FATMA NUR REİS

CELIAC DIAGNOSIS BY USING EXPERT SYSTEM

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCE

OF

NEAR EAST UNIVERSITY

By

FATMA NUR REİS

In Partial Fulfillment of the Requirements for

the Degree of Master of Science

in

Computer Engineering

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Approval of Director of Graduate School of

Applied Science

Prof. Dr. Nadire ÇAVUŞ

We certify this thesis is satisfactory for the award of the degree of Master of Science in

Computer Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that I have fully cited and referenced all material and results that are not original to this work, as required by these rules and conduct.

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To my parents, daughter and husband…

ABSTRACT

In this thesis, the different type of computer programming for Celiac diagnosis is presented by using VP Expert System. The computer programming plays a significant role in people life for diseases diagnosis. In particular, in the region of health system of humans, the programming assists people to develop their health system. The programs make peoples' mistakes decrease, save their times and money. According to these thoughts, Celiac diagnosis programming which has no any background in the area of medicine by using expert system is constructed about medical.

The data about genetics, age, blood test, patient status, physical syndromes are searched for diagnosis of Celiac and by using these data, 192 rules are obtained. According to these rules, patients decide about their health which is called at risk, at high risk, intestinal biopsy and healthy. One of most important point of these rules is about children who are less than 2 years old. Even they have negative blood test but they have sign of diagnosis, it is better to check by a doctor for them. The other significant thing about these rules is having a relative who is Celiac. This situation gives a risk to people on the way of getting Celiac in future. Additionally, after being aware of diagnosis Celiac and having a positive blood test, the intestinal biopsy is applied to understand about certain result of diagnosis.

After all, this program has been designed by using real knowledge that is obtained from masters. According to this, it can be said that it is success in correct diagnosis and gives a huge confidence of using this program.

Keywords: Celiac; gluten; VP Expert System; artificial intelligence; diagnosis system

ÖZET

Bu tezde, Çölyak tanısı için farklı bir bilgisayar program tipi, uzman sistemler kullanarak tanıtıldı. Bilgisayar programı, hastalık tanıları için insanların hayatında önemli rol oynamaktadır. Özellikle insanların sağlık sistemi alanında, programlama insanların sağlık sistemini geliştirmek için onlara yardımcı oluyor. Programlar insanların hatalarını azaltır, onların zaman ve para tasarrufunu sağlar. Bunlara göre, tıp alanında herhangi bir bu tarz çalışması olmayan Çölyak tanı programı, uzman sistemler kullanılarak tıbbi alanda oluşturuldu.

Genetik, yaş, kan testi, cinsiyet ve fiziksel sendromlar hakkında Çölyak tanısı için veriler araştırıldı ve bu verileri kullanarak 192 kural elde edildi. Bu kurallara göre hasta, sağlık durumu ile ilgili risk, yüksek risk, bağırsak biyopsisi ve sağlıklı olarak adlandırılan sonuçlar hakkında karar verir. 2 yaşından küçük çocuklar bu oluşturulan kuralların en önemli noktalarından biridir. Kan testleri negatif ve Çölyak izlenilmelerine sahip oldukları durumda bile bir doktor görünmeleri daha iyi olacaktır. Bu kurallar ile ilgili bir diğer önemli durum ailede Çölyak hastası olması. Bu durum ileride Çölyak hastalığına yakalanma konusunda insanları risk sahibi yapar. Ek olarak, Çölyak izlenimlerini fark edip, pozitif kan testine sahip olduktan sonra kesin tanıyı anlayabilmek için böbrek biyopsi uygulanır.

Son olarak, bu program uzmanlardan elde edilen gerçek bilgiler ile hazırlanmıştır. Buna göre, programın doğru tanı bulmada başarılı olduğu ve yüksek bir güvenilirlik verdiği söylenebilir. Böylece bu program hem doktor hem de hastalara daha doğru ve daha hızlı karar verebilmeleri için yardım eder.

Anahtar Kelimeler: Çölyak; glüten; VP Uzman Sistem; yapay zeka; tanı sistemi

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LIST OF ABBREVIATION

AI:	Artificial Intelligence
KB:	Knowledge Base
KBES:	Knowledge Base Expert System
MAI:	Medical Artificial Intelligence
IS:	Intelligence system
FES:	Fuzzy Expert System
FIS:	Fuzzy Interference System
NN:	Neural Network
Anti-tTG:	Tissue Transglutaminase Test
EMA:	Eosin-5′-Maleimide Test
DGP	Deamidated Gliadin Peptide Test
NLP	Natural Grammar Programming
IBS	Irritable Bowel Syndrome
PwC	Price Waterhouse Coopers

CHAPTER 1

INTRODUCTION

1.1 Overview

The basic and essential information is declared about Artificial intelligence, Expert system, celiac and the aim of research in this chapter. The structure of Artificial intelligence and its correlation in medical field are explained in Section 1.1. The concept, application and component of Expert system are presented in Section 1.2. Brief definition, the concept and demography of celiac have been examined in Section 1.3. In Section 1.4, the main idea of the problem is explained. In Section 1.5 the investigate objective is stated and finally, the practice of the thesis is shown in Section 1.6.

1.2 Artificial Intelligence (AI)

Artificial intelligence is a branch of computer science whose aim is to create intelligent machines that can perform various activities in a similar way for intelligent living things. It is usually developed by analyzing methods of human thought and becoming an important part of the industry. The ability of man-made knowledge, reasoning, problem solving, perception, learning, planning, manipulating and carrying objects with can be provided by using artificial intelligence. Besides, it is aimed to be able to express these reactions physically and producing them from people thoughts. Artificial intelligence allows machines to learn, set up new inputs and perform human-like tasks. Most of the artificial intelligence you hear today is an example of learning and reasoning which can be said from computers chess-playing and self-driving cars. Using these technologies, computers can be trained to perform certain tasks by processing large amounts of data and identifying patterns in the data.

In order to continue our living in a quality and peaceful way, health is our first need. According to our research, the development and the most powerful area that will bring many solutions in the future about artificial intelligence will be seen in health sector during future. When the artificial intelligence and health sector are examined together, the biggest deficiency of today is the acquisition of patient information. However, if the annual, monthly, daily and even hourly information can be obtained from each patient, the patient-related situation can be analyzed in

real-time with artificial intelligence, and in the case of illness or period, the treatment process can be provided in a more coordinate and more well-timed manner. Although there are many applications and studies in this field, we think that more effective solutions will be created in a shorter time with the applications of the patient's information, mobile devices, wearable devices and IOT devices in the future.

Especially in the field of health, many patients can hope to use artificial intelligence to prevent disease in later stages. It can also be used to explore space. Intelligent robots can be sent to know more about space and find answers for many questions that humanity has been searching their results for a long time. In addition, robots can take care of laborious tasks such as mining and fueling. Time, power, events without requiring the bottom of the event and fatigue, can also be improved with the least error. Because they do not have emotions, it is not difficult to make logical decisions and they can increase productivity in their work. In the automotive field, progress has been made to minimize accidents or even to destroy them almost. In the future, we are going to see more often in cars, stop the event of the collisions automatically that can easily come to the eyes, and then simplifying human life and property security has begun to develop experience.

