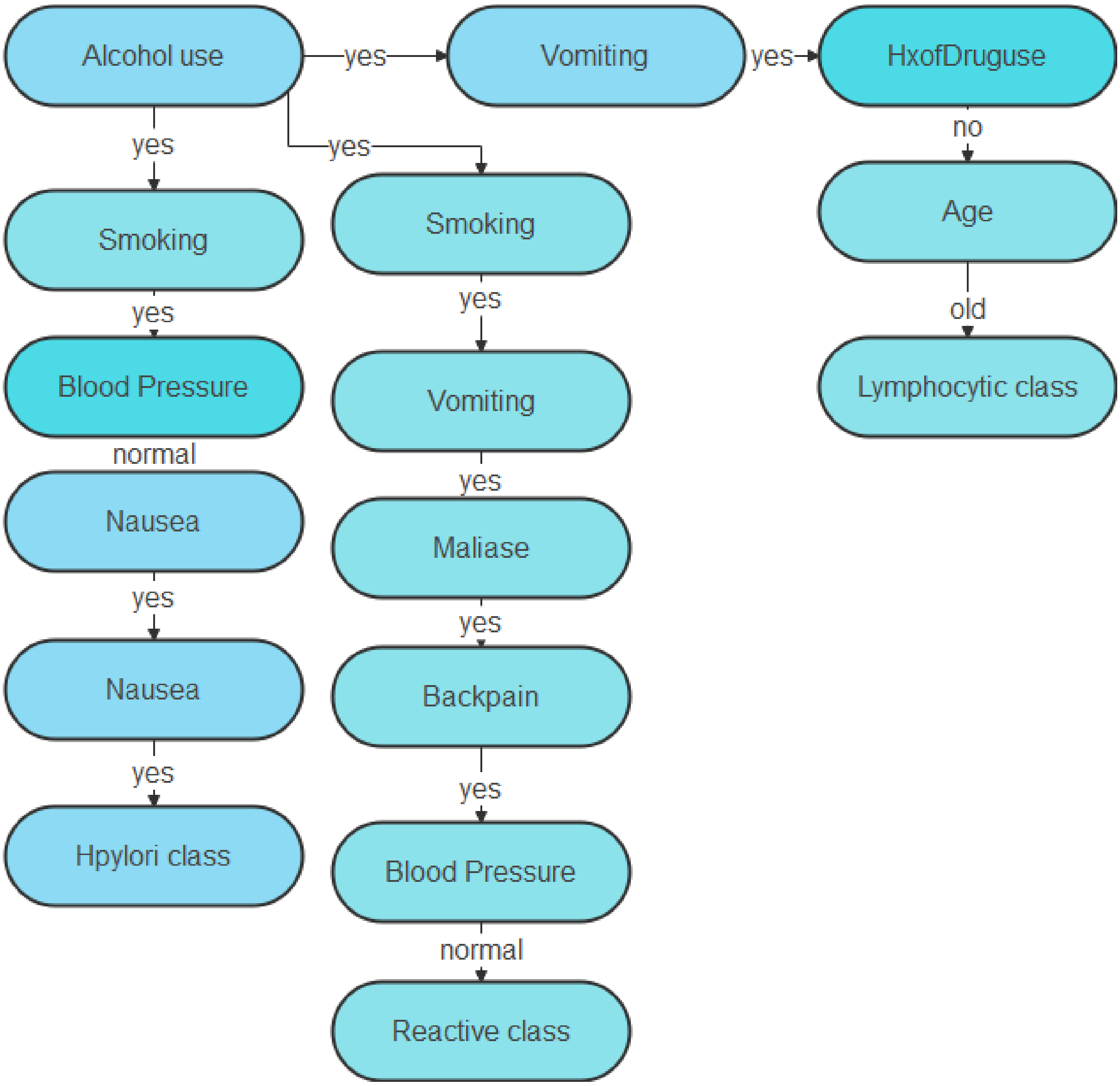

Figure 3.1 Decision tree for Gastritis disease from discussion of domain expert

3.3.1. Knowledge about sign and symptoms

Gastritis is an inflammation, irritation, or erosion of the lining of the stomach. It can occur suddenly or gradually. Gastritis can be caused by irritation due to excessive alcohol use, chronic vomiting, stress or use of certain medications such as asprin or anti-iflammatory.

Table 3.1 Attributes and their Description

No.	Attribute name	Data type	Description
1	Age	Numeric	Age of the patient in years
2	Blood Pressure	Numeric	The patients' blood pressure
3	Nausea	Nominal	Is the patient has symptom of nausea, yes or no
4	Vomiting	Nominal	Is the patient has symptom of vomiting, yes or no
5	FoodorFasting	Nominal	When the disease risk becomes high, when eating food or fasting
6	Anorexia	Nominal	Is the patients way of eating decreased, yes or no
7	Fatigue	Nominal	Is the patient has fatigue, yes or no
8	Weight Loss	Nominal	Is the patient losing weight, yes or no
9	Belching	Nominal	Is the patient has sign of belching yes or no
10	Abdominal Bloating	Nominal	Is the patient has sign of Abdominal bloating, yes or no
11	Alcohol use	Nominal	Is the patient use alcohol, yes or no
12	Hx of drug use	Nominal	Is the patient used drug before, yes or no
13	Back pain	Nominal	Is the patient has sign of back pain, yes or no
14	Maliase	Nominal	Is the patient has sign of malaise, yes or no
15	Smoking	Nominal	Is the patient smokes, yes or no

Gastritis symptoms and risk factors differ between individuals and in many people. The most common symptoms include:

- Nausea
- Vomiting
- Abdominal pain
- Anuroxia

- Epigastric pain
- HeadAche
- Backpain
- Burning sensation
- Abdominal Cramp
- Epigastric burning pain
- Loss of Appetite
- Chest pain
- Abdomenal Bloatin
- belching
- Joint pain
- Maliase
- Fatique

The original dataset contains 22 attributes and common gastritis disease with six class labels namely Autoimmune, Dyspepsia, Hpylori, reactive, Lymphocytic and Atrophic gastritis. From this total of 15 attributes were selected for this research based on their relevance and pre-processing in diagnosing gastritis disease with the help of domain experts. There were attributes excluded from the original dataset like sex, medical record number and duration that are not relevant in classifying gastritis class labels. We select the attributes based on their effect in the outcome in determining the final result and with the help of medical experts. The selected attributes in diagnosing gastritis and their description was presented in the above table.

Table 3.2 Concepts of Age and blood Pressure

Attribute	Range	New value
Age of patient in year	Age	Age < = 15 child, age = (15-35] = young, age = (35-55) = adult and age > =55=old.
Blood pressure(BP)	BP	BP < = 120/80 = normal, BP = (120-139/80-89] = pre-stage, BP = (139-159/89-100] = stage 1 and BP > 159/100 = stage2

Domain experts first listen the general symptoms from patient and asking the age of the patient. Knowing age of patient helps domain expert in trying to classify the suspected gastritis as atrophic, reactive, lymphocytic, autoimmune, Hpylori and Dyspepsia.

3.4. Methods of Knowledge Collection

In this study explicit and tacit knowledge are acquired from both codified (documented) sources and non-codified (non-documented) sources respectively. Non-codified sources of knowledge are acquired from Internists and medical doctors who work in the Bethel Referral Hospital by using interview (both structured and unstructured) and critique (analyzing) knowledge elicitation methods to filter the acquired knowledge. Similarly, codified sources of knowledge such as medical books, training manuals and journal medical articles are acquired by using document analysis technique.

3.5. Sampling Technique

There are many sampling methods that are used for different research purposes. In this study purposive sampling technique is used to select the domain experts based on the researcher decision to get the required knowledge to conduct the study. The selection criteria of domain experts for the study are based on the professions/expertise, educational qualification level, year of experience and their immediate position.

