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# Expert System for Diagnosing Malnutrition Using the Certainty Factor Method

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**Abstract**

Malnutrition in toddlers causes a negative impact on motor nerve development, inhibits behavioral and cognitive development causing a decrease in academic performance and social skills . In addition, malnutrition during infancy can cause long-term risks that focus on later in life, increasing the risk of disease or disability or even death. With advances in information technology today, it is very helpful in predicting or identifying an event, one of which is an expert system that can help an expert in identifying a disease in the world of medicine. Therefore, an expert system is needed that can help doctors and the public find out the type of malnutrition they are suffering from based on the symptoms they are experiencing. The expert system uses the Certainty Factor method in reasoning to obtain diagnostic results from the symptoms shown. This method uses the value of an expert's belief in the symptoms of a disease. The aim of this research is to apply the certainty factor method in identifying malnutrition and providing definitions and suggestions for the disease suffered. The expert system was built using PHP and MySQL database. The results of applying the Certainty Factor method based on the tested data showed that the disease suffered by the patient was Kwarshiorkor with a Certainty Factor level of 0.958528 or 95%. The results of this test show that the certainty factor method expert system is able to identify a disease based on the symptoms experienced.

Keywords: Malnutrition, Expert System, Diagnosis, Certainty Factor, Risk



## 1. Introduction

Malnutrition or malnutrition in children is still a public problem in developing countries, including Indonesia. This should be a concern because the first 1000 days of life is the period of most rapid brain development. To achieve the expected outcomes, apart from being precise, nutritional intervention for patients must be fast. A good understanding by medical personnel in the field regarding child nutrition is very necessary in order to provide education to the public to reduce the incidence of malnutrition in Indonesian toddlers [1].

Nutritional status is one of the factors that influences children's intellectual development . Good nutrition is capital for human resource development. Malnutrition at a young age. Can affect mental development and thinking abilities. The brain reaches its maximum form at the age of two years. Malnutrition can also result in permanent disruption of brain function [2].

Malnutrition is a lack of food intake that a person needs and results in biological disorders of that person. In general, malnutrition is divided into several parts: undernutrition and overnutrition. Malnutrition includes wasting, kwashiorkor and wasting kwashiorkor, while excess nutrition is called obesity. Malnutrition that occurs early in growth increases the risk of infection, morbidity and mortality along with decreased mental and cognitive development [3]

A system is a collection of objects and connects these objects with their attributes or in other words, a system is a unit consisting of a number of parts, attributes of the parts and relationships between parts and attributes. It can also be called an order that describes the existence of a series of various components that have a harmonious, coordinated relationship and shared goals that work or run within a certain and planned period of time [4]. A system is an organization that interacts with each other, is interdependent and integrated into a single variable or component [5]. The definition of a system in various fields differs from one to another, but the concept of a system has general requirements, a system has elements, an environment, interactions between systems, and what is important is that a system has a goal to be achieved. An information system is a number of components where the components are interconnected with each other in order to achieve an expected goal [6].

Systems are a branch of artificial intelligence which is special *knowledge for* solving problems at the human *expert level* . Expert systems are often developed in various fields, including the health sector. Currently, the human need for better medical services is very urgent, which means that the support of modern medical instrumentation and informatics (telemedicine) is urgently needed, including methods to assist analysis so that a more optimal diagnosis is produced [7].

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System is defined as a computer system that uses facts, reasoning and human knowledge to be able to solve problems like an expert or expert in its field. In studying the field of science. Expert systems are also built by forming an experienced system or computer to solve a problem and use reasoning by imitating or applying expert experience [ 8]. The expert system is structured by two main parts, namely the development environment *and* the consultation *environment* . The expert system development environment is used to incorporate expert knowledge into the expert system environment, while the consultation environment is used by non-expert users to obtain expert knowledge [9].

*Certainty Factor* is a method for proving whether a fact is certain or uncertain in the form of a metric which is usually used in expert systems. This method is very suitable for expert systems that diagnose something that is uncertain [10]. *Certainty Factor* (CF) is a method proposed by Shortliffe and Buchanan in 1975 to accommodate the uncertainty of an expert's thinking *(inexact reasoning)* . An expert, for example a doctor, often analyzes information with the expressions "possible", "most likely", "almost certain". So with the *Certainty Factor method* , it can describe the level of confidence of an expert regarding the problem being faced [11][12].

## 2. Research methodology

The research framework is the concept or stages that will be carried out in the research. So that the steps taken by the author in this design do not deviate from the main discussion and are easier to understand, the sequence of research steps will be made systematically so that it can be used as a clear and easy guide for solving existing problems. The research framework that the author carried out in the research can be depicted in Figure 1.