Together with the developing technology, the key stakeholders in the health sector see digitalization as a tool to perfect patient experience and achieve the goal of meeting patients' who need lower cost, sustainable profitable growth and competitive advantage in the fastest way. Based on the fact that is digitalization is an in-house competence from strategy to implementation. It is indispensable to bring industrial, technological, analytical and functional depths within the health ecosystem for organizations to close the gap between ideas and operational business results. This medical depth should be established for all stakeholders to ensure the integrity of the seven-step integrated patient experiences journey, called awareness-raising, disease prevention, diagnosis, treatment selection, medication and medical equipment procurement, treatment administration and control.

Using artificial intelligence in medicine is no longer legendary. Now every doctor in the field is the greatest help, algorithms, machine learning systems and resourceful robots. Artificial intelligence is revolutionizing in health as it is in every area of our life. Worldwide health care

services are also significantly affected by this change. Machine learning and artificial intelligence affect doctors, hospitals and all other health-related areas.

The wide using of artificial intelligence can save patients cost and improve efficiency and accessibility for health services. It has been investigated how artificial intelligence can improve quality and productivity while reducing healthcare expenditures in Europe, and publicly available data in European countries were examined and interviews were conducted with hospitals, clinics, payment agencies and technology companies from Austria, Germany and the Netherlands which are active in the field of artificial intelligence. In the analysis of the obtained information, it was revealed that the artificial intelligence application was effective in terms of prevention, diagnosis and treatment. It is also active in terms of estimated savings in health expenditures for the diseases analyzed.

The using of artificial intelligence can save over 90 billion euro in the next decade. This savings estimation included, in addition to the benefits resulting from lower health expenditures, the decreasing in sickness permits and losses caused by low yields. Artificial intelligence can also help increase productivity in a person's self-monitoring to prevent obesity.

According to GE's data, the artificial intelligence market for the health sector will exceed 6.5 billion dollars by 2021. By considering about 40% of health sector investors' investment plans in this market, this number seems to increase in the coming years.

The health sector is changing rapidly and people are preparing for it. According to a recent study by PwC, people are eager to adopt these technologies that improve health care. With over 11 thousand participants from 12 countries in Europe, Middle East and Africa, PwC asked to them "How will artificial intelligence and robotics shape the health sector?." The research titled or sharing results, shows that how artificial intelligence and robotics are accepted by consumers in the healthcare industry.

1.3 Expert System (ES)

Expert systems are knowledge-based systems and are an area of application of artificial intelligence that aims to simulate human intelligence in a broader perspective. In this imitation, the algorithm and the inference mechanisms work by interacting. A more specific definition is an interactive computer-assisted decision-making tool, based on information from an expert, using events and experiences to solve complex problems. These intelligent systems solve the problem of an area by thinking as an expert person and learn the problem it has solved and store it in the information store and do not go through a structural change in the information that is a result of what they have learned before, thus ensuring that there is no need for a change in the structure of the expert system. It was developed by researchers in the field of artificial intelligence in the 1970s and was introduced commercially in the 1980s. These programs are programs that solve a specific problem, provide solutions to problems, and offer a work sequence to make corrections depending on the design.

In the creation of the expert system, the field engineer must obtain the necessary information and translate them in a manner to be stored in the knowledge base. Expert systems use deductive methods based on experience rather than precise and clear algorithms.

Expert System is a computer package that allows users to access and utilize their knowledge and reasoning skills (Jackon 1990). Alberico and Micco (1990) describe expert systems as computer programs that can be used instead of experts in problem analysis and decision making.

The expert system can normally perform functions that require human expertise or play a supporting role in the human decision maker. If the person in the decision-making process is an expert, he / she makes a contribution to the decisions. People using such programs can reach the expert level in practice thanks to the technical information given by the program even if they are not experts in the subject.

1.3.1 Applications of expert system

Intelligent systems, including expert systems, are used in a wide variety of disciplines and professions. It is possible to group the application areas of such systems as follows:

- Extension of existing expertise into wider areas. In this way, the information of the experts, who are very expensive and scarce, is ready to be used by people who have lower levels of knowledge and who are in different places. For example, the knowledge and experience of an on-line scanner in such a system can be used directly by the user or by less experienced personnel.
- used to accelerate complex problem solving
- time-saving for analyzing more difficult and complex problems by analyzing routine and relatively easy problems
- for any reason, the loss of information that can be caused by the termination of work, to prevent the store of expertise by storing
- staff to educate themselves through their ability to explain the causes and consequences
- It is used when no one has enough knowledge. The information of more than one expert is used here.
- They are used when one or more experts need to provide information to many people.

Expert systems are also successfully used in areas such as data interpretation (such as sonar signals), diagnostics of faults and diseases, structural analysis of complex objects (such as chemical compositions), design of complex objects such as computer systems, and planning of processing sequences.

1.3.2 Expert systems in the region of medicine

Expert systems are used in medical diagnosis and treatment planning, problem solving in education, industrialization and data analysis, automation, computer system interfaces, debugging.

The dissemination of expertise in medicine has been one of the most important reasons for the development of US medicine. In the 1970s, MYCIN was the first medical US to develop bacterial

infectious diseases and especially for the diagnosis and treatment of meningitis at Stanford University in the 1970s. One reason for the development of the system is the reduction of excessive use of antibiotics. MYCIN takes patient registration information, laboratory results and symptom queries as input, performs witnessing, prescription writing and treatment planning functions. The system consists of 400 to 700 rules.

The system can be used interactively with the user in natural language (English). MYCIN offers all the rules to the user when he / she finds a suitable rule. He also explains what rules he has come to conclusion by chaining backwards to open a diagnosis. When asked why the system does not use a rule, it can also explain the same.

Medical school fourth grade students to read ECG developed to teach, can present a clinical case using menus and graphs. Turbo Pascal and DOS environment, prepared in 1997, Windows has moved to the environment. ONCO-HELP – personal it is designed for the diagnosis of tumors, using multimedia, histological data, type of tumor, type, location, number of metastases, diagnosis and treatment of side effects (1986). In 1980, it was developed as a shell to develop specialist systems in medicine. This system, which includes 1000-7000 rules, contains rheumatology, ophthalmology and endocrinology. This system, which is written in FORTRAN programming language, uses 82 rules that diagnose AIDS.

1.4 Celiac and its demography

The food taken into the small intestine is decomposed into its components and mixed into the blood through the intestinal mucosa. The ability of our body to receive enough food is provided by the so-called villus protrusions found in the small intestine. Celiac Patients When they consume gluten-free foods, villus protrusions and folds are reduced and diminished due to allergies in the intestinal mucosa. Thus, the surface area of the intestine decreases gradually and the foods taken can’t be absorbed. As a result, nutritional deficiency followed by symptoms.

Celiac disease is a disease that causes the digestion and absorption of nutrients in the intestine. People with celiac disease; wheat, barley, rye and to some extent a protein found in oats 'Gluten' to show sensitivity. When they are fed with gluten-containing foods, they cause inflammation and damage in the cells as a result of immunological reactions in their small intestine. As a result of

this damage, digestion and absorption of nutrients will deteriorate, diarrhea and lack of some substances in the body occur with time.

Celiac disease is a genetic disease, and up to 10 percent of patients have other individuals with celiac disease in the family. In twins, it is seen as 30 percent, while in twins, the incidence is 80 percent.

Some viral infections and stress conditions can lead to the emergence of the disease. It occurs more frequently in children between the ages of 8-12 months and in the 30-40 age range. It can also occur in advanced ages. "Latent" or "silent celiac" is a term used for patients with hereditary predisposition, but not typical symptoms of this disease. The true frequency of celiac disease is unknown. Serological studies on blood bank blood suggest that this disease can be found in every one in 300 people.