Purposive sampling is one of the most common sampling techniques in qualitative research in which participants group are decided to pre-selected criteria relevant to a particular research question. Purposive sampling helps the researcher to use different characteristics to select the subject of the study. The general principle, however, remains, "Think of the person or place or situation that has the largest potential for advancing your understanding and look there".

3.6. Knowledge modelling and Representation Technique

After the knowledge has been acquired and modeled, the next step is knowledge representation using appropriate format that is both understandable by end-users, experts and inference engine. Once the knowledge being extracted from codified and non-codified sources, it is modelled using decision tree and represented using production rule which is one of the knowledge representation techniques. Decision trees models by constructing a tree based on training instances with leaves having class labels is used. These are easy to interpret. Production rules are easy for a human expert to read, understand and maintain. Production rules contain simple syntax that is flexible and easy to understand and are reasonably efficient in diagnosing problems. In this study a rule-based knowledge representation and reasoning is followed. They are one of the most commonly used technique for the development of knowledge-based systems. Knowledge is represented in the form of condition-action pairs: IF this condition (or antecedent-condition or premise) occurs, THEN some action (or conclusion or consequence) will occur.

Rules generated with the help of domain experts:

Rule 1: IF Alcohol use = YES AND Vomiting = YES AND Hxofdruguse = NO AND Age = Old: THEN Lymphocytic

Rule 2: IF Alcohol use = YES AND Smoking = YES AND Agbyfoodorfasting = FOOD AND Abdomenal bloating = YES AND Belching = YES AND Blood pressure = Stage2: THEN Dyspepsia

Rule 3: IF Alcohol use = YES AND Smoking = YES AND Vomiting = YES AND Malaise = YES AND Backpain = YES AND Blood pressure = Normal: THEN reactive

Rule 4: IF Alcohol use = YES AND Smoking = YES AND Agbyfoodorfasting = FOOD AND Abdomenal bloating = YES AND Backpain = YES AND Blood pressure = Prestage AND Age = Old: THEN reactive

Rule 5: IF Alcohol use = YES AND Smoking = YES AND Blood pressure = Normal AND Malaise = YES AND Vomiting = NO AND Age = Adult AND Belching = NO: THEN Hpylori

Rule 6: IF Alcohol use = YES AND Smoking = YES AND Blood pressure = Normal AND Nausea = YES AND Malaise = YES: THEN Hpylori

Rule 7: IF Alcohol use = YES AND Vomiting = YES AND Agbyfoodorfasting = FASTING AND Blood pressure = Normal AND Age = Old AND Malaise = YES: THEN Atrophic

Rule 8: IF Alcohol use = YES AND Backpain = NO AND Malaise = YES AND Nausea = NO AND Age = Old AND Agbyfoodorfasting = FOOD: THEN Hpylori

Rule 9: IF Alcohol use = YES AND Vomiting = YES AND Agbyfoodorfasting = FASTING AND Smoking = YES AND Blood pressure = Prestage: THEN reactive

Rule 10: IF Alcohol use = YES AND Agbyfoodorfasting = FOOD AND Belching = NO AND Hxofdruguse = NO AND Nausea = YES AND Abdomenal bloating = YES: THEN Dyspepsia

Rule 11:IF Anuroxia = YES AND Agbyfoodorfasting = FASTING AND Nausea = YES AND Backpain = NO: THEN Hpylori

Rule 12: IF Anuroxia = YES AND Hxofdruguse = YES AND Blood pressure = Stage2 AND Alcohol use = NO: THEN Lymphocytic

Rule 13: IF Anuroxia = YES AND Hxofdruguse = NO: THEN reactive

Rule 14: IF Anuroxia = NO AND Nausea = NO AND Hxofdruguse = NO: THEN Atrophic (

Rule 15: IF Anuroxia = NO AND Nausea = YES AND Fatigue = YES AND Agbyfoodorfasting = FOOD: THEN Lymphocytic

Rule 16: IF Fatigue = NO AND Blood pressure = Normal AND Weight loss = NO AND Agbyfoodorfasting = FOOD AND Age = Young: THEN Hpylori

Rule 17: IF Fatigue = YES: Hpylori (6.0) Nausea = YES AND Blood pressure = Normal AND Agbyfoodorfasting = FASTING AND Weight loss = NO AND Abdomenal bloating = YES: THEN Hpylori

Rule 18: IF Nausea = YES AND Blood pressure = Stage1: THEN Dyspepsia

Rule 19: IF Nausea = YES AND Hxofdruguse = NO AND Abdomenal bloating = NO AND Blood pressure = Normal: THEN Lymphocytic

Rule 20: IF Hxofdruguse = NO: THEN Dyspepsia

Rule 21: IF Age = Adult AND Backpain = YES AND Blood pressure = Stage2 AND Nausea = NO: THEN Hpylori

The acquired domain knowledge is represented as a set of ―IF – THEN rules in the prototype.

Rule 1:

IF Blood pressure = Normal AND

Agbyfoodorfasting = FASTING AND

Vomiting = NO AND

Nausea = YES AND

Alcohol use = NO AND

Age = Adult AND

Hxofdruguse = YES AND

Fatigue = YES:**THEN** Hpylori

Rule 2:

IF Blood pressure = Normal AND

Agbyfoodorfasting = FASTING AND

Anuroxia = YES AND

Vomiting = NO AND

Fatigue = YES: **THEN** Lymphocytic

Rule 3:

IF Blood pressure = Normal AND

Agbyfoodorfasting = FASTING AND

Anuroxia = YES AND

Malaise = YES AND

Nausea = NO: **THEN** Dyspepsia

Rule 4:

IF Blood pressure = Normal AND

Agbyfoodorfasting = FASTING AND

Anuroxia = YES AND

Malaise = NO AND

Age = Adult:**THEN** reactive

Rule 5:

IF Vomiting = NO AND

Agbyfoodorfasting = FASTING AND

Fatigue = YES AND

Backpain = YES AND

Alcohol use = NO:**THEN** Lymphocytic

Rule 6:

IF Weight loss = NO AND

Fatigue = NO AND

Vomiting = YES AND

Blood pressure = Normal AND

Abdomenal bloating = YES: **THEN** Atrophic

CHAPTER FOUR

IMPLEMENTATION AND DISCUSSION OF RESULTS

In the following sections, the implementation includes the real construction of the prototype system for diagnosis and treatment of gastritis. Facts can be represented as a rule in the knowledge base. The knowledge engineer has to represent the gathered knowledge into an appropriate format which is easily understandable by computer system using rule-base knowledge representation method. In addition to this, the researcher used other techniques such as document analysis and interview by interviewing domain experts who are doing in Bethel referral hospital and work on diagnosing type of Gastritis and Treatments for management of Gastritis patients. Data collected from Bethel referral hospital is stored as facts and represented in Knowledge base system. The final step is developing the knowledge base using the knowledge acquired from domain expert and document analysis. The knowledge base is a place to store knowledge where rules are going to be stored and it serves as the warehouse of knowledge. After the necessary knowledge is represented using a rule-based knowledge representation technique, the next step is coding the represented knowledge using Prolog programming language into a suitable format that is understandable by the inference engine. Besides to this, since knowledge is always dynamic, the researcher tried to narrow the gap by developing knowledge base system using SWI-prolog and Java Neat Beans.

