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# Development of an Expert System Application to Detect Vitamin Deficiencies in the Human Body

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**Abstract**

Vitamins are organic foods that are important to the body's growth and development. People may have more faith in physicians and nutritionists when there are health problems, particularly vitamin deficiency. Using technological resources such as expert systems, the need for society to identify vitamin deficiency early can be recognized. A subset of artificial intelligence that learns how to do this is The Expert Framework. This implementation is a refining of the system that has been created. The forward-chaining method and the first methodology for search engine depth are used in this software. The difference is that the Forward Chaining method uses a data-driven mechanism in this approach, where tracking begins by evaluating and then attempting to infer the information entered through the "AND" logic gate. The introduction of this expert system would make it easier for the public to save time, resources, and make it easier for users to detect vitamin deficiency early.

**Keywords:** Vitamin deficiencies, human body, forward-chaining method, expert system

## 1. Introductrion

Health is a factor in the realization of quality human capital that plays an important role. Through improvement in the health sector, public health and sufficient health facilities are required to be strengthened so that they can be felt by all individuals [1].

Nutrition is an ingredient contained in food, such as carbohydrates, protein, fat, vitamins, minerals and water, and is beneficial for the body. The body requires healthy nutrition, especially for toddlers in their infancy. The Indonesian Health Research and Development Agency's research findings (2013: 211) suggest that in 2013, the prevalence of underweight was 19.6 percent, consisting of 5.7 percent malnutrition and 13.9 percent underweight. The prevalence rate data in 2013 appears to be growing relative to the national prevalence rate in 2007 (18.4%) and 2010 (17.9%) [2]. This explains why the Indonesian people's nutritional needs are also poorly met. In order to overcome this problem, the government has made different efforts.

Nutrients are chemical bonds that the body requires to perform its functions, namely the development of energy, the creation and maintenance of tissues and the regulation of tissue processes [3]. The broader understanding is that nutrition is characterized as the process of organisms utilizing food normally ingested through digestion, absorption, transport, storage, metabolism, and nutrient release processes to sustain life, development, and normal organ function and generate energy. Nutrients are contained in foods containing carbohydrates, fats, proteins, vitamins and minerals that are important to human growth and development, to preserve the functions of the body and to provide energy for everyday activities. Nutrition is food that the body eats to produce energy, create and sustain the body's tissues.

According to data from the Padang City Health Office (2013: 35), 119 cases of under-five malnutrition in the city of Padang in 2013, with the number of boys (65 infants) and girls (54 infants)

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and the number of boys (54 infants) suffering from malnutrition. This is due to a shortage of vitamins in the body of the toddler [2].

Vitamins are organic food ingredients that are needed for health and body development. Research has shown that many vitamins are important ingredients in the carbohydrate, protein and fat oxidation method. In the body's biochemical processes, vitamins are assumed to serve as catalysts.

Another source notes that vitamins are a group of organic compounds containing tiny molecules that play a vital role in every organism's metabolism which cannot be created by the body [5]. Basically, the body requires this vitamin compound to grow and develop normally, this product is very important as a fuel for everyday activities, since it can make the body vulnerable to disease if the body is deficient in vitamins [6]. A greater risk of illness in our bodies is caused by the poor effects of vitamin deficiency. The metabolism in our body would be disturbed if the need for vitamins is ignored, since its role cannot be substituted by other compounds. Avitaminosis is referred to as this health condition. For eg, if we are vitamin A deficient, then we will experience intoxication. Furthermore, since it can disturb the metabolism in the body, vitamin intake should not be excessive.

Vitamins are classified into two groups: vitamins that are fat soluble (vitamins A, D, E, and K) and vitamins that are water soluble (vitamin C and B complex).

Nowadays, in coping with vitamin deficiency disorders, people trust specialist doctors more for treatment. The weakness, however, lies in the short working hours of doctors, in addition to people having to wait in line. We need a specialist in this situation who can make it easy to identify the disease faster so that we can take prevention faster than if we visit a nutritionist who needs a lot of time to do so.

This can be solved by using applications of expert system technology that can support the limitations of skilled physicians in remote areas. Computer systems that use intelligence, evidence and reasoning techniques to solve computer systems are expert systems.