Depending on the degree of absorption and digestive disorder, celiac disease manifests itself in children and adults with different symptoms. Development and growth retardation in children may be an early sign of celiac disease. Abdominal pain, nausea, vomiting, diarrhea, moodiness, drowsiness, behavioral disorders, and other symptoms can be seen in school failure. It may take years for the findings to emerge and intensify. Although celiac disease usually occurs in adults around 30-40 years of age, it can be seen in older ages. Symptoms are manifested in two ways: Depending on the absorption disorder and nutrients, minerals and vitamins are due to deficiency.

Basic food sources in patients; Fat, protein, carbohydrate and fat absorption is impaired and the most serious absorption is fats. Diarrhea and bloating may occur in the patients as a result of impaired fat absorption. As a result of carbon hydrate absorption defect, lactose intolerance occurs in patients, which can cause complaints such as abdominal pain and bloating in patients after milky foods.

1.5 Explanation of Problem

Nowadays, Celiac is one of important disease whose is seen on people in the world, mostly. The people who have Celiac got this disease by their genetic or rarely because of their psychological situation that happening, suddenly. So, having a relative who has Celiac in the family is significant to know that people are at risk. On the other hand, the certain diagnosis on the people is the blood test which shows that the people should check by a doctor. However, for a person

who is less than 2, even they have some sign of Celiac and the blood test is negative, they should check by a doctor. Then the age limited by 2 years is one of the important data. If people ignore and do not have a treatment against to Celiac, they could have more important disease in their healthy life.

The purpose of the writing dissertation is to help people who are Celiac and do not have access to the physician, so artificial intelligence helps to diagnose disease by using programming in expert system.

1.6 Purpose of This Scientific Work

The main goal of this dissertation is to help people who feel some diagnosis of celiac to understand something about their healthy life against to Celiac before meeting a doctor. On the way of this duty, the artificial intelligence gives an important advantage to understand it easily by using some rules in the program that is obtained by VP Expert System. Additionally, it is known that early diagnosis is a significant case in people healthy life. So, the study of the dissertation assists people for early diagnosis

CHAPTER 2

RELATED WORK

2.1 Overview

In this section, some studies about diagnosis of celiac are presented in the field of different type algorithm and VP-Expert System which was encouraged us on the way of our study.

2.2 The Study of Diagnosing Celiac By Using Different Type Algorithm

Shirts and his friends focused on showing a positive texture positive duodenal biopsy using the transglutaminase IgA antibody and the nearest neighbor algorithm in 2013. In the study of Shirts and his friends, the closest neighboring algorithms concept was to estimate the whole tissue transglutaminase IgA results of the subject to results of predict biopsy using previously drawn disease patient data for celiac disease with positive and negative results in a multi-dimensional test field. A point is defined by each value within this multi-dimensional field. These data are evaluated and regulated according to the proximity of the diagnostic point of an unknown subject containing validated diagnostic topics. Data were obtained by 17207 patients or 70 clinics from 17 hospitals in Intermountain Healthcare, Utah, between the dates 2008 January and 2011 October. Shirts and his friends used the number of cases and controls in the immediate vicinity to evaluate the probability of binomial.

Ludvigsson and his colleagues obtained a computerized algorithm to try to identify people who need to be tested by using a different thought that comes by Shirts and his friends' work. For celiac disease, Natural Grammar Programming (NLP) algorithm is used in the Mayo Clinic. By using 280 controls and 216 celiac patients, the text and related terms are searched by the team in electronic medical (Rochester, Minnesota USA). Text controls; abnormal weight loss, hyperthyroidism, Hashimoto, iron supplementation, Down syndrome, malabsorption, anorexia, short stature, growth failure, lack of development, hypertitosis / hypothyroid , small intestine, poor growth, watery stool, diabetes type 1 / type 1 diabetic, irritable bowel syndrome (IBS), abdominal, autoimmune thyroid, diarrhea, low ferritin, microcytic, frequent stool, depression and

Fosamax. It is important to note that Ludvigsson and his colleagues rely on a closed third center, the Mayo Clinic, not to establish a internal medicine or common gastroenterology, while they indicate a sensitivity of 72.9% and a specificity of 89.9%. In addition, Ludvigsson and his colleagues state that their algorithms are not suitable for individual physicians. This may lead to a lack of understanding by the physician when they leave the Mayo clinic and enter another gastrointestinal environment. In addition, doctors may not use the algorithm in an external facility. What does the doctor really learn if he doesn't understand the nuances of the disease These doctors may leave the Mayo clinic and work in other gastrointestinal environments and may miss countless cases of celiac disease as they are not exposed to a proper training tool. In this study, the mean age of the selected celiac disease patients was 42 years and the mean age of the controls was 70 years. This completely ignores the segment of children at risk of celiac disease present in different symptomatologies that cannot be taken by different symptomatologies. NLP algorithm used in this study. Ludvigsson (Ludvigsson, 2014) and his colleagues published an article about finding signs and symptoms of celiac disease in a pediatric population that was part of a previous prospective cohort study aimed at defining the risk of immune system diseases, including celiac disease in the Swedish pediatric population. The researchers agree with Walker-Smith and Murch, who have celiac disease with different symptoms in pediatric cases. 50,100 Walker-Smith, Murch, and Ludvigsson et al., Short-term, thin limb, fatigue, in children aged 2 to 15 years are abdominal distention, onset of puberty, personality disorders and anemia. 50,100 It is the fact that the Ludvigsson study is a multicenter study from rural and urban areas (academic and non-academic). Furthermore, Ludvigsson and his colleagues' algorithm work is not a complete CDSS and is definitely the training tool for health professionals. Ideally, a mixture of common natural language terms adopted with clinical decision support for the appropriate route of complete serological and histological study in the adult and pediatric population will promote a complete celiac disease CDSS for educational and diagnostic purposes.

A review of the literature shows the decision-making expert system and a celiac disease risk estimate including serology and histology based on the algorithm of Mayo Clinic, including similar diseases and emerging autoimmunity, is not available because it is an Exsys Corvid expert system obtained for irritable bowel syndrome, which is currently being produced using Exsys Corvid Software. It's not celiac disease.

A CDSS detailed the testing algorithm Mayo Clinic celiac disease that considers the need for an educational model that combines the correct signs language and other related diseases, which will be part of an ECHR, and the developments in the celiac disease test with an accepted histology and serology component. The expert system is the best option for decision making and risk estimation. In modern models of health education, the aim is to define, treat diseases and diagnose, to be a celiac disease risk prediction and decision-making, the system is not currently available, is certainly needed, and will result in the prevention of false future and inadequate diagnosis, and all of these will help the experience learning, develop and present clinicians for the future.

2.3 Development of Other Disease Diagnosis System Using VP-Expert System

The researches which are called a Malaria diagnosis system and diagnosis chronic hepatitis B were given by Adamu(2018) and Mirzaei(2019), respectively. Adamu developed the research by giving rules according to his research to determine the results about a person who is at risk or severa malaria or simple malaria or healthy.This VP expert programming has been tried on 35 patients and it was succeed in giving correct result as 93%. Mirzaei gave a similar study about diagnosis chronic hepatits B expert system which was applied for 20 patients and gave 95% accurate.