4. Architecture of the prototype knowledge base system

An architecture is a blueprint showing how the components of the prototype knowledge-based system interacts and interrelates. The proposed knowledge base system architecture shows how the components of the prototype, the knowledge base construction techniques used to diagnosis patients with gastritis. The knowledge acquisition problem of rule based reasoning by supplying extracted knowledge to rule based reasoning system. We construct the rules with the help of domain experts, patients dataset and literature review, prolog is used for model/rule construction and evaluation, java net beans for building interactive user interface with rule based reasoning and for knowledge representation.

In the design paths, the design of knowledge based system for gastritis diseases, diagnosis and treatment was expanded into system architecture to ensure that it supported gastritis disease and treatments. The general framework shows the tasks used for generating knowledge from collection of Bethel hospital dataset. The generated knowledge is represented in the knowledge base. Figure 4.1 illustrates the architecture of the prototype system.

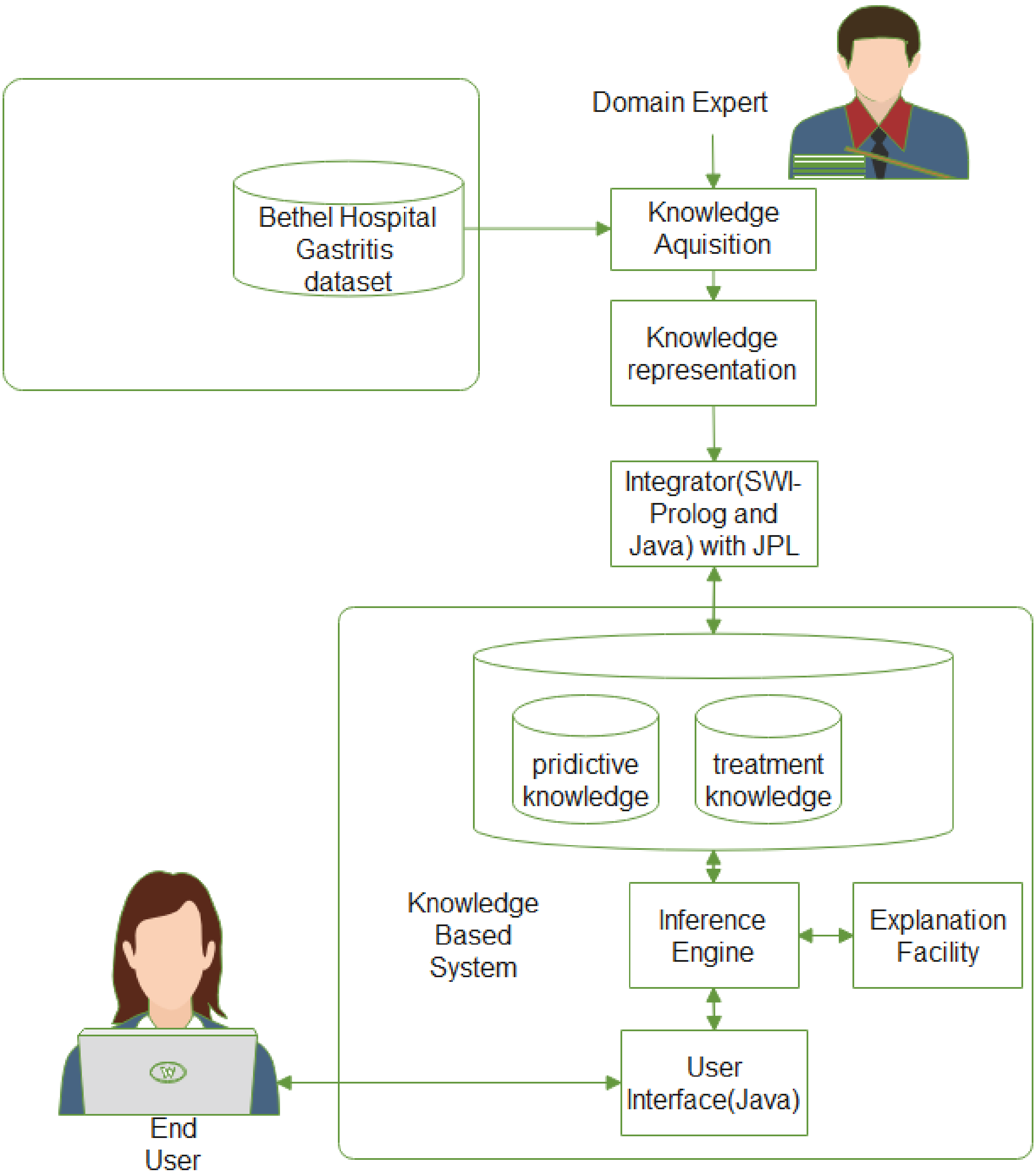

Figure 4.1 Architecture of the prototype knowledge based system

As shown in figure 4.1, the developed prototype system functions by asking questions to the new patient who came for diagnosis and treatment of gastritis. First it checks the appearance of the basic symptoms of gastritis in the patient and sends the patient for a check up to decide whether the patient has gastritis or not. If the patient has gastritis, then it further diagnoses the patient to identify which type of gastritis the patient has. To decide whether the patient has atrophic, reactive, lymphocytic, autoimmune, Hpylori and Dyspepsia, it considers the sign and symptoms of Gastritis, causative agents of gastritis and place of accusation. Besides, if the previous diagnosed result of a certain patient shows the patient has Hpylori and when the patient wants to diagnose again, the result shows the patient has gastritis. Finally, the system recommends treatments for patients based on the type of gastritis the patient has and the prototype system enable the users to interact with it using a user friendly GUI.

4.2. Knowledge Base

The knowledge base stores all relevant knowledge, fact, rules, and relationships used by the knowledge based system. The knowledge base incorporates the relevant knowledge that was acquired from the domain experts. The sample validated knowledge is represented in the form of rules by rule-based representation technique. The numbers of facts depends on the numbers of rules incorporated into the knowledge base. Functionally, the facts in the facts base are used to compare against the "if" (condition) part of rules stored in the knowledge base. The rules are simplified in to the knowledge base of the prototype system using Prolog programming language as follows.

```
go :-
write('What is the patient"s name? '),
read(Patient),get_single_char(Code),
hypothesis(Patient,Disease),
write_list([Patient,', probably has ',Disease,'.']),nl.
symptom(Patient,backpain) :-
verify(Patient," have a Backpain (y/n) ?").
symptom(Patient,vomiting) :-
verify(Patient," have a Vomiting (y/n) ?").
symptom(Patient,young) :-
verify(Patient," age is  Young (y/n) ?").
symptom(Patient,food) :-
verify(Patient," eat ag  by FOOD (y/n) ?").
symptom(Patient,alcohol_use) :-
verify(Patient," have addiction of Alcohol_use (y/n) ?").
```

Rule1:

```
hypothesis(Patient,lymphocytic) :-
symptom(Patient,backpain),
symptom(Patient,vomiting),
symptom(Patient,young),
symptom(patient,food),
symptom(patient,smoking),
symptom(Patient,alcohol_use).
```

Rule2:

```
hypothesis(Patient,reactive) :-
symptom(Patient,alcohol_use),
symptom(Patient,weight_loss),
symptom(Patient,stage1),
symptom(Patient,fatigue),
symptom(Patient,nausea),
symptom(Patient,fasting).
```

4.3. Inference Engine

The inference engine consists of inference mechanism and control strategy that enables deriving conclusion for a given query. It comprises formal reasoning involving matching and unification, similar to the one performed by human experts to solve problems in a specific area of knowledge.

Since the objective of the proposed Knowledge Based System to diagnosis a type of gastritis and the Prolog's built-in inference mechanism is backward chaining.

The researcher chooses to use backward reasoning purposively implemented in this study because it is appropriate that the goals are defined and the rules, which fit these goals are also available. On the other hand, the Prolog programming language in which the prototype is constructed also uses backward chaining mechanism. The proposed knowledge based system prototype has two significant parts. The front end is seen by end user is the user interface which is developed by java using NetBeans development tool. The backend is the base of this prototype system which is called knowledge base developed by SWI-prolog.