**2. Methods**

An expert system is described as an intelligent computer program that uses knowledge and inference procedures to solve problems that are very difficult, according to Professor Edward Feigenbaum, so it needs someone who is an expert to solve them [4][11][12]. Other sources claim that a system of experts is a system that is adopted into a machine from human intelligence so that computers can solve problems such as what experts do [4][13][14][15]. A computer system that emulates (emulates) the decision-making skill of an expert is an expert system. The word emulates implies that it is assumed that an expert method would operate like an expert in all respects.

In order to address time and cost issues, expert systems are developed. The forward chaining technique utilizes this expert device framework design. In this method, the approach is driven by data (data-driven), where the monitoring begins from the observations' input information and then attempts to draw conclusions. The forward chaining technique is also a tool for the diagnosis of human vitamin deficiency, making it easier for users to diagnose vitamin deficiency.

The Forward Chaining approach is a data-driven technique in which the search process begins by observing input data and then attempting to draw conclusions [5]. Forward chaining is a collection of multiple inferences which search for a solution to a problem [15][16][17]. The quest starts with searching for information, then concludes an information-based theory, in which case the facts or laws must be valid. Using forward chaining if an application creates a tree that is large and not deep.

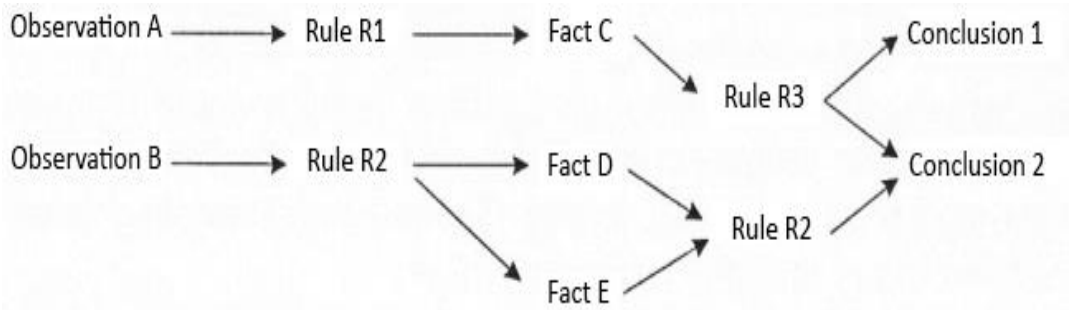
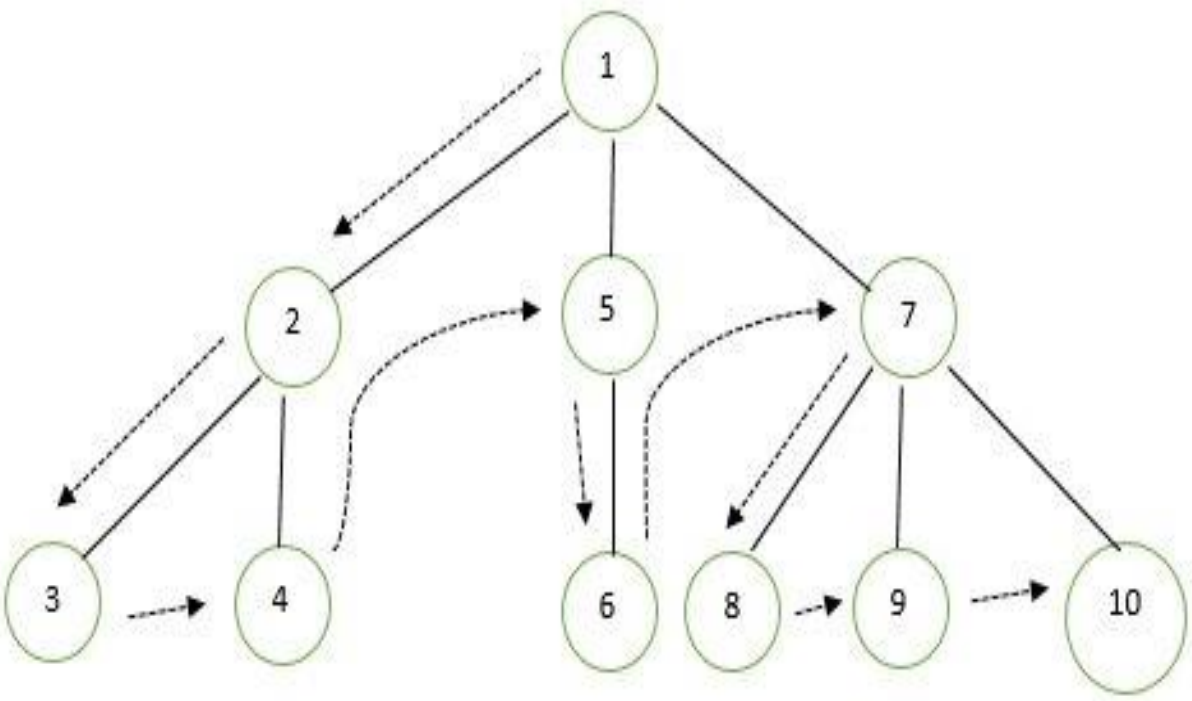