CHAPTER 3

EXPERT SYSTEM AND VP-EXPERT SHELL

3.1Overview

Expert Systems can be defined as computer programs which are equipped with information about that area in a certain area and can bring solutions to the problems in the same way as an expert in that field. The information developed by the person who develops the system and the person or persons in the field in which the system will be developed are exchanged with the information base of the system. If a change is made in the future, this change can be made easily on the knowledge base. The completed system uses the information base to solve the problems specified by end users. In this study, it is also mentioned about the differences between expert systems and procedural programs and the first developed Expert Systems.

In this chapter, the different components of expert System and VP-Expert System Shell are briefly clarified.

3.2 Expert System

The first studies of the Expert Systems were started at Standford University. Edward Feigenbaum, a professor at Stanford University, made the description of Expert Systems as ba intelligent computer programs that solve difficult problems that require expert knowledge using knowledge and inference procedures Stan. Here, knowledge is an important word. Because, expert systems conclude the information that is available in their bodies.

Expert Systems are very different from procedural programs. The procedural programs are programs that are based on the algorithm that is the exact result. However, there may not be final results in Expert Systems. We have information and our system uses this information to make comments.

Expert Systems use expert knowledge in problem solving, ie human knowledge. In these systems, expert knowledge is called a set of information or rules. This information and set of rules is used if needed in problem solving. The books and handbooks have a lot of information, but they need

to be read and converted into a format that can be used by the computer in order to use this information. The procedural programs use simple algorithms rather than knowledge in solving a problem. In addition, this information is used in the program code should be placed. But here we have a problem. When there is a change in our knowledge, it is necessary to write the changed information again as it changes into our code and recompile the program. Expert Systems collect small pieces of information into the knowledgebase and use it to evaluate and solve an appropriate problem. When a different problem is encountered, in contrast to procedural programming, the problem can be solved without reprogramming within the boundaries of the knowledge base. In addition, reasons such as explaining the reasons of the transactions, dealing with confidence levels and doubts are plus features of Expert Systems according to procedural programs. While programming languages such as Basic, Pascal are used in procedural programs, Artificial Intelligence languages such as Lisp and Prolog are used in Expert System design.

3.3 Working Principle of Expert System

The basic working principles of the Expert Systems are as follows: The person who uses the program gives the Expert System program the facts and receives expert advice or expertise. Expert Systems generally consist of two main elements. The first one is the Knowledgebase, which contains the facts that are known for accuracy. The second element, Decision Engine, uses the information contained in the Knowledge Base to draw conclusions to the user's questions.

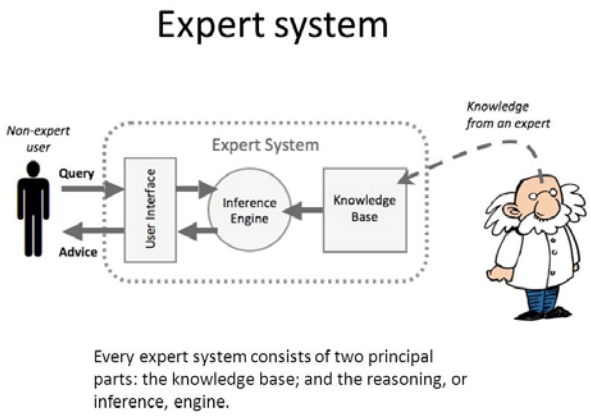

Figure 3.1: Expert System Working Principle

3.3.1 Knowledge based

It is the database where information based on specific experience is stored. It consists of rules and facts. Cases; The relationship between objects the knowledge base contains all the information necessary to understand, formulate and solve problems. For example, it includes information about events and situations, and the logical relationship structures between them. It also includes standard solution and decision-making models. Rules are; define the logical relationships between concepts related to the problem area.

3.3.2 Inference engine

In the field of Artificial Intelligence, the inference engine is a component of the system that implements logical rules in the knowledge base to reveal new information. The first inference engines were parts of expert systems. The typical expert system consisted of a knowledge base and an inference engine. Knowledge base hid facts about the world. The inference engine applies logical rules to the knowledge base and extracts new information. This process repeats as each new case in the knowledge base may trigger additional rules in the inference engine. Inference engines operate in one of two modes, mainly special rules or facts: forward chaining and back-chaining. Forward chaining begins with known facts and sets forth new facts. It starts with backward chained targets and works backwards to determine which facts should be put forward to achieve targets.

3.3.2.1 Forward chaining

In an expert system, someone can start with the state of preparation and try to achieve the goal state for a particular subject. It is called a view of the strategy of acting on different arrangements in order to continue from the preparatory situation to the objective state and is also the area of view of all possible forms of opinion. There are two glance strategies where show-based frameworks are widely used in forward chaining and reverse chaining. During forward chaining, the view continues in the forward direction. Forward chaining can be an information-oriented view. Forward chaining is useful when the number of objective conditions increases when it relates to the initial state. The leading section goes to the next section and then starts.

3.3.2.2 Backward chaining

A system assumed to perform reverse chaining if it attempts to support an objective situation or proposal by analyzing information known in the frame. With the application of reverse managers, it looks at the running status area from objective to readiness. When there are non-objective objective situations and a large number of preparatory states, the goal of returning to controller status may be better at the beginning. Reverse chaining objective can be a guided or assertive view.

3.3.2.3 Hybrid chaining

Hybrid chaining continuously begins with sending chaining and anyplace a reality is required from the administrator, go into opposition to the leaf hub of the knowledge and have it to continue with sending chaining component.

3.3.3 Context

The working memory or Context refers to the collection of images or reliable data consisting of information collected during the execution of problems, reflecting the condition of the problem

3.3.4 Interface user

The interface users prepare demands for benefit from system-user and from application layer components.

3.4 Advantage of Knowledge in Expert System

The main property of knowledge in expert system can be ordered as follows:

- As expert systems are faster than expert people, this speed difference can be reflected in production. At the same time, it is important to note that the production cycle should be completed in a shorter period of time and the system should maintain its continuity. Data and information are not lost over time to maintain continuity.
- Knowledge can clarify behavior through a regulatory facility

- Knowledge is not unilateral and does not make quick or unreasonable choices that use a regular approach to finding the answer to the question.

3.5 Limitation of Expert System

The restriction of Expert System is given as below:

- Methods of reasoning are limited.
- Almost no learning skills exist.
- The information on the floor is superficial.
- It needs extreme human-expert labor.

3.6 VP-Expert Shell

VP Expert could define as Rule-Based Expert System Shell. VP-Expert gives the user interface, the inference motor, and each required thing to make an active expert system. A shell is an expert system including zero knowledge base. Employing a shell one can do an Expert System in several spaces. VP-Expert supports as it were Knowledge Ruled-Base representation, which is easy English like run the show development.

3.7 Advantage of Using VP-Expert

Using VP-Expert gives significant advantage as follows:

- The capacity to trade information with VP-info or DBASE information base records, VP-Planner, VP-Planner also, or 1-2-3 work sheet records and ASCII Content files.
- An actuate command that consequently makes information from a table contained in a content, database or worksheet file.
- A deduction motor which employments "Backward Chaining".
- Optimal improvement windows that creates it conceivable to watch what is going on behind the screen as the inference motor navigates the knowledge base.
- Certainty components that lets one account for dubious data in the knowledge base.
- Straight forward English like run the show construction.
- Commands that permit VP-Expert to clarify its actions during consultation.