4.4. User Interface

The graphical user interface acts as a media of communication between the system and the end user. This prototype graphical user interface is developed based on the model generated by part classification algorithm with all defined attributes. The user interface is a bridge through which the user interacts and communicates easily with the system prototype. Its duty is to translate the prolog rules of the prototype from its representation in the knowledge base which may not be clear by the users to the user understandable form. The user interface that include graphical elements, such as windows, icons and buttons is called a graphical user interface (GUI).

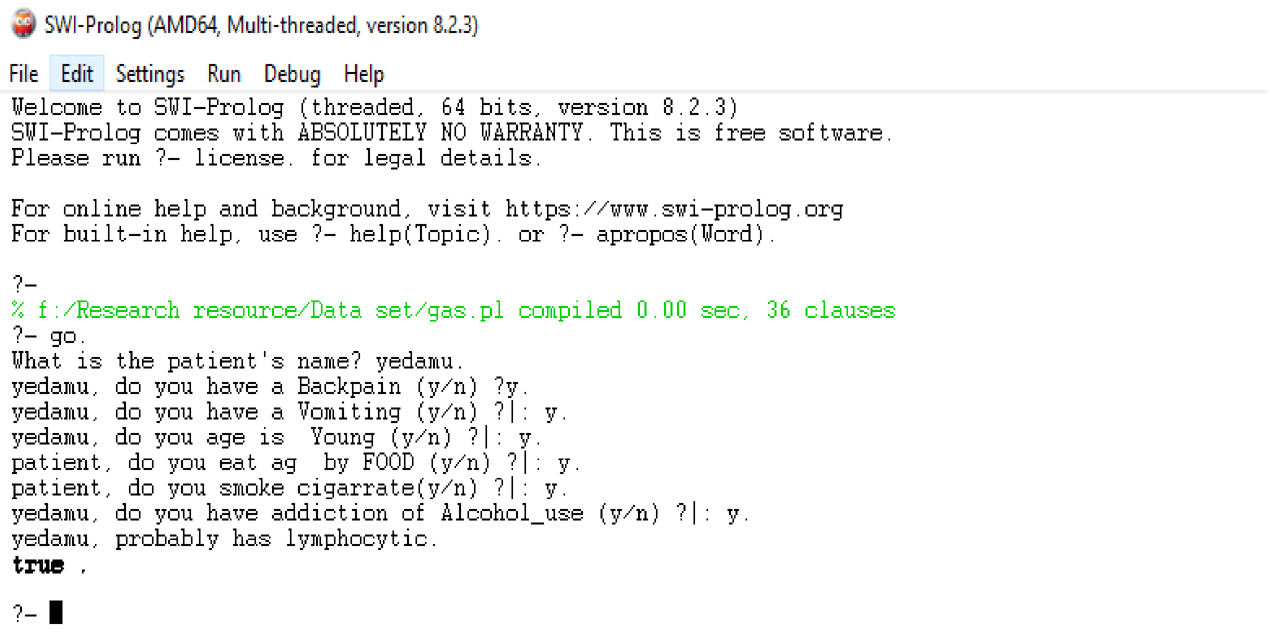

Figure 4.2 Gastritis diagnosis using prolog

A knowledge base system for diagnosing gastritis disease used a java graphical user interface to display the information. Since the interface of Prolog is not interactive and user friendly for non-computer professionals, we select to develop the graphical user interface of the proposed gastritis diagnosis system using Java Net Beans IDE 8.2 with JDK 11 as Figure 4.3 shows.

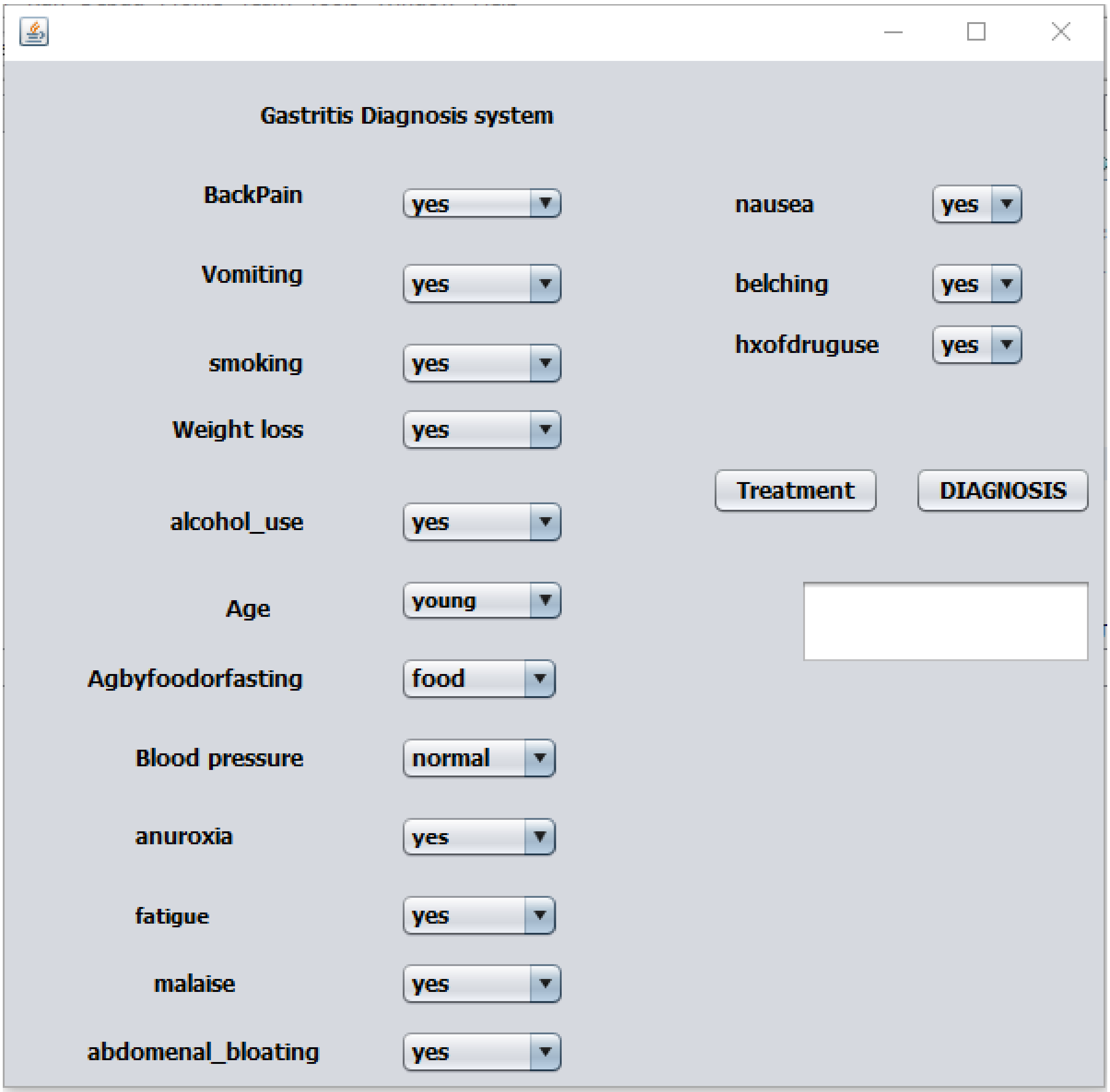

Figure 4.3 Prototype of the graphical user interface for types of gastritis diagnosis.