Figure 1. **Forward Chaining Process**




The next approach is the first-search engine inference depth approach. Depth-first search engine to browse root node rules in depth to step down to the level with the "AND" logic gate in the series.

Figure 2. **Flowchart of the dept-first search**

The system of experts is not graded into a system that can eliminate the human expert 's position in seeking a solution to a specific problem, thus supporting the expert. In particular, the expert system can be used to deepen and broaden information, even though it can be used to assist the activities of experts as an experienced assistant.

Using the following systematic ware model such as context diagram, even list, levelled data flow diagram and some UML diagrams such as class diagram, use case diagram, sequence diagram, and operation diagram, the design of this expert system will be constructed. UML (Unified Modeling Language) is a general syntax used to create a logical model of a specific system and to figure out the system. Thus, in the research and design process, it will be easy to understand. UML is a kind of visual language used by diagrams to model and communicate about a system and to support texts[6]. UML, including inheritance, affiliation, and composition, is typically served in a diagram or figure type. When it is expressed in a simple model that defines the entire system, any complex system would be better.

**3. Analysis and System Design**

The measures that must be taken first are evaluating the structure before carrying out the stages of developing a system. Analysis of the system is the decomposition of the information system as a whole into sections in order to define and analyze the challenges , opportunities and barriers that are likely to emerge later[7]. After collecting data from the results of problem identification, the next step is to organize the data into simple data in the form of a relational table[5]. The aim of system analysis is to analyze the system 's problems and provide a clear image of the system to be constructed.

It is important to recognize the signs it produces in advance in order to detect vitamin deficiency. Although it is just an ordinary symptom, doctors may draw conclusions from nutritionists, but there are occasions when further investigation is required. There are signs linked to vitamin deficiency in humans based on the findings of studies and interviews with Prof. Dr. Nur Indrawati Liputo, MSC, PhD, SPGK as Dean of the Faculty of Public Health of Andalas University. A table of symptoms of vitamin deficiency in humans is given below:

*Table 2.* **Symptoms of vitamin deficiency in humans**

| No | Deficiency Symptoms | Vitamin | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B1 | B2 | B3 | B5 | B6 | B7 | B9 | B12 | C | D | E | K |
| 1 | Decreased body resistance | V | | | | | | V | | | | | | |
| 2 | Weight loss | | V | | | | | | | | | | | |
| 3 | Digestive system disorders | | V | | V | V | | | V | | | | | |
| 4 | Reduced appetite | V | V | | V | | | V | | | | | | |
| 5 | Nausea | | | | | | | V | | | | | | |
| 6 | Throw up | | | | | V | | V | | | | | | |
| 7 | Stomach cramps | | | | | V | | | | | | | | |
| 8 | Diarrhea | V | | | V | V | | | V | | V | | | |
| 9 | Frequent infections | V | | | | | | V | | | | | | |
| 10 | Berry disease | | V | | | | | | | | | | | |
| 11 | Spinal disorders | | | | | | | | | | | V | | |
| 12 | Anemia | V | | | | V | V | | V | V | V | | V | |
| 13 | There is bleeding in the body | | | | | | | | | | | | | V |
| 14 | Blood is difficult to clot when injured | | | | | | | | | | V | | | V |
| 15 | Cramps | | | | | V | | | | | | V | | |
| 16 | Muscle weakness | | V | | V | | | | | | V | | V | |
| 17 | Excessive tiredness | | | | | V | | V | V | | V | | | |
| 18 | Pain in muscles | | | | | | V | V | V | | | | | |
| 19 | Reduced coordination and muscle reflection | | | | | | | | | | | | V | |
| 20 | Needles in hand | | | | | | V | | | | | | | |

**A. Application Design Concept**

The creation of the application of an expert method to diagnose human vitamin deficiency can be carried out in some steps; Creating a knowledge base through the compilation of data on vitamin names, signs of vitamin deficiency, dosage of vitamin deficiency based on percentage of daily value (AKG) and others. In the basic rule, the knowledge base addresses the method by which experts can get and organize data into the output "rule."