3.8 Knowledge Base in VP-Expert

An information panel record at the VP-Expert System includes three key components, which are the Action Block, Rules and Expressions. The operating part is given according to the perspective of the interrupt motor and regulations. Targets are defined with the activities square and other numerical calculations are made. IF / THEN recommendations, the rules expressed, the actual knowledge of the knowledge base. The VP-Expert rules are based on four basic principles:

- The rule conclusion
- The rule name
- A semicolon at the end of rule
- The rule premise

The description typically includes data relating to the call itself. Most VP-Expert comments divide extraordinary features into knowledge base variables. A test knowledge bases record with Actions Block, Rules and Expressions. In the activity block, the primary process is to show the title and the deduction motor shows the same situation. Another activity Target Discovery is the main target expression and the inference engine searches for rules for' settling 'the target. If it doesn't find the target, it goes to the articulation. Here, for the ASK description, it finds the expression "Enter the input quantity in meters" and keeps the user's input. At this point, he calculates the rise of the equation in the activity block.

3.9 VP-Expert's Screen

VP-Expert screen has two parts as rule window and the values window. The Rules part allows one to detect the movement of the VP-Expert's deduction motor because of it interatomic with the knowledge base amid interview. The values part signs the halfway and last result values among the course of the conservation. The values are reported as variable and value of CNFn.

3.10 Significant Terms in VP-Expert

In the VP Expert, "Term (or Keyword)" are words that have a rare meaning in the knowledge base. A few of the critical keywords are summarized here. ACTIONS: The Activities keyword recognizes the beginning of a ACTIONS frame. The Activities square in a VP-Expert knowledge

base determines the agenda of the VP-Expert discussions by sending one or more sentences to be executed. PROBLEM: The VP-Expert interrupt motor, no matter what point it is, cannot discover a show to respect a particular variable, looking for an Inquire articulation that names the variable.
B CALL: This clause executes a DOS batch (BAT) direction record. After the execution of the group registration has ended, the discussion of the VP-Expert continues. BECAUSE: Because Catchphrase is used to provide explanatory content in response to the cause for the show? Or how? Command. CHAIN: The CHAIN direction used in conjunction with SAVEFACTS and LOADFACTS clauses uses knowledge bases. The broad knowledge base can be divided into two or three information bases and can be chained. Example: CHAIN COMMON 1 Common 1. The KBS is executed after the execution of the current file has ended. ELECTIONS: SELECTIONS will work together with the Inquiry Command. The address generated by an Inquire command is shown in the middle of a consultation and the values given in the comparison of CHOICES articulation are shown to the customer as a preferred menu.
Display: The Show command is used to display messages to the user. When the article is conducted in a meeting, the content in two-fold citations is shown in the lawyer window. EXECUTE: The command causes the meeting to start automatically upon the fulfillment of most menu advisory commands. If this command is not shown in a knowledge base, the customer must give an extra "Go" command to start a consultation.

Find: The discovery agent is used in a VP-Expert knowledge base to distinguish the required values from the values for the efficient completion of the consultation. LOADS: This loads the values of all factors in the history records in the CHAIN clause and these values are automatically taken in the new record. PURCHASE: Get clause is used to retrieve value from external files into VP-Expert.

The Ship: Transport command stores the contents of the header variable as the last item of the text record specified in the Ship command.

CHAPTER 4

DEVELOPMENT OF CELIAC DIAGNOSIS Based On EXPERT SYSTEM

4.1History of Celiac

Celiac disease first emerged as the transition of human beings to agriculture. Gluten in wheat grown is a complex protein in which human metabolism is foreign. This makes digestive systems in humans extremely difficult to digest. All complaints of celiac patients; bloating, muscle contractions, constipation and similar problems stem from the inability of wheat gluten. History of the first celiac disease M.S. 200 It is stated in the history. History confirms our knowledge of celiac. The first diagnosis of celiac disease was recorded in 1888 by Samuel Gee. Samuel Geeinis diet has made many patients more comfortable during the day.

Research on celiac continued in full swing. In 1950, Wim Dicke showed that when the oats, wheat and rye were removed from the meals, the edema in the body was discarded and the body was more comfortable. Dicke's colleagues Weijers and Van de Kamer showed that fecal fat measurement reflects clinical status. Early studies were performed in children, but stool fat measurements showed that the condition could be recognized in adults. Histological abnormalities of the small intestinal lining were demonstrated by Paulley in 1954 without any suspicion, and by Royer in 1955, oral biopsy techniques and in 1956 Shiner made a reliable diagnosis. In monozygotic twins, a genetic component was proposed, accompanied by studies of HLA antigens. Additional, non-genetic factors seem likely. The circulating antibodies show an immunological damage mechanism and offer non-invasive screening tests. Lymphoma, adenocarcinoma and ulcer in the small intestine and various immunological disorders are associated. In 1955, a relationship with dermatitis herpetiformis was proposed by Samman and was founded in 1965 and 1968 by Shuster and Marks in England. From 1968 to the present, many celiac associations - the celiac foundation - help people with gluten sensitivities and inform them about their feeding patterns.

4.2 Intense Celiac

Some celiac patients do not respond to treatment despite diet. In these cases, questioning of compliance with diet, review of the diagnosis, pancreatic insufficiency, microscopic colitis, bacterial overgrowth of the small intestine and possible lactose intolerance; If celiac disease is unresponsive to treatment, cortisone therapy is recommended. Untreated celiac disease can turn into lymphoma or another type of cancer in the future.

4.3 Some Numerical Datas for Celiac

Screening studies have shown an increasing incidence of CD frequency worldwide. In European societies, between 1 / 85-1 / 300 (average 1/100), 1% of children in regional studies, 1% in children, between adults and healthy blood donors between 0.8-1.3% was found in the last performed. In healthy-looking school children, the frequency of CD was 0.47% (1/212). In addition, the highest frequency in the world, unlike the previous information, was surprisingly found to be 5.6% in the study conducted in Western Sahara Africa. Studies have shown that the incidence of CD increases with age.

4.4 Celiac Diagnosis

Celiac disease usually does not produce a very specific symptom; however, celiac disease can cause problems such as bloating, gas, diarrhea if it causes extensive damage in the cells of the small intestine. If the elevated levels of liver enzymes are found due to tests carried out for any reason, the reason for these elevated enzymes is celiac disease. Celiac disease may also be a source of anemia.

There are two important procedures for the diagnosis of celiac disease. One of them is the blood antibodies. Articors in blood include antibodies against gluten. Positive detection of these antibodies does not mean that you have celiac disease. If the patient has celiac suspicion, these determinations can be used for screening purposes. Apart from that, the patient should undergo endoscopy and especially biopsies from the duodenum. In biopsies, compatible findings for celiac disease are determined. The fact that these two tests support celiac disease suggests that the patient has celiac disease and treatment accordingly. Even the children who are not higher than 2

years old have negative blood test, they must be checked by a doctor because for those children test could give a false result.

4.5 Methodology

The generated system utilizes an expert to gather information from an expert through coordinate reception and other important resources to provide the rules using the expert system technique for the realization of the VP-Expert system for the diagnosis of Inveterate Celiac patients. The planned system development method is divided into two categories; Information Acquisition and Information Presentation. Information Acquiring The safety of information from a master, paper, book and other important sources. Information the representation clarifies how the information is spoken and includes encoding for the IF-THEN description. The VP master will run the frame in the computer program and ultimately stack the program for consultations.