Based on the above figure (4.3) in order to diagnosis gastritis disease patients and other trainees for using the system, the users should select form combobox items form the given symptoms and risk factors. Then the user should click diagnosis button for getting results of the system. If the condition is satisfied the types of gastritis with its treatment would be displayed. If the condition is not met appropriate message would be displayed using popup message as shown in the figure 4.3 below.

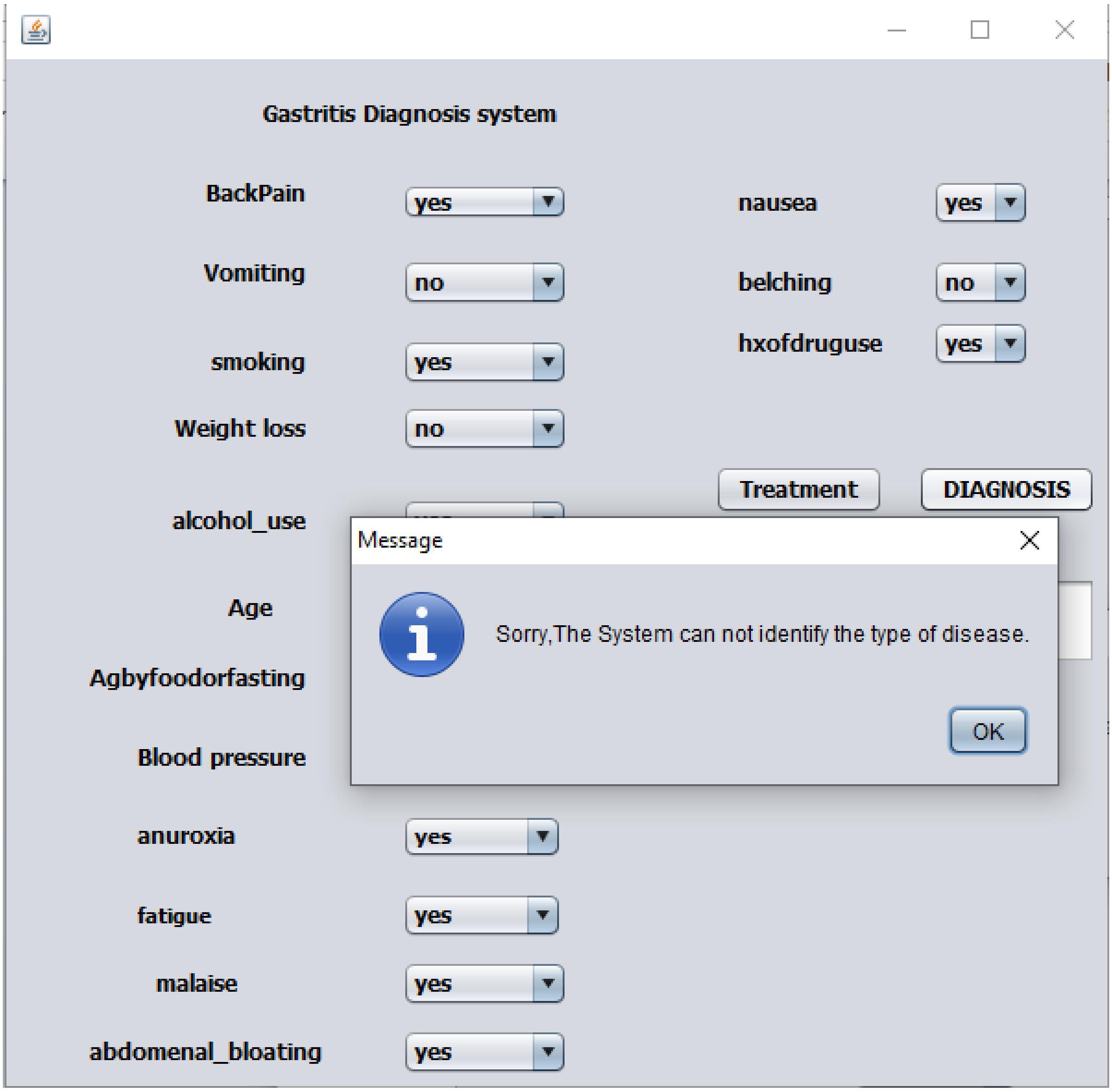

Figure 4.4 Sample dialogue windows between the user and the system to display error message

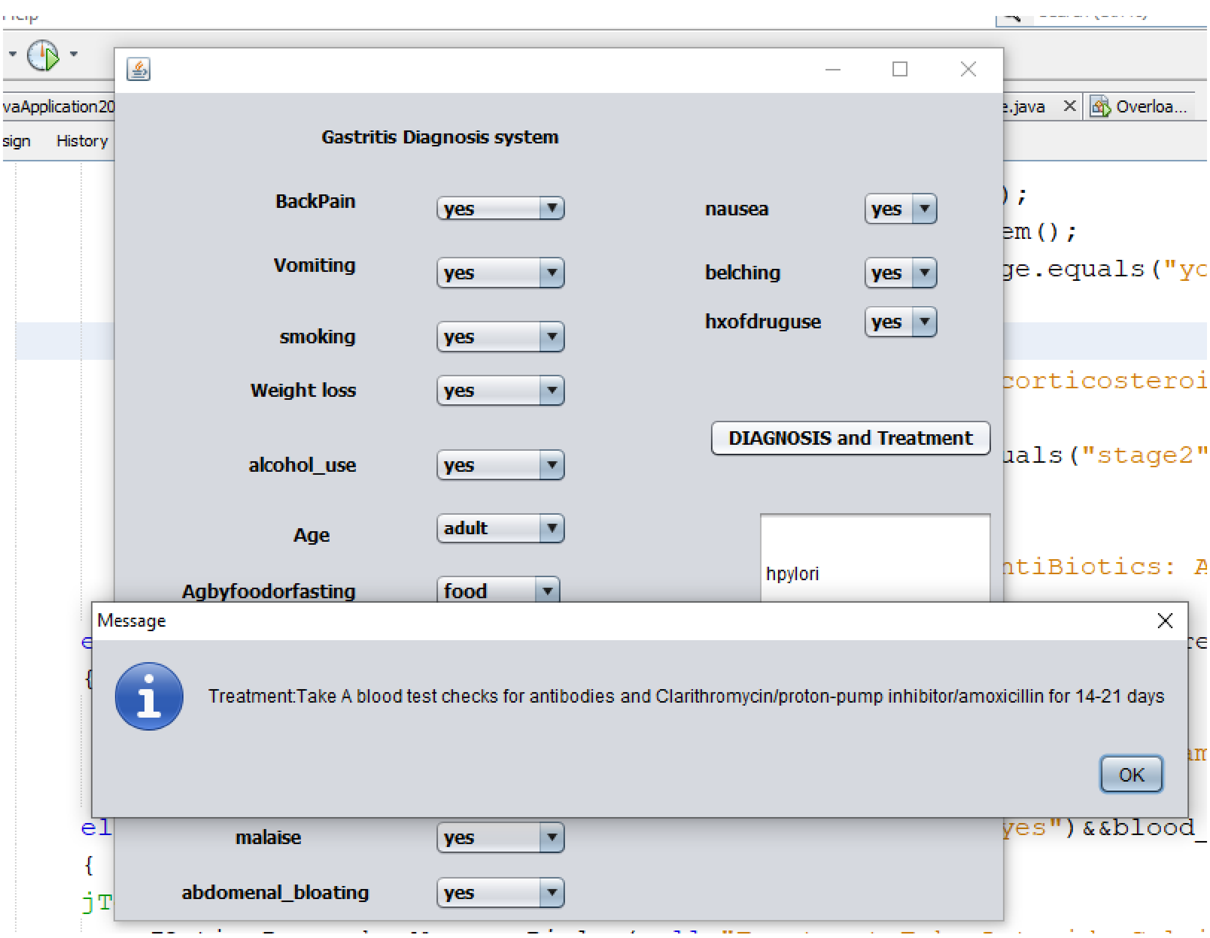

Figure 4.5 Sample dialogue windows between the user and the system to display treatment message

4.5. Explanation Facility

Explanation facility is part of knowledge-based system which explains in case if the user needs further explanation about a specific attribute, goal or conditions implemented in the system. The prototype developed also has this feature, which explains based on the user need. Before the system has executed the goal, it asks the user if he/she needs an explanation for the specific conditions. Then, the system continues depending on the answer that the user enters. It is used for answering what and why questions that might be created in user's mind during their interaction with the system. This ability is usually important since the type of problems to which knowledge-based systems are carried out need an explanation of the result delivered to the end-users.