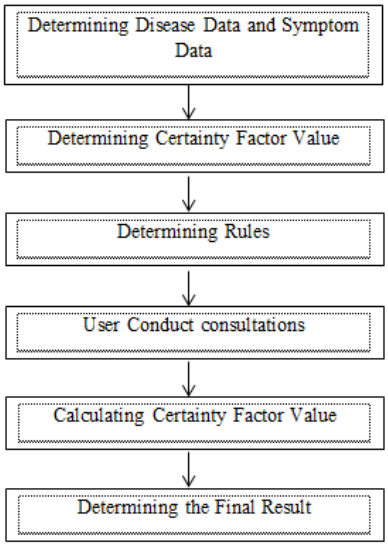



Figure 1. Research Framework

Identifying relevant diseases and symptoms in the Certainty Factor method and using this data to build expert systems or applications that can assist in diagnosis or decision making. Determining the Certainty Factor value is a stage in applying methods in expert systems or knowledge-based decision making. Next, determining the Certainty Factor value reflects the level of confidence or lack of confidence in a hypothesis or event based on existing evidence or information. In a medical or diagnostic context, the Certainty Factor value is used to measure the level of confidence in the possibility of a disease diagnosis based on the symptoms observed. After determining the data that will be used , determining the rules is an important step in developing an expert system or knowledge-based application. These rules help the system to connect existing symptoms, facts, or information with the decisions or recommendations it wants to produce.

The process of calculating the percentage of belief begins with breaking down a rule that has multiple symptoms into rules that have a single symptom. Then each new rule calculates its CF using the equation:

$$CF(H,E) = CF_{(user)} * CF_{(rule)}$$

Among the conditions that occur is that there are several antencendents (in different rules) with the same consequence . In this case, we must aggregate the overall CF value of each existing condition. The following formula is used:

If both CFs > 0, then the formula is:

$$CF[H,E] = CF_{[lama]} + CF_{[baru]}\ (1 - CF_{[lama]}$$

If both CF < 0, then the formula is:

$$CF[H,E] = CF_{[lama]} + CF_{[baru]}\ (1 + CF_{[lama]}$$

If both CF < 0, then the formula is:

$$CF[H,E] = CF_{[lama]} + CF_{[baru]} / (1 - min\ CF_{[lama]}|CF_{[lama]}$$

The expert system diagnosis results are in the form of disease percentages. The percentage of diseases used for diagnosis results is the largest percentage. The percentage of disease is obtained from the calculation of the Certainty Factor value based on the symptoms selected by the user.

## 3. Results and Discussion

The first thing that needs to be done is to determine the problem for which a solution will be sought. In this case, determine the questions that will be asked first. The problem faced in creating this expert system is malnutrition in toddlers. The expert system is only used to diagnose malnutrition in toddlers. Sample data as initial data for the types of disease detected are 3 (three) types of malnutrition. Below we will explain the types of malnutrition, symptoms of the disease and how to treat it. Symptoms of malnutrition are shown in Table. 1.

Table. 1. Symptoms of disease

| Symptom Code | Symptom Name |
|---|---|
| G1 | Edema (swelling) |
| G2 | Glazed eyes |
| G3 | Thin reddish hair |
| G4 | Mental status becomes apathetic and irritable |
| G5 | Liver enlargement |
| G6 | Muscle shrinking *(hypotrophy)* |
| G7 | Skin disorders in the form of red spots that then darken |
| G8 | Often accompanied by infection |
| G9 | Anemia and diarrhea |
| G10 | Body looks very thin |
| G11 | Face like an old person |
| G12 | Easy to cry and whiny |
| G13 | Skin becomes wrinkled |
| G14 | There is little fat tissue |
| G15 | Sunken stomach and xylophone ribs |
| G16 | Have an infectious disease |
| G17 | Chronic diarrhea or constipation |

Disease data and information from the Malnutrition Disease Diagnosis expert system can be seen in Table 2.

Table. 2. Disease

| Code | Disease Name | Information |
|---|---|---|
| P01 | Kwarshiorkor | Kwashiorkor is a form of severe protein malnutrition or protein deficiency caused by inadequate protein intake with normal or high carbohydrate intake. |
| P02 | Marasmus | Marasmus is a form of severe calorie deficiency. This situation is the end result of the interaction between food shortages and infectious diseases. |
| P03 | Marasmic-kwarshiorkor | Marasmik-kwashiorkor. is a combination of marasmus and Kwashiorkor. This condition is quite serious because 2 different malnutrition conditions attack one body. |

In Table. 2 explains that there are 3 diseases of toddlers who experience malnutrition. Each disease has several symptoms and is grouped into a disease code as in the table above. Symptom data for each malnutrition disease can be seen in the table. 3.