4.5.1 Knowledge procuring and its representations

The information procurement stages for the development of this system were realized by meeting the restorative experts in the celiac area, therapeutic lecture readings, master recommendation, articles and related scientific materials. The basic interrogations are very summarized, based on the stages preceding the stages of the specialization system, which are introduced in the organization.

Created system rules are presented, description IF-THEN rules representing the information was used., where there is no chance of making arrangements. For writing experts systems' knowledge to mentioned rules, 3 common stages must be refer with which are "Block Graph and Decision Tables". For proving the diagnosis of Celiac, the knowledge was illustrated in a Block diagram as shown in Figure 4.1.

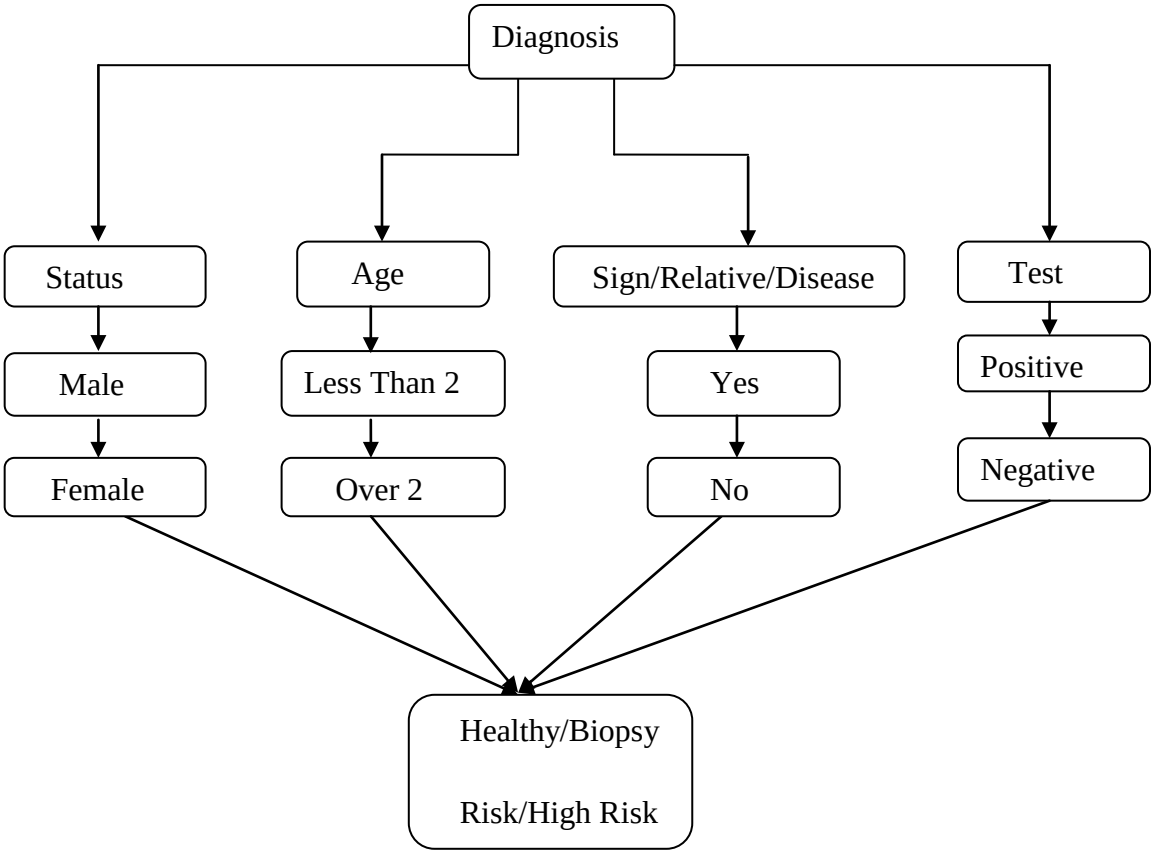

Figure 4.1: The Block Diagram of Diagnosis

After Constructing Block Diagram for diagnosis of Celiac, it is available to show the decision of signs where plays important role on the way of the diagnosis.

Table 4.1: The Decision Table of Signs

Signs Table	Healthy	Celiac
Abdominal swelling/pain	No	Yes
Diarrhea	No	Yes
Vommiting	No	Yes
Iron deficiency Anemia	No	Yes
Depression	No	Yes
Faitgue	No	Yes
Bloating	No	Yes

The significant symptoms were shown above. After feeling these signs on your body for a while, it is better to test in your blood for early diagnosis. It is ideal to mention about some important diseases and the level of lgA, lgG in the blood which are related to Celiac, directly.

Table 4.2: The Decision Table of Related Disease

Related Disease	Healthy	At Risk
Down Syndrome	No	Yes
William Syndrome	No	Yes
Osteoporoz	No	Yes
Adisson Syndrome	No	Yes
Type 1 Diabetes	No	Yes
Tiroidil	No	Yes

Table 4.3: The Decision Table of lgA/G level

lgA/G Level	Healthy	At Risk
High/Intermediate	Yes	No
Low	No	Yes

As a last table for the diagnosis of Celiac, it is given a table in below. The column relative shows that if someone has a relative who is celiac, he/she is under risk as extra %10 to have celiac. The test coulumn is applied for the test Anti-tTG (tissue transglutaminase test), EMA (measurement of eosin-5′-maleimide test) and DGP (Deamidated Gliadin Peptide test). The diagnosis celiac can not be put on the people without making biopsy even the test is positive. So for the certain diagnosis, the doctor must be seen. Now let us explain all possibilities situation for making decision of the diagnosis.

Table 4.4: The Decision Table of Celiac Diagnosis

Status	Age	Sign	R.Disease	Relative	Test	LgA/G	Diagnosis
Female	Yes/No	Yes/No	Yes/No	Yes/No	Positive	H/I/L	Biopsy
Female	No	Yes	Yes/No	Yes/No	Negative	H/I/L	At Risk
Female	Yes	No	No	No	Negative	H/I	Healthy
Female	Yes/No	Yes/No	Yes	Yes	Negative	L	High Risk
Female	Yes	Yes	No	No	Negative	H/I	Healthy
Female	Yes/No	No	No	No	Negative	L	At Risk
Male	Yes/No	Yes/No	Yes/No	Yes/No	Positive	H/I/L	Biopsy
Male	No	Yes	Yes/No	Yes/No	Negative	H/I/L	At Risk
Male	Yes	No	No	No	Negative	H/I	Healthy
Male	Yes/No	Yes/No	Yes	Yes	Negative	L	High Risk
Male	Yes	Yes	No	No	Negative	H/I	Healthy
Male	Yes/No	No	No	No	Negative	L	At Risk

4.6 Coding

The Celiac Diagnosing Expert system is coded using a VP-Expert shell, the shell is a definite device for planning ES, so expert system designers are also familiar with this. The VP-Expert operates based on inverse thinking for induction. To answer the questions, the tool has an initiative engine to control the knowledge base, an editor who manages the coding rules of the knowledge base, and a customer to address questions, ask questions by the customer, and create an interface to attractive ad recommendations and descriptions. Moreover, it has limited graphic capabilities. The production rules of this ES include 7 quality addresses that serve as the input of this system.

1. WHAT IS YOUR PATIENT_STATUS?
2. IS YOUR AGE HIGHER THAN 2 YEARS?
3. WHAT IS YOUR SIGN RESULT?
4. DO YOU HAVE A RELATED DISEASE?
5. DO YOU HAVE A CLOSE RELATIVE WHO IS CELIAC?"