The knowledge base of the proposed system would be modified by knowledge engineer. First, it has to open the prolog code in Notepad++ and include the new knowledge at the appropriate place in the knowledge base of the proposed system and finally save it such that the knowledge based could be updated accordingly.

4.6. Evaluation of the prototype

After the prototype is implemented in integrating ProLog using SWI-Prolog editor tool and java using NetBeans IDE tool, ultimately every knowledge-based system must be tested and evaluated to ensure that whether the performance of the system is accurate and the system is usable by the end-users.

For this study we used system performance testing and user acceptance testing. In system performance testing section, a number of patient histories are selected by the researcher in order to test the accuracy of the prototype system. The correct and incorrect outcomes are identified by comparing decisions made by domain experts on the patient's history and with the conclusions of the prototype system.

Under user acceptance testing section, the process of ensuring that whether the prototype system satisfies the requirements of its end-users is performed. The scope of testing and evaluation that is accomplished and the significance involved to it rely on the size, complexity, and other features of the knowledge-based system. As the aim of testing and evaluation of the knowledge-based system is to assure that the prototype system does what it is required to do, we can test and evaluate a knowledge-based system as long as we already understand what to expect.

4.6.1. System Performance Testing

System performance testing is the process of determining whether the prototype system is correct, that is whether it meets the level of accuracy as required. It confirms whether the right prototype system has been built.

This testing method is basically used to measure the accuracy of the system using parameters F-measure, Recall and Precision measure how accurate the system is. Confusion matrix is used for comparing the performance of the system with domain experts.

The performance of the system is evaluated by preparing test cases. The test cases include samples of types of gastritis instances taken from Bethel referral hospital data set. The instances include 15 attributes with their respective values. The test cases, which are unclassified types of gastritis instances are delivered to domain experts to label them Autoimmune, Dyspepsia, Hpylori, reactive, Lymphocytic and Atrophic gastritis. About 28 instances including 15 attributes are taken for the test. Few numbers of instances are taken for testing by considering the time is takes for the domain experts to label each instances for system performance testing.

In the process of testing the performance of the prototype system, the domain experts classify correctly and incorrectly diagnosed patients' cases by comparing the judgments reached by the prototype system with that of the domain experts' judgments reached on the same patients test cases.

Performance of this prototype system is usually evaluated using the data in the matrix. Table 4.1 below shows the confusion matrix for a six-class.

Table 4.1 Confusion matrix for evaluation of proposed system compared to experts decision

	Gastritis Diagnosis System							**Total**
Domain experts Feedback	**Types of Gastritis**	**Autoimmune**	**Dyspepsia**	**Hpylori**	**Reactive**	**Lymphocytic**	**Atrophic**	
	Autoimmune	7	0	1	0	0	0	8
	Dyspepsia	0	6	0	0	1	0	7
	Hpylori	0	0	3	0	0	0	3
	Reactive	0	0	0	4	0	0	4
	Lymphocytic	0	0	0	0	4	0	4
	Atrophic	0	0	0		0	2	2
Total	**Total**	7	6	4	4	5	2	28

The confusion matrix on table 4.1 shows matrix of test cases evaluation by gastritis disease diagnosis system and domain experts' decision. The rows illustrate evaluation of domain expert and the columns illustrate result of gastritis diagnosis system.

The entries for Autoimmune, Dyspepsia**,** reactive and Atrophic columns show that the system has correctly identified seven instances as autoimmune gastritis, six instances as dyspepsia gastritis , four instances as reactive gastritis and two instances as atrophic gastritis respectively.

The entries under column Hpylori, the system testified that 4 instances are Hpylori gastritis. But three of the instances are correctly identified Hpylori gastritis and one instance is identified as autoimmune gastritis. The entries in the confusion matrix under Lymphocytic column describe that five instances are correctly identified by the system as Lymphocytic gastritis. But four instances are correctly classified as Lymphocytic and one instance is Dyspepsia gastritis.

The entries in the confusion matrix under Lymphocytic column describe that Dyspepsia gastritis instance incorrectly identified by the system as Lymphocytic. With regard to Lymphocytic diagnosis the system achieved the lowest result as compared to the others. But as shown in the confusion matrix, one autoimmune gastritis instance is incorrectly identified as Hpylori and one Dyspepsia gastritis instance is incorrectly identified as Lymphocytic gastritis.

In general, from 28 diagnosed patient's cases 26 diagnosed patient's cases are classified correctly and 2 diagnosed patient's cases are classified incorrectly. This means the system has 92.8% classified correctly and two instances out of twenty four are incorrectly classified which is 7.2%.

As the accuracy result shows the prototype system has almost similar judgment skill like the domain experts in diagnosing and treating patients with gastritis. This result is encouraging for using the system prototype for diagnosis and treatment of gastritis, and providing respective advice for users.

Table 4.2 Detail accuracy by class that include the true positive rate (TP rate), false positive rate (FP rate), precision (P), recall(R) and F-measure

	TP rate	FP rate	Precision	Recall	F-Measure	Types of Gastritis
	87.5%	0	100%	87.5%	93.3%	Autoimmune
	85.7%	0	100%	85.7	92.2%	Dyspepsia
	100%	25%	75%	100%	85.7%	Hpylori
	100%	0	100%	100%	100%	Reactive
	100%	20%	80%	100%	88.9%	Lymphocytic
	100%	0	100%	100%	100%	Atrophic
Weighted Average	95.5%	7%	92.5%	95.5%	93.3%	

As shown in table 4.2, TP rate and Recall values show the type of gastritis that are correctly classified out of all gastritis type shows that atrophic, lymphocytic, reactive and hpylori class scores the highest TP Rate and recall (100%), followed by the autoimmune gastritis class (87.5%) and dyspepsia (85.7%).

The performance of the system achieves weighted average of 95.5% TP Rate& recall, 92.5% precision, 93.3% F-Measure, and 7%FP Rate. Generally, the System has accuracy 95.5%. This result is promising for using the system for diagnosing gastritis disease and providing respective treatment for the users.

4.6.2. User Acceptance Testing

User acceptance testing is usually a crucial factor in the success of a knowledge-based system. Irrespective of how accurate the performance measures are, how complete the system may be, or how trustworthy the knowledge-based system is, all development may be useless if the knowledge-based system is not acceptable by end-users.

Every domain expert evaluator offers various patients history test to the prototype system and search decisions made by the prototype system. The evaluators assess the accuracy of the prototype system by using the following standards, these are:

- Simplicity of use and interact with prototype system
- Attractiveness of the prototype system
- Efficiency in time
- The accuracy of the system in reaching decision to identify the types of gastritis
- The ability of the system to make the right conclusion and recommendation
- Importance of knowledge base system in the domain area

These evaluation standards are customized from [26] and [27] QUIS (Questionnaire for User Interface Satisfaction). The questionnaires used to test the performance of the prototype system by domain experts are found in appendix III.