Table. 3. Knowledge Base

| Symptom Code | Symptom Name | Disease | | |
|---|---|---|---|---|
| | | P01 | P02 | P03 |
| G1 | Edema (swelling) | √ | | √ |
| G2 | Glazed eyes | √ | | √ |
| G3 | Thin reddish hair | √ | | √ |
| G4 | Mental status becomes apathetic and irritable | √ | | √ |
| G5 | Liver enlargement | √ | | √ |
| G6 | Muscle shrinking *(hypotrophy)* | √ | | √ |
| G7 | Skin disorders in the form of red spots that then darken | √ | | √ |
| G8 | Often accompanied by infection | √ | | √ |
| G9 | Anemia and diarrhea | √ | | √ |
| G10 | Body looks very thin | | √ | √ |
| G11 | Face like an old person | | √ | √ |
| G12 | Easy to cry and whiny | | √ | √ |
| G13 | Skin becomes wrinkled | | √ | √ |
| G14 | There is little fat tissue | | √ | √ |
| G15 | Sunken stomach and xylophone ribs | | √ | √ |
| G16 | Have an infectious disease | | √ | √ |
| G17 | Chronic diarrhea or constipation | | √ | √ |

In Table. 3. Combine the symptom and disease data according to the data that has been obtained so that you know what disease, symptoms and treatment should be carried out when a toddler is infected with the disease as in the table above. Several *samples* of production rules for analyzing malnutrition in toddlers have created a formula that will be entered into a web-based programming which can be seen in the table. 4.

Table 4. Rule Table

| No | Rules |
|---|---|
| Rule 1 | IF (G1) AND (G2) AND (G3) AND (G3) AND (G4) AND (G5) AND (G6) AND (G7) AND (G8) AND (G9) **THEN P01** |
| Rule 2 | IF (G10) AND (G11) AND (G12) AND (G13) AND (G14) AND (G15) AND (G16) AND (G17) **THEN P02** |
| Rule 3 | IF (G1) AND (G2) AND (G3) AND (G4) AND (G5) AND (G6) AND (G7) AND (G8) AND (G9) AND (G10) AND (G11) AND (G12) AND ( G13) AND (G14) AND (G15) AND (G16) AND (G17) **THEN P03** |

Example of manual calculation to find the confidence value of each symptom based on rules / existing *rules :*

A patient experiences the following symptoms:

1. The patient experiences edema (swelling) in the body
2. The patient's eyes are glazed
3. The patient's hair looks thin and slightly reddish in color
4. According to his parents, the patient's mental status changed to apathetic and cranky
5. The patient's muscles experience wasting
6. The patient experiences anemia and diarrhea

Solution:

1. Determine the possibility of a disease that has symptoms similar to those experienced by the patient.

Possible Diseases:

a. Kwarshiorkor

IF Edema (swelling) (G001) AND Glazed eyesight (G002) AND Thin, reddish hair (G003) AND Mental status becomes apathetic and fussy (G004) AND Enlarged liver (G005) AND Muscle shrinkage ( hypotrophy) (G006) AND Skin disorders in the form of red spots then darken (G007) AND Often accompanied by infection (G008) AND Anemia and diarrhea (G009) THEN Kwarshiorkor (P001).

2. Calculate the probability of illness from each symptom

a. Kwarshiorkor ( P001 )

Symptom Name : Edema (swelling) (G001)
Mb Md [h, e1] = 0.2
CF [H, e1] = 0.8 – 0.2
= 0.6
[ h , e1] = 0.8

Symptom Name : Misty vision (G002)
Mb [h, e1] = 0.6
MD [h, e1] = 0.2
CF [H, e1] = 0.6 – 0.2
= 0.4

Symptom Name : Thin red hairs (G003)
Mb [h, e1] = 0.8
Md [h, e1] = 0.4
CF [H, e1] = 0.8 – 0.4
= 0.4

Symptom Name : Mental status becomes apathetic and fussy (G004)
Mb [h, e1] = 0.6
MD [h, e1] = 0.2
CF [H, e1] = 0.6 – 0.2
= 0.4

Symptom Name : Muscle shrinking (hypotrophy) (G006)
Mb [h, e1] = 0.6
MD [h, e1] = 0.2
CF [H, e1] = 0.6 – 0.4
= 0.2

Symptom Name: Anemia and diarrhea (G009)
Mb [h, e1] = 0.8
MD [h, e1] = 0.2
CF [H, e1] = 0.8 – 0.4
= 0.4