6. WHAT IS YOUR BLOOD TEST RESULT?
7. WHAT IS YOUR lgA-lgG LEVEL IN YOUR BLOOD?

The one of rules for celiac diagnosis in expert system is illustrated as follows:

According to Rule 14;

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor.

CHAPTER 5

RESULTS, TESTING AND CONFIRMATION

5.1 Construct Presentation

In this section, we first introduce the construction of presentation of VP Expert system. We apply the essential changes to the rules and paths to denote the design system. In fact, the VP expert system is a special programming file used to design the system. Rules that is constructed in this program, is obtained by masters' information and our research. VP expert system programming works under the disk operating system.. The diagram that is given below gives information:

Figure 5.1: Relation Between Human and The System

The following program is constructed for diagnosis of celiac utilizing expert system.

5.2 Results and Testing

First of all, it is better to show Knowledge Base part in VP-Expert System as follows:

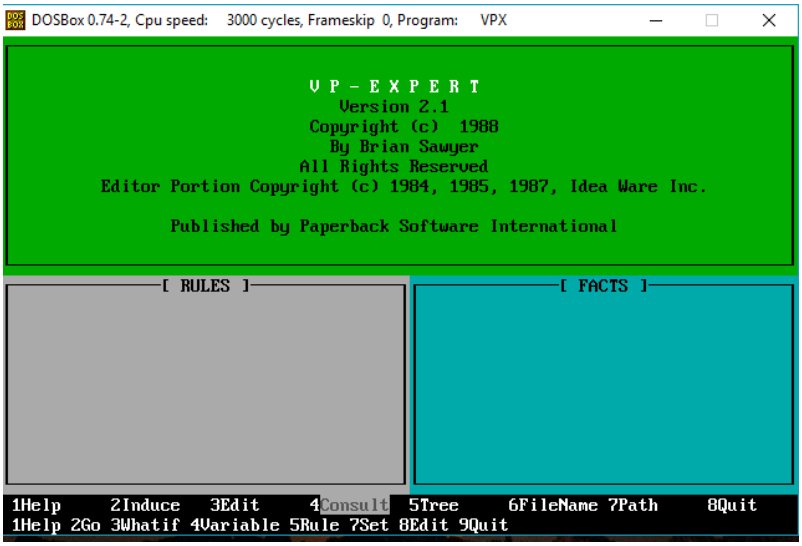

Figure 5.2: Knowledge Base System

The following figure shows the first page after running the system. This page asks for some information. These data relate to some information on how long Celiac has been diagnosed, the patient's condition, and the post-test report. In fact, patients give this information to the system and receive feedback on Celiac. Then people begin answering some question as it is shown below:

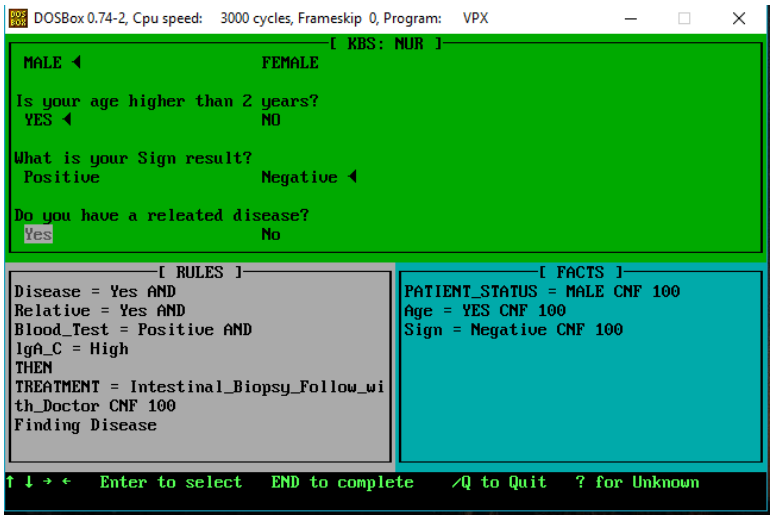

Figure 5.3: Answering Questions by Patients

Finally, the program gives a result which is at risk or at high risk or intestinal biopsy or healthy to users according to their answer. The following figure shows one of example:

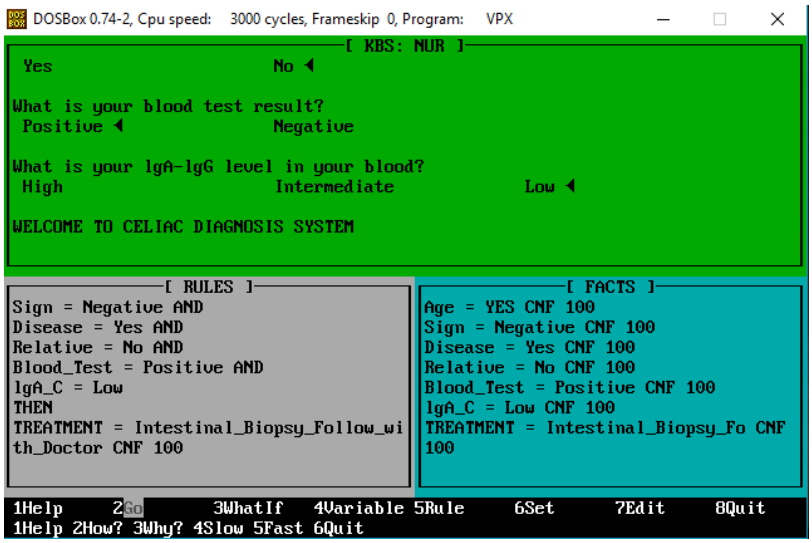

Figure 5.4: An Example of a Result of Diagnosis

According to our information which is collected by masters and according to researcher, this system gives highly performance in obtaining correct diagnosis.

On the other hand, the disadvantage of this program can be ordered as follows:

Narrow Space: It means that the expert systems address a very narrow space and as a result of this, problems occur when the system goes out. For example, if it is found that there is an expert in every subject and that a specialist does not have more than one branch of expertise, if the fields are started to be expanded due to its small number, confusion will start in the system.

Retention of Senior Managers: Skeptical approach to new technology and cost-effectiveness suggest all managers. While there is a person who can do the same job, they cannot allocate costs to such a computer program.

High Cost and Time Limits: Designing an expert system should be considered as costly. Costs of systems varying between 3-5 years should be taken into consideration with Information Engineer, Expert and Programmer.

CHAPTER 6

CONCLUSION

6.1 Conclusion

In this study, diagnosis of Celiac has been presented by using VP expert system to help people for checking their healthy life against to Celiac. According to research which needs much effort, the most significant symptoms as questions are described and asked to decide the diagnosis of Celiac. This program helps people to realize something before going to a doctor. Therefore, for the financial situation, it is better to use this program for people. Moreover, it also gives an importance, on the way of early diagnosis to patients. This type program is using in the medicine field for any diagnosis of disease. On the other hand, there are lots of studies about economics, tourism (etc…) by many scientists.

The VP expert program that is created in this thesis contains 192 rules that are obtained by using the information from some articles and medical center. Especially the most important diagnosis of Celiac to apply one of the blood tests which is called Anti-tTG (tissue transglutaminase test), EMA (measurement of eosin-5′-maleimide test) and DGP (Deamidated Gliadin Peptide test). On this step, the most interesting result, even it is negative for children who are less than 2 years old, it does not show that they are healthy, Just in case, they must checked by a doctor. Additionally, if there is no symptom and the blood test is negative for people who are more than 2 years old, it is not necessary for them to feel uncomfortable. Of course, if they have a relative who has Celiac, they have a risk towards to Celiac.