The next step is to assemble these data into simple data in a relational table form after obtaining the data from the knowledge base process.

An expert system is also part of building an inference engine. By using prior agreed rules, it is used to do an analysis and demonstrate how experts change saved data or the latest one.

Arrangement of a user interface that becomes a platform for user-expert interaction.

**1) User Analysis**

If we can have an overview of anyone who accesses the system, a system can function well and acceptable to our standards. Here is the user who can access the device; Admin is the system administrator who is allowed to do vitamin, symptom, law and user data management.

Expert (doctor and nutritionist) is an individual who specializes in nutritional aspects who is allowed to handle nutrient, symptoms, law, and patient medical record data. Patients are people who have a role in disclosing their diagnosis of vitamin deficiency by entering their personal data and symptoms of vitamin deficiency.

**2) Vitamin Analysis**

Vitamin A, referred to as retinol, is a vitamin that creates good vision, especially in the evening. Vitamin A is also required as a retinal vitamin in the retina of the eye. In order to protect the skin and immune system, this vitamin also plays an important function. Vitamin A is easy to crack when attacked by heat, sun and air.

Vitamin B1, known as tiamine, is a single form of vitamin that plays an important role in preserving the health of the skin and helping to turn carbohydrates into energy for our everyday routines. In addition, this vitamin is also useful in aiding the phase of protein and fat metabolism.

Vitamin B2, or riboflavin, functions as one portion of the mononucleotide coenzyme flavin and di-nucleotide flavin adenine. In the energy regeneration of the body through breathing, these two enzymes are essential. Steroid molecules, red blood cells, and glycogen are also helpful for the production of this vitamin. It is also used to help

certain organs, such as skin , hair and nails, grow.

Vitamin B3, or niacin, plays a role in the metabolism of carbohydrates to produce energy. It has a role in the metabolism of fat and protein as well. This vitamin contributes significantly to blood glucose regulation, high blood pressure, recovery of migraines, and vertigo.

Vitamin B5, also known as pantotenat acid, plays a major role in many types of metabolisms of the body, such as breaking food nutrition reactions , especially fat. Another benefit of this vitamin is to regulate contact between the central nervous system and the brain, producing compounds of fatty acids, sterols, neurotransmitters, and hormones of the body.

An essential vitamin for body growth is vitamin B6, known as pyridoxine. This vitamin plays an essential role in the digestion of nutrients. As a defense against harmful antigens or uncertain structure, it often creates antibodies.

Often known as biotin or vitamin H, vitamin B7 is Vitamin B7 helps absorb glucose in the body so that energy can be generated by our body. This vitamin can reduce blood glucose and help develop and protect muscle, bone marrow, and nervous tissue.

Folic acid is also known as vitamin B9. It is helpful to assist the body in developing the new cell. This vitamin can support the growth of infants, prevent cancer of the cervix and prevent osteoporosis in women as well. This vitamin is used by man to heal lever, medicine by anemia, and hemoglobin building.

Vitamin B12, or sianokalabamin, is a type of vitamin that only animals produce. This vitamin plays a part in taking care of the nervous cell, producing molecules of RNA and DNA, and then producing platelets in the blood.

In forming the composition of collagen, vitamin C or ascorbic acid play an significant role. In the structuring of skin fabrics, joints, bones and other supporting fabrics, this composition is an essential protein. The basic antioxidant composition of this vitamin is to protect the body from free radicals and pollutants.

In fish , eggs, milk and cheese, vitamin D is commonly included. This vitamin plays a major role in the development of the bones of humans. Vitamin D assists in the metabolism of calcium and the mineralization of bones. After being affected by sunlight (ultraviolet), skin cells can directly produce vitamin D.

In caring for many cells in the human body, vitamin E plays an important role, beginning from the skin cells, eyes, red blood cells, to the liver. This vitamin will protect the lungs of humans from air pollution, too. This health importance deals with the function of vitamin E as an important antioxidant composition in the body of humans.

In creating improved blood circulation and wound cover, vitamin K plays a part. If injury occurs, any deficiency of this vitamin can cause bleeding within the body and blood coagulation difficulties.