Calculation of CF disease based on formula 2:

a. Edema (swelling) (G001) = 0.6
b. Glazed vision (G002) = 0.4
c. Thin reddish hair (G003) = 0.4
d. Mental status becomes apathetic and fussy (G004) = 0.4
e. Muscle shrinking (hypotrophy) (G006) = 0.2
f. Anemia and diarrhea (G009) = 0.4

$$CF(1) = CF(a) + CF(b)\,(1 - CF(a))$$
$$= 0.6 + 0.4\,(1 - 0.6) = 0.76$$
$$CF(2) = CF(c) + CF(1)\,(1 - CF(c))$$
$$= 0.4 + 0.76\,(1 - 0.4) = 0.856$$
$$CF(3) = CF(d) + CF(2)\,(1 - CF(d))$$
$$= 0.4 + 0.856\,(1 - 0.4) = 0.9136$$
$$CF(4) = CF(e) + CF(3)\,(1 - CF(e))$$

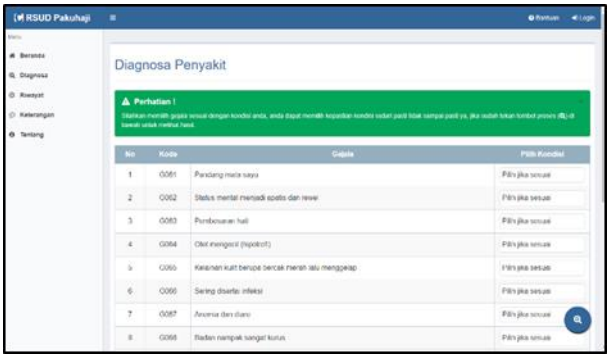
$$= 0.2 + 0.9136 ( 1 – 0.2 ) = 0.93088$$

$$CF( 5) = CF(f) + CF(4) ( 1 – CF(f) )$$

$$= 0.4 + 0.93088 ( 1 – 0.4 ) = 0.958528$$

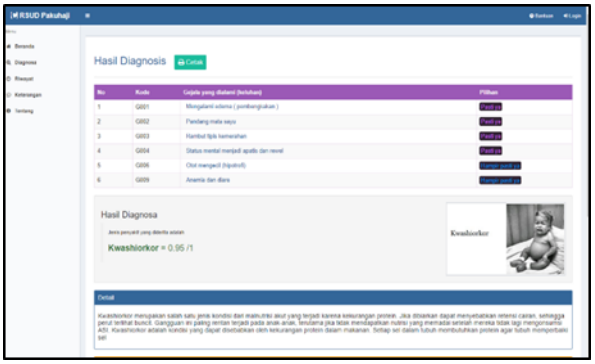
So the disease suffered by the patient is Kwarshiorkor with a *Certainty Factor level* of 0.958528 or 95%.

After data processing and system design, a web-based system was created with a diagnostic page where patients can consult about any symptoms the patient is experiencing. Patients can fill in the data required by the diagnostic system without logging in. An image of the diagnostic page can be seen in Figure



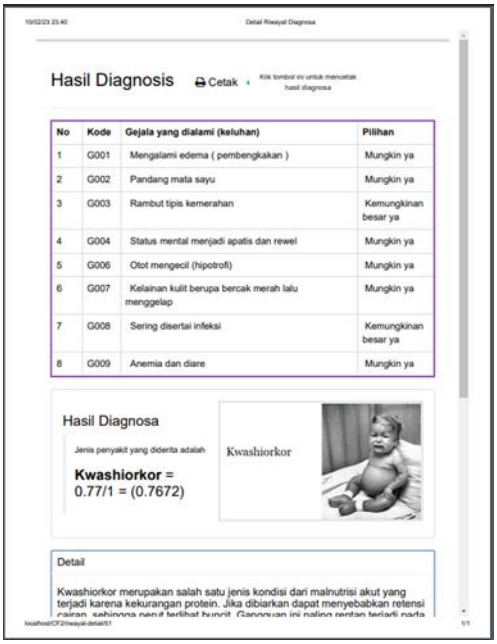

Picture. 2. Diagnostics page

After carrying out the consultation, the results of the consultation will come out where the patient can find out what diseases the patient is suffering from and will be given solutions and treatment methods that must be carried out. Can be seen in Figure 5.




Picture. 3. Diagnostic Results Page

After the patient knows the results of the consultation, the patient can print the results of the consultation that the patient has carried out. A print of the consultation results can be seen in Figure. 6.




Picture. 4. Print consultation results

## 4. Conclusion

Based on the research that has been carried out, the conclusion is that using the Expert System, the Certainty Factor method of analyzing malnutrition in toddlers has succeeded in analyzing the symptoms and can determine diseases related to malnutrition in toddlers so that solutions and initial steps for handling them can be determined. So, based on the data tested, it was found that the disease suffered by the patient was Kwarshiorkor with a Certainty Factor level of 0.958528 or 95%.

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