Finally, this program does not give admission for the diagnosis of Celiac. For certain result, a patient must apply intestinal biopsy. To understand the diagnosis, the program contains 7 input questions and 4 outputs which are given as healthy, at risk, at high risk and intestinal biopsy, by comparing 192 rules.

6.2 Future work

This VP expert program is extended and developed to diagnosis of Celiac and other type diagnosis related to Celiac by increasing the input questions. Moreover, this development is increased the achievement of this program on patients. Increasing the number of questions support to realize the diagnosis quickly and more correctly. Also it encourages other scientist to create programs for other type disease to save money and time for people.

Additionally, some test can be applied on Celiac patient by using this program in future to get some numerical results.

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APPENDIX

CELIAC DIAGNOSIS SYSTEM KNOWLEDGE BASE

```
ACTIONS
    FIND TREATMENT
    DISPLAY "WELCOME TO CELIAC DIAGNOSIS SYSTEM";


RULE 0
IF   PATIENT_STATUS=MALE AND
    Age=YES AND
    Sign=Positive AND
    Disease=Yes AND
    Relative=Yes AND
    Blood_Test=Positive AND
    lgA_C=High
THEN  TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 1
IF   PATIENT_STATUS=MALE AND
    Age=YES AND
    Sign=Positive AND
    Disease=Yes AND
    Relative=Yes AND
    Blood_Test=Positive AND
    lgA_C=Intermediate
THEN  TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 2
IF   PATIENT_STATUS=MALE AND
    Age=YES AND
```

Sign=Positive AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 3

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=AT_RISK;

RULE 4

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=AT_RISK;

RULE 5

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=AT_HIGH_RISK;

RULE 6

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 7

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 8

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 9

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=AT_RISK;

RULE 10

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=AT_RISK;

RULE 11

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=Yes AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=AT_MORE_RISK;

RULE 12

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 13

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 14

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 15

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=AT_RISK;

RULE 16

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=AT_RISK;

RULE 17

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=AT_HIGH_RISK;

RULE 18

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Positive AND
Disease=No AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=High
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 19

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Positive AND
Disease=No AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=Intermediate
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 20

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Positive AND
Disease=No AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=Low
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 21

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Positive AND
Disease=No AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=High
THEN TREATMENT=No_celiac_search_other_medical_disease;

RULE 22

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Positive AND
Disease=No AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Intermediate
THEN TREATMENT=No_celiac_search_other_medical_disease;

RULE 23

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Positive AND
Disease=No AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=AT_RISK;

RULE 24

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=High
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 25

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=Intermediate
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 26

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=Low
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 27

IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=High
THEN TREATMENT=AT_RISK;

RULE 28
IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Intermediate
THEN TREATMENT=AT_RISK;

RULE 29
IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=AT_HIGH_RISK;

RULE 30
IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 31

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 32

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 33

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=AT_RISK;

RULE 34

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=AT_RISK;

RULE 35

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=AT_MORE_RISK;

RULE 36

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 37

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 38

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 39

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=No AND

Relative=Yes AND
Blood_Test=Negative AND
lgA_C=High
THEN TREATMENT=AT_RISK;

RULE 40
IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Intermediate
THEN TREATMENT=AT_RISK;

RULE 41
IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=AT_HIGH_RISK;

RULE 42
IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=No AND
Relative=No AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 43

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=No AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 44

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=No AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 45

IF PATIENT_STATUS=MALE AND

Age=YES AND

Sign=Negative AND

Disease=No AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=High
THEN TREATMENT=HEALTHY;

RULE 46
IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=No AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Intermediate
THEN TREATMENT=HEALTHY;

RULE 47
IF PATIENT_STATUS=MALE AND
Age=YES AND
Sign=Negative AND
Disease=No AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=AT_RISK;

RULE 48
IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 49

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=Intermediate
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 50

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=Low
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 51

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=High
THEN TREATMENT=Follow_with_Doctor;

RULE 52

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Intermediate
THEN TREATMENT=Follow_with_Doctor;

RULE 53

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=Follow_with_Doctor;

RULE 54

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=High
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 55

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=Intermediate
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 56

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=Low
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 57

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=High
THEN TREATMENT=Follow_with_Doctor;

RULE 58

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Intermediate
THEN TREATMENT=Follow_with_Doctor;

RULE 59
IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=Yes AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=Follow_with_Doctor;

RULE 60
IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Positive AND
Disease=No AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=High
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 61
IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 62

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 63

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=Follow_with_Doctor;

RULE 64

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=Follow_with_Doctor;

RULE 65

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=Follow_with_Doctor;

RULE 66

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 67

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 68

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 69

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=Follow_with_Doctor;

RULE 70

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=Follow_with_Doctor;

RULE 71

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Positive AND

Disease=No AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=Follow_with_Doctor;

RULE 72

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 73

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 74

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 75

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=AT_RISK;

RULE 76

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=AT_RISK;

RULE 77

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=Yes AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=Follow_with_Doctor;

RULE 78

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=High

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 79

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=Yes AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Intermediate

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 80

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=Yes AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 81

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=Yes AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=High

THEN TREATMENT=AT_RISK;

RULE 82

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=Yes AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Intermediate

THEN TREATMENT=AT_RISK;

RULE 83

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=Yes AND
Relative=No AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=Follow_with_Doctor;

RULE 84

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=High
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 85

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=Intermediate
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 86

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Positive AND
lgA_C=Low
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 87

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=High
THEN TREATMENT=AT_RISK;

RULE 88

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Intermediate
THEN TREATMENT=AT_RISK;

RULE 89

IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=Yes AND
Blood_Test=Negative AND
lgA_C=Low
THEN TREATMENT=Follow_with_Doctor;

RULE 90
IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=High
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 91
IF PATIENT_STATUS=MALE AND
Age=NO AND
Sign=Negative AND
Disease=No AND
Relative=No AND
Blood_Test=Positive AND
lgA_C=Intermediate
THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 92
IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=No AND

Relative=No AND

Blood_Test=Positive AND

lgA_C=Low

THEN TREATMENT=Intestinal_Biopsy_Follow_with_Doctor;

RULE 93

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=No AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=High

THEN TREATMENT=HEALTHY;

RULE 94

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=No AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Intermediate

THEN TREATMENT=HEALTHY;

RULE 95

IF PATIENT_STATUS=MALE AND

Age=NO AND

Sign=Negative AND

Disease=No AND

Relative=No AND

Blood_Test=Negative AND

lgA_C=Low

THEN TREATMENT=Follow_with_Doctor;

ASK PATIENT_STATUS: "Please enter your patient_status?";

CHOICES PATIENT_STATUS:MALE,FEMALE;

ASK Age:"Is your age higher than 2 years?";

CHOICES Age:YES,NO;

ASK Sign: "What is your Sign result?";

CHOICES Sign:Positive,Negative;

ASK Disease: "Do you have a releated disease?";

CHOICES Disease:Yes,No;

ASK Relative: "Do you have a close relative who is celiac?";

CHOICES Relative:Yes,No;

ASK Blood_Test: "What is your blood test result?";

CHOICES Blood_Test:Positive,Negative;

ASK lgA_C: "What is your lgA-lgG level in your blood?";

CHOICES lgA_C:High,Intermediate,Low;