**3) Vitamin Deficiency Symptoms Analysis**

It is easier to know the signs of the problem in order to detect vitamin deficiency. Since it is only a normal symptom, a decision should be taken by the doctor and nutritionist. The following are some signs coping with vitamin deficiency in humans[7][8][9][10].

**4) Diagnosis Decision Tree Vitamin Deficiency in Humans**

The decision tree diagram is a model used to construct an expert method. The decision tree diagram will make it easier to draw up the vitamin deficiency diagnosis knowledge base and guidelines.

The decision tree uses the forward chaining method of searching in this expert framework. This relates to the diagnosis in humans of the issue of vitamin deficiency. This approach is shown to be beneficial in identifying patients' signs of vitamin deficiency. This diagram of the tree consists of 13 vitamins and 50 deficiency symptoms. They are given the facility to select the current symptoms to diagnose a vitamin deficiency that is felt by the patients. It can be shown on the basis of this decision tree diagram that each symptom can be entered directly into the decision. More than one symptom of vitamin deficiency can, in fact, be observed as a result of this decision.

**5) System Production Rule**

**B. System Modeling Devices**

There are several types of instruments that the scheme uses. It is not absolute, however, that any modeling system is incorporated into the scheme. It implies that we can use half of the facilities.

**1) Event List**

a) In designing the framework, the first thing that we can do is make a list of any current case. The accidents are:

b) Patients enter into the list of symptoms some

details on vitamin deficiency issues they have endured.

*Tabel 1.* **Vitamin Deficiency Symptoms**

| No | Vitamin Deficiency Symptoms |
|---|---|
| 1 | Decreased endurance |
| 2 | Weight loss |
| 3 | Digestive system problem |
| 4 | Loosing appetite |
| 5 | Queasy |
| 6 | Spewing out |
| 7 | Stomach cramps |
| 8 | Diarrhea |
| 9 | Infected easily |
| 10 | Scurvy |
| 11 | Back bones anomaly |
| 12 | Anemia |
| 13 | Bleeding inside the body |
| 14 | Difficulties in blood coagulation |
| 15 | Cram |
| 16 | Muscle weakness |
| 17 | Over tiring |
| 18 | Muscle ache |
| 19 | Decreasing in muscle coordination and reflection |
| 20 | Sense of needles in hands |
| 21 | Sense of needles on feet |
| 22 | Tingling in hands |
| 23 | Tingling on feet |
| 24 | Burning sensation in the feet |
| 25 | Difficult to walk |
| 26 | Rachitic |
| 27 | Osteomalasia |
| 28 | Bleeding under the skin |
| 29 | Dermatitis |
| 30 | Dry skin |
| 31 | Scaly skin |
| 32 | Decreased vision |
| 33 | Cataract |
| 34 | Xeropthalmia |
| 35 | Eyes cannot stand the light |
| 36 | Feels hot and itchy eyes |
| 37 | Inflammation of the lips |
| 38 | Cracked corners of the mouth |
| 39 | Inflammation of the tongue |
| 40 | Wound redness of the tongue |
| 41 | Thrush |
| 42 | Rapid tooth loose |
| 43 | Bleeding gums |
| 44 | Depressed |
| 45 | Insomnia |
| 46 | Hallucinations |
| 47 | Senility |
| 48 | Arising acne |
| 49 | Baldness |
| 50 | Rapid hair graying |