The researcher fixed values for each attributes of the questionnaire for the purpose of evaluating the performance of the prototype system on the side of the end-users. The values for all attributes are fixed as: Excellent = 5, Very good = 4, Good = 3, Fair = 2 and Poor = 1. This allows the domain experts to put their values for each criteria of evaluation. Table 4.3 below illustrates the outcomes achieved after evaluation by domain experts.

Table 4.3 Summary of domain experts' evaluation of the system

NO	Criteria of evaluation	Poor	Fair	Good	Very good	Excellent	Average
1	Easiness to use and interact with the	0	0	0	1	5	4.83

	prototype system						
2	**Attractiveness of the system**	**0**	**0**	**1**	**1**	**4**	**4.5**
3	**Efficiency in time**	**0**	**0**	**1**	**1**	**4**	**4.5**
4	**The accuracy of the system in reaching a decision to identify the types of gastritis**	**0**	**0**	**1**	**0**	**5**	**4.67**
5	**The ability of the system to make right conclusion and recommendation**	**0**	**0**	**0**	**2**	**4**	**4.67**
6	**Importance of the KBS in the domain area**	**0**	**0**	**0**	**1**	**5**	**4.83**
					Total average		**4.66**

As shown in the above table 4.3, 83.33% of the evaluators scored **the easiness to use and interact with the prototype** system criteria of evaluation as excellent and 16.67% as very good. The second evaluation criteria, **attractiveness of the prototype** system showed that 66.67% as excellent, 16.67% as very good, and 16.67% as good. In the **efficiency** of the prototype system with respect to time criteria of evaluation, 66.67% of the evaluators scored as excellent, 16.67% as very good, and the rest 16.67% as good. In the **accuracy** of the system in reaching a decision to identify the types of gastritis, 83.3% of the evaluators scored as excellent and 16.67% as good. In **the ability of the system to make right conclusion and recommendation**, 66.6% of the evaluators scored as excellent and 33.33% as very good. In the **importance of the KBS in the domain area**, 83.33% of the evaluators scored as excellent and 16.675 as very good.

Based on the results obtained the overall average performance of knowledge based system for diagnosis and treatment of type of gastritis with user's point of view is 4.66 out of scale of 5 or 93.2%. This implies that the modelled prototype was performs excellent in making right decisions on the diagnosis and treatment of gastritis from the domain Expert point of view.

4.7. Discussions

As we have discussed in the evaluation section, the proposed system achieves a promising results with 95.5% system performance testing result and 93.2% user acceptance testing result. The overall performance of the prototype system is 94.35%.

At the beginning, this study has four research questions to answer and let us discuss how these questions have been answered with this study. The first research question of this study was "What are the main symptoms and risk factors that can properly predict the types of gastritis disease? To answer this question, information gain method and the domain expert's interview and questionnaires were used. This study finds out that all instances of the rule generated discloses that the strong and significant attribute for predicting the gastritis disease performance was selected with the help of domain experts.

The second question was "How to model and represent the acquired knowledge for developing the knowledge-based systems? To answer this question, , a prototype Knowledge Based system were developed using the knowledge that is acquired from domain Experts' Interview, questionnaires and documents analysis using Prolog.

The third question was "How to design a user friendly knowledge-based system that is easily accessible by users? The knowledge base done by SWI-prolog editor tool and GUI developed by java using NetBeans IDE tool is integrated by JPL library. JPL is a bi-directional interface either calling java object from prolog or calling prolog fact and rule from java side. However, complex queries in java to prolog have to be coded manually by concatenating strings containing the specific prolog code.

The final question was "To what extent the prototype works in the diagnosis and treatment of Gastritis? To answer this question the researcher also evaluates the Knowledge based system using system performance testing by preparing test cases and users' acceptance testing questionnaire which helps the researcher to make sure that whether the potential users would like to use the propose system frequently and whether the propose systems meets user requirements.

The knowledge base done by SWI-prolog editor tool and GUI developed by java using NetBeans IDE tool is integrated by JPL library. JPL is a bi-directional interface either calling java object from prolog or calling prolog fact and rule from java side. However, complex queries in java to prolog have to be coded manually by concatenating strings containing the specific prolog code. The prototype system classifies gastritis disease as Autoimmune, Dyspepsia, Hpylori, reactive, Lymphocytic and Atrophic gastritis.

CHAPTER FIVE
CONCLUSIONS AND FUTURE WORKS

5.1. Conclusion

Gastritis is an inflammatory condition of gastric mucosa that displays changes related to ethology and the host response. It was identified in the 1800s as a result of autopsies. There may be similar morphological images of gastritis based on different etiologist, and there may be more than one etiologic agent in a gastritis chart. It can lead to other problems. Gastritis can come on suddenly acute or chronic. Medications and dietary changes can reduce stomach acid and ease gastritis symptoms. Due to this reason, patients need self-diagnosis and consistent treatment. But, in our country, there are no sufficient numbers of physicians, doctors and nurses. This condition leads to disproportional numbers of physicians and patients with gastritis. Because of this problem, gastritis patients are not getting enough diagnosis and treatment.

Therefore, in this study an effort has been made to design and develop a prototype of a user friendly graphical user interface(GUI) knowledge-based system that can provide advice for physicians and patients to facilitate the diagnosis and treatment of patients living with gastritis. For the development process samples of gastritis dataset was taken from Bethel referral hospital. Knowledge gained from the domain experts who work in this referral hospital and document analysis from internet, thesis and research paper were used.

During the course of the study, knowledge is acquired using both structured and unstructured interviews with domain experts and from relevant documents by using documents analysis method to find the solution of the problem. The acquired knowledge is modeled using decision tree that represents concepts and procedures involved in diagnosis and treatment of gastritis.

Also in testing and evaluation of the prototype system, fifteen cases of patients are selected using purposive sampling method in order to test the accuracy of the prototype system. The correct and incorrect results are identified by comparing decisions made by the domain experts on the cases of patients and with the conclusions of the prototype system. And also the process of ensuring that the prototype system satisfies the requirements of its end-users is performed. This permits end-users to test the prototype system by actually using it and evaluating the benefits received from its use. The strong side of the prototype system is that, the integration of prolog and java by their respective SWI-prolog editor tool and NetBeans IDE tool using JPL library enables to provide a user friendly GUI knowledge-based system to the end-user. JPL is a bi-directional interface either calling java object from prolog or calling prolog fact and rule from java side. However, complex queries in java to prolog have to be coded manually by concatenating strings containing the specific prolog code. The generated rules are embedded in SWI-prolog and Java software has enabled building gastritis diagnosis and treatment knowledge based system. Finally, system performance evaluation testing and user acceptance testing were conducted using different criteria. As a result, the proposed system could perform with the absence any help from domain experts with 95.5% system performance testing result and 93.2% user acceptance testing result. This result indicates that the Knowledge Based System has the necessary knowledge for diagnosis and treatment of gastritis which in turn implies that the study was effective in acquiring knowledge through collaborated knowledge acquisition techniques. The overall performance of the prototype system is 94.35%. The performance analysis indicates that the prototype system of prediction model with the knowledge based system for diagnosis and treatment of type of gastritis accomplished acceptable performance.

Generally, the prototype system achieves a good performance and meets the objectives of the study. However, the current system is not learning or adopt automatically as new knowledge is obtained through experience.