*Tabel 2.* **System Production Rule**

| | | | |
|---|---|---|---|
| Rule 1:<br>If symptoms: xerophthalmia, or cataracts, or dry skin, or dermatitis, or susceptible to infection or decreased immunity.<br>Hence: vitamin A deficiency | Rule 2 :<br>If symptoms are: muscle weakness or decreased appetite or insomnia or scabies or memory problems or weight loss or digestive system problems.<br>Hence: vitamin B1 deficiency | Rule 3 :<br>If the symptoms are: cataract or decreased vision or the eyes feel hot and itchy or the eyes are not resistant to light or dermatitis or inflamed lips or glossitis or depression.<br>Hence: vitamin B2 deficiency | Rule 4:<br>If symptoms: Diarrhea or muscle weakness or insomnia or indigestion or decreased appetite or dermatitis or inflammation of the tongue or hallucinations.<br>Hence: vitamin B3 deficiency |
| Rule 5:<br>If the symptoms are: muscle spasms or numbness in the legs or a burning sensation in the feet or hands tingling or digestive problems or vomiting or diarrhea or breakouts or rapid gray hair.<br>Hence: vitamin B5 deficiency | Rule 6 :<br>If symptoms: anemia or reddish sores on the tongue or muscle spasms or a feeling of needles in the feet or a feeling of needles in the hands or depression or dermatitis or a corner of the mouth or a ruptured insomnia.<br>Hence: vitamin B6 deficiency | Rule 7:<br>If symptoms: nausea or decreased endurance or numbness of the legs or tingling hands or decreased appetite or vomiting or baldness.<br>Hence: vitamin B7 deficiency | Rule 8:<br>If the symptoms are: inflammation of the tongue or diarrhea or depression or digestive problems or fatigue or anemia or acne.<br>Hence: vitamin B9 deficiency |
| Rule 9 :<br>If the symptoms are: depression or anemia or memory is damaged or the hair quickly begins to turn white.<br>Hence: vitamin B12 deficiency | Rule 10 :<br>If the symptoms are: canker sores or bleeding under the skin or muscle weakness or depression or fatigue or anemia or bleeding gums or failure to heal a common wound or infection.<br>Hence: vitamin C deficiency | Rule 11 :<br>If symptoms are: muscle spasms or insomnia or brittle bones or spinal or rachitic abnormalities and osteomalacia or restlessness.<br>Hence: vitamin D deficiency | Rule 12 :<br>If the symptoms are: decreased vision or anemia or muscle spasms or muscle weakness or difficulty walking.<br>Hence: vitamin E deficiency |
| Rule 13 :<br>If symptoms: difficulty in blood clotting or bleeding in the body or bleeding under the skin.<br>Hence: vitamin K deficiency | | | |

These rules are based on the previously discussed method of tree decision and forward chaining. Another type can be built through the rules to create an expert framework for the diagnosis of human vitamin deficiency.

c) The program conducts an interpretation based on the data of the patients. The results of the review will decide the list of problems and remedy that is acceptable for the deficiency.
d) Diagnosis and solution data are given to the patients.
e) The administrator cultivates the data on the device
f) The administrator obtains information from device data.

g) Experts take over the administration of the framework
h) Specialists receive knowledge from data processing at the device level.

**2) Use Case Diagram**

The Case Diagram is a model for the behavior of the information system. It is designed to recognize any roles that occur in an information system and individuals that are entitled to use the feature.

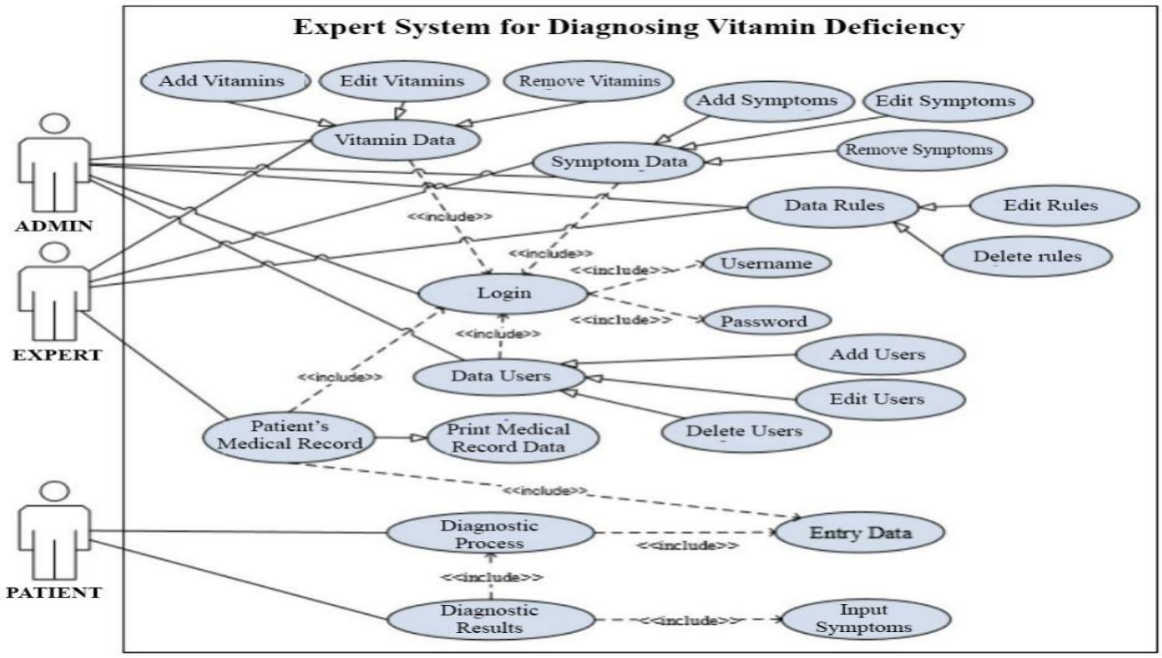



Figure 4. **Use Case Diagram for Expert System to Diagnosing Vitamin Deficiency**

**C. Database Designing**

1) Entity Relationship Diagram (ERD)

ERD is part of the Human Vitamin Deficiency Diagnosis Expert Framework, which consists of five bodies, including vitamins, signs, laws, users, and history. There are 3 relationships between the ERD.

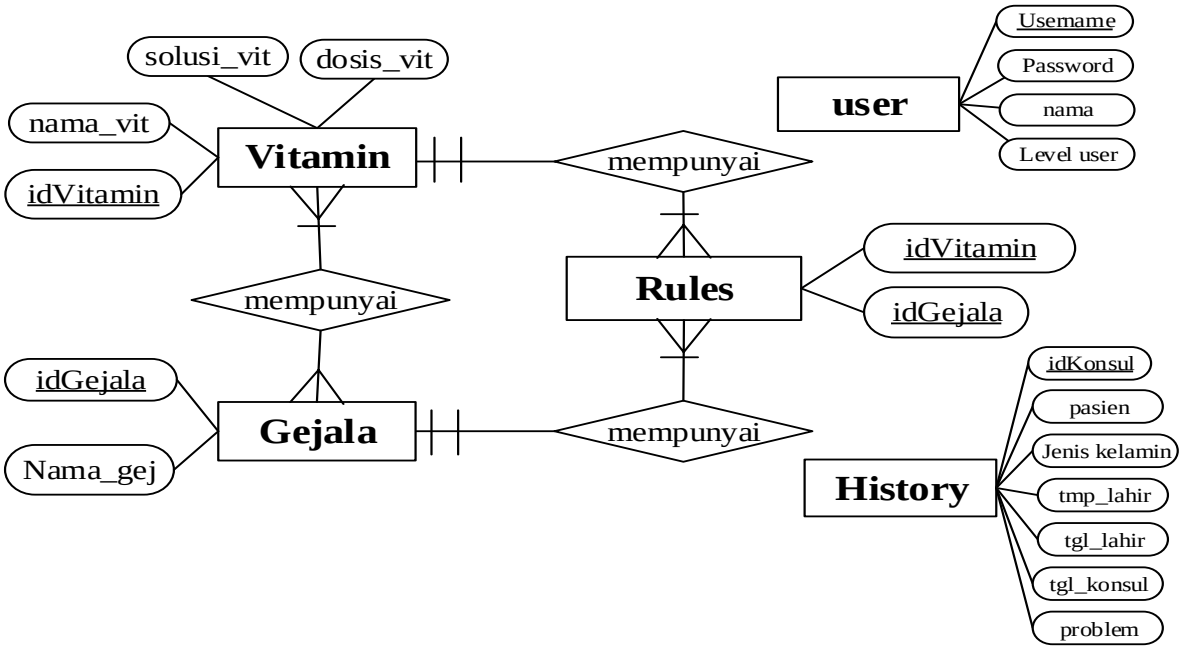



Figure 5. **ERD**

## 4. Result

The product of interface modeling is applied by using the programming language JAVA as its language creation and DBMS MySQL as the data storage in the human vitamin deficiency expert system test point.

The implementation is carried out by interpreting the design outcome into complete software, and converting the interface design structure into a complete interface system type. This is done to explain whether, based on the previous design, the planned system will run well.

### *A.* Patient Diagnosis Page

This website is a website that is used in the diagnosis process for patients. The user does not need to login first in order to access this page. Prior to conducting the diagnostic procedure, patients just need to enter their name.