5.2. Future Works

This study shows the application of rule based knowledge-based system for diagnosis and treatment of gastritis. It is an encouraging study to fully implement the prototype and conduct other researches in different methodologies in the domain area. Based on the findings of the study the following recommendations reveal the research opportunities in the domain area:

- Future researches can be done on integrating data mining results with knowledge based system for diagnosing gastritis disease by designing user interface with different local languages.
- Building hybrid knowledge based system which is capable of employing rule based reasoning and case based reasoning with integrated data mining techniques.
- Since there is shortage of research on gastritis disease, a system can be developed for different types of gastritis disease by considering different symptoms and risk factors with support of domain experts.
- A system can be developed for diagnosing gastritis disease using different machine learning techniques.

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APPENDIX 1

Selected attributes used for model building and their description

No.	Attribute name	Data type	Description
1	Age	Numeric	Age of the patient in years
2	Blood Pressure	Numeric	The patients' blood pressure
3	Nausea	Nominal	Is the patient has symptom of nausea, yes or no
4	Vomiting	Nominal	Is the patient has symptom of vomiting, yes or no
5	FoodorFasting	Nominal	When the disease risk becomes high, when eating food or fasting
6	Anorexia	Nominal	Is the patients way of eating decreased, yes or no
7	Fatigue	Nominal	Is the patient has fatigue, yes or no
8	Weight Loss	Nominal	Is the patient losing weight, yes or no
9	Belching	Nominal	Is the patient has sign of belching yes or no
10	Abdominal Bloating	Nominal	Is the patient has sign of Abdominal bloating, yes or no
11	Alcohol use	Nominal	Is the patient use alcohol, yes or no
12	Hx of drug use	Nominal	Is the patient used drug before, yes or no
13	Back pain	Nominal	Is the patient has sign of back pain, yes or no
14	Maliase	Nominal	Is the patient has sign of malaise, yes or no
15	Smoking	Nominal	Is the patient smokes, yes or no

APPENDIX 2

Interview Questions

The following interview questions are used to elicit the tacit knowledge from the domain experts. The interviewer stores the answerers' reply using pen, paper, and voice recorder of mobile phone as well. I would like to thank for your cooperation and valuable information.

1. What is gastritis?

2. What are the risk factors of gastritis?

3. What are the complications of gastritis?

4. What is the cause of gastritis?

5. What are the common signs and symptoms of gastritis?

6. What is the type of gastritis?

7. What are the most common and frequently occurred types of gastritis?

8. What is the general rule of diagnosis for gastritis?

9. What are the most fundamental symptoms that you consider when making diagnosis of gastritis?

10. In diagnosis using only signs and symptoms of gastritis, can we say the new patient is get gastritis or not?

11. What are the laboratories testing methods used for diagnosis of gastritis? Which one is the most common laboratory testing method used for diagnosis of gastritis?

12. Differentiating gastritis type is necessary for treatment? If so, how can we differentiating during diagnosis?

13. How to treat generally gastritis and what are the recommended treatments?

14. How to treat type of gastritis and what are the recommended treatments?

15. What are the main challenges encountered during diagnosis and treatment of gastritis?

16. What are the prevention mechanisms to be used?

APPENDIX 3

Domain experts' evaluation form

Dear Evaluator,

The importance of this evaluation form is to evaluate to what extent the prototype system is usable by the end-users in the domain area. Therefore, you are kindly requested to evaluate the system by labeling (X) symbol on the space provided for the corresponding attributes values for each criteria of evaluation.

I would like to appreciate your collaboration in providing the information. Note: - the values for all attributes in the table are related as excellent=5, Very good=4, Good=3, Fair=2, and Poor=1.

NO	Criteria of evaluation	Poor	Fair	Good	Very good	Excellent	Average
1	Easiness to use and interact with the prototype system						
2	Attractiveness of the system						
3	Efficiency in time						
4	The accuracy of the system in reaching a decision to identify the types of gastritis						
5	The ability of the system to make right conclusion and recommendation						
6	Importance of the KBS in the domain area						

APPENDIX 4

Partial prolog code

```
:-style_check(-singleton).
/* prolog Library*/
:- use_module(library(jpl)).

go:-
sleep(0.4),
write('----------------------------------------------------------------'),nl,
sleep(0.4),
write('******************************************************************'),nl,
sleep(0.2),
write('############||| GASTRITIS DISEASE DIAGNOSIS SYSTEM |||##############'),nl,
sleep(0.4),
write('******************************************************************'),nl,
sleep(0.4),
write('----------------------------------------------------------------'),nl,nl,nl,
write('What is the patient''s name? '),
read(Patient),get_single_char(Code),
hypothesis(Patient,Disease),
write_list([Patient,', probably has ',Disease,'.']),nl.
go:-
write('Sorry, I don''t seem to be able to'),nl,
write('diagnose the disease.'),nl.
symptom(Patient,backpain) :-
verify(Patient," have a Backpain (y/n) ?").
symptom(Patient,vomiting) :-
verify(Patient," have a Vomiting (y/n) ?").
symptom(Patient,young) :-
verify(Patient," age is  Young (y/n) ?").
symptom(Patient,food) :-
verify(Patient," eat ag  by FOOD (y/n) ?").
```

```
symptom(Patient,alcohol_use) :-
verify(Patient," have addiction of Alcohol_use (y/n) ?").
symptom(Patient,weight_loss) :-
verify(Patient," have a Weight_loss (y/n) ?").
symptom(Patient,stage2) :-
verify(Patient," have a blood pressure of at Stage2 (y/n) ?").
symptom(Patient,anuroxia) :-
verify(Patient," have a Anuroxia (y/n) ?").
symptom(Patient,fatigue) :-
verify(Patient," have a Fatigue (y/n) ?").
symptom(Patient,malaise) :-
verify(Patient," have a Malaise (y/n) ?").
symptom(Patient,abdomenal_bloating) :-
verify(Patient," have a Abdomenal_bloating (y/n) ?").
symptom(Patient,stage1) :-
verify(Patient," have a blood pressure of at Stage1 (y/n) ?").
symptom(Patient,nausea) :-
verify(Patient," have a Nausea (y/n) ?").
symptom(Patient,belching) :-
verify(Patient," have a Belching (y/n) ?").
symptom(Patient,hxofdruguse) :-
verify(Patient," have a Hxofdruguse (y/n) ?").
symptom(Patient,normal) :-
verify(Patient," have a blood pressure of Normal (y/n) ?").
symptom(Patient,adult) :-
verify(Patient," is at  adult age (y/n) ?").
symptom(Patient,old) :-
verify(Patient," is at old age (y/n) ?").
symptom(Patient,fasting) :-
verify(Patient," eat ag  by FOOD (y/n) ?").
symptom(Patient,smoking) :-
verify(Patient," smoke cigarrate(y/n) ?").
ask(Patient,Question) :-
        write(Patient),write(', do you'),write(Question),
        read(N),
```

```
        ( (N == yes ; N == y)
      ->
       assert(yes(Question)) ;
       assert(no(Question)), fail).

:- dynamic yes/1,no/1.

verify(P,S) :-
   (yes(S) -> true ;
    (no(S) -> fail ;
     ask(P,S))).

undo :- retract(yes(_)),fail.
undo :- retract(no(_)),fail.
undo.
hypothesis(Patient,lymphocytic) :-
symptom(Patient,backpain),
symptom(Patient,vomiting),
symptom(Patient,young),
symptom(patient,food),
symptom(patient,smoking),
symptom(Patient,alcohol_use).
hypothesis(Patient,dyspepsia) :-
symptom(Patient,weight_loss),
symptom(Patient,stage2),
symptom(Patient,fasting),
symptom(Patient,anuroxia),
symptom(Patient,fatigue).
hypothesis(Patient,atrophic) :-
symptom(Patient,backpain),
symptom(Patient,malaise),
symptom(Patient,stage1),
symptom(Patient,abdomenal_bloating),
symptom(patient,weight_loss),
symptom(Patient,young).
```