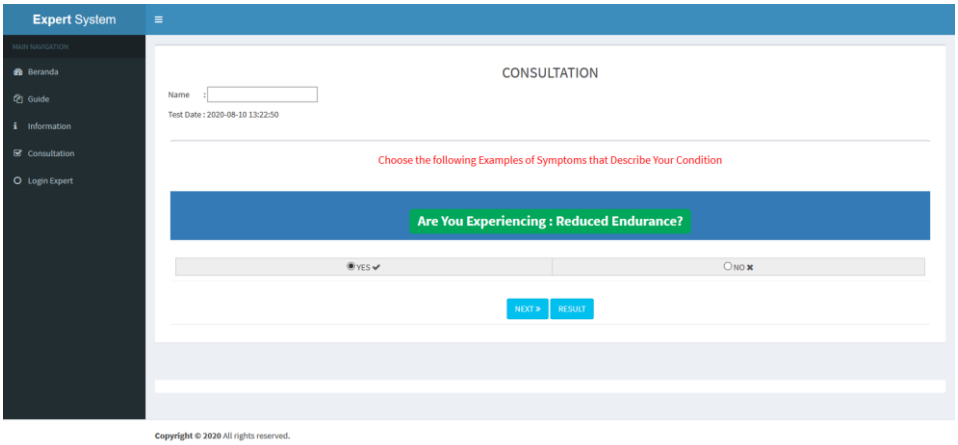



Figure 6. **Patient Diagnosis Page**

### *B.* Form Dialogue Consultation Results Vitamin Deficiency

Shape Dialog Consultation Results the Vitamin Deficiency dialog appears after clicking on the button (√) on the consultation shape. Here is the view of the outcomes of the dialog on the consultation form in Figure 7.

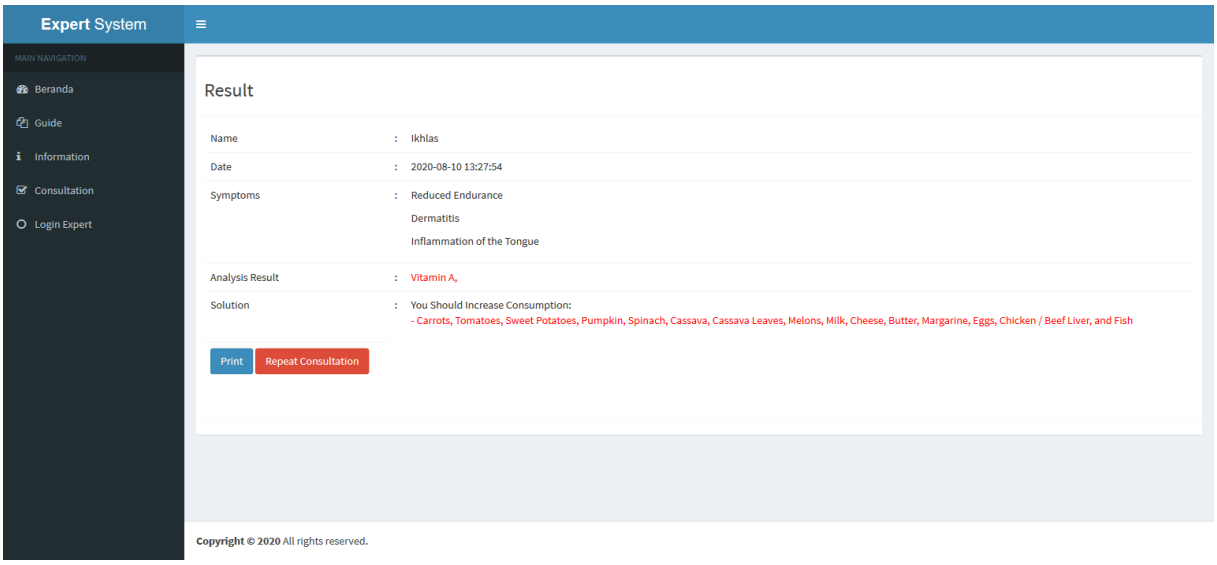



Figure 7. **Form Dialogue Consultation Results Vitamin Deficiency**

The results of the consultation dialog will be shown on the form along with the diagnosis and remedy dosage form based on the consultation input data.

## 5. Conclusion

The results derived from the creation of this Expert System Framework are as follows: as an

assistant, create a deficiency identification framework that can assist physicians and experts due to limited time and schedules in examining patients; Produce software that can assist in the testing of vitamins by health centers or hospitals that lack or lack specialist physicians; Produce a web application that can be accessed by patients anywhere using the Laravel Platform to minimize long queue schedules; and create a solution to vitamin deficiency by offering alternative fruit intake in line with human vitamin deficiency.

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