Expert system to determine healthy food menu for heart and cardiovascular disease therapy

EG Wahyuni¹, N Haritsah¹
¹Department of Informatics, Faculty of Industrial Technology, Universitas Islam Indonesia

Coresponding author: elyza@ui.ac.id

Abstract. Cardiovascular disease is a disease caused by disorders of the heart and blood vessels. This disease is very dangerous for health because of the vital cardiovascular system. One of the most important organs associated with this disease is the heart. But there are still many people who are less concerned about their heart health. Therefore it takes a variety of therapies for the prevention or treatment for those already diagnosed with cardiovascular disease. Eating healthy foods is one of the best prevention or treatment. This expert system intends to help patients find out about heart disease. In addition, the system is also used to provide information about a healthy diet for the patient. This system design uses PHP programming language and is displayed in the form of a website. The patient or user may consult by entering personal data such as age, sex, height, weight, and symptoms suffered by using this system. The system will display possible illnesses and food menu recommendations.

1. Introduction
The heart disease death rate is very high in Indonesia reached 7.6 million people per year. Most deaths are due to coronary heart disease, and 325 thousand cases of heart disease sufferers die before arriving at the hospital [1].

Heart health which is the most important organ in the body is often ignored. Therefore if someone has been diagnosed with cardiovascular disease, he needs various therapies for treatment. Even though there is better prevention or treatment, that is by eating healthy foods. Foods that contain vitamin C, high omega-3 lycopene and quercetin are good for cardiovascular patients.

Based on the problems that have been described, it is needed an application that can provide recommendations for healthy food for cardiovascular sufferers. One implementation that can be applied is to use an expert system. The expert system is a system that adopts human knowledge into a computer [2]. With expert systems, people can solve the quite complicated problem that can only be solved with the help of experts [2]. Through this system, cardiovascular patients can find out how a good and healthy diet is a prevention and treatment based on symptoms and the BMR (Basal Metabolic Rate) value. Calculation of basal calorie requirements can be determined by the Harris-Benedict formula, which is by multiplying the value of the BMR and the type of activity [3].

2. Related Work
Several studies that have been carried out related to the diagnosis of heart disease are: 1) An expert system for diagnosing heart disease with the forward chaining method conducted by Rachmawati And Ulinuha [3]. This study requires the user to fill in the data and choose the symptoms suffered, then it
will display the diagnosis of the illness. Things need to be added in this research is the advice that can prevent or treat diseases. In addition, it is also necessary to test the accuracy of the results between the system and experts.

2) Web-based expert system application to diagnose early heart disease by [4]. This application is created using the PHP programming language, MySQL database and backward chaining method. This system displays a form containing questions that must be filled by the user, then it displays the results of the diagnosis based on the questions that have been answered. The system also displays suggestions that can help users anticipate heart disease. The advantages in this application is the question and answer forum between users and experts.

3. Theoretical Framework

3.1. Certainty Factor

Certainty factor shows a measure of certainty in a fact or rule [2]. In a kusrini said that the certainty factor introduced by Shortliffe Buchanan in the making of MYCIN notes that a doctor often analyzes the information that exists with an expression of uncertainty, such as: probably, most likely, almost and as much as possible [6]. Therefore the MYCIN team used the certainty factor method used to describe the level of expert confidence in the problem at hand. The certainty factor notation is defined as follows [6]:

\[
\text{CF} [h, e] = \text{MB} [h, e] - \text{MD} [h, e] \quad (1)
\]

with:
- \( \text{CF} [h, e] \) = certainty factor hypothesis influenced by the evidence \( e \) is known with certainty.
- \( \text{MB} [h, e] \) = measure of belief, a measure of trust in hypothesis \( h \), if influenced by evidence \( e \) (between 0 and 1).
- \( \text{MD} [h, e] \) = measure of disbelief, size of distrust of hypothesis \( h \), if influenced by evidence \( e \) (between 0 & 1).

The combination of uncertainty rules is 3 things, among others [2]:

1. Several combined evidence to determine the CF of a hypothesis (figure 1.a). If \( e_1 \) and \( e_2 \) are observations, then:

\[
\text{MB}[h, e_1 \land e_2] = \begin{cases} 
0 & \text{if } h \in \text{MB} [h, e_1] + \text{MB} [h, e_2] - \text{MB} [h, e_1 \land e_2] \\
\text{MB}[h, e_1 \land e_2] & \text{if } h \in \text{MB} [h, e_1 \land e_2] - \text{MB} [h, e_1] - \text{MB} [h, e_2]
\end{cases} 
\quad (2)
\]

\[
\text{MD}[h, e_1 \land e_2] = \begin{cases} 
0 & \text{if } h \in \text{MD} [h, e_1] \text{ or } \text{MD} [h, e_2] \\
\text{MD}[h, e_1 \land e_2] & \text{if } h \in \text{MD} [h, e_1 \land e_2] - \text{MD} [h, e_1] - \text{MD} [h, e_2]
\end{cases} 
\quad (3)
\]

2. Certainty Factor is calculated from a combination of several hypotheses (Figure 1.b). If \( h_1 \) and \( h_2 \) are hypotheses, then:
3. Some rules go hand in hand, the uncertainty of a rule becomes the input for another rule (figure 1.c), then:

\[ MB[h_1 \land h_2, e] = \min \{MB[h, e], MB[h_2, e]\} \]  \hspace{1cm} (4)

\[ MB[h_1 \lor h_2, e] = \max \{MB[h, e], MB[h_2, e]\} \]  \hspace{1cm} (5)

\[ MD[h_1 \land h_2, e] = \min \{MD[h, e], MD[h_2, e]\} \]  \hspace{1cm} (6)

\[ MD[h_1 \lor h_2, e] = \max \{MD[h, e], MD[h_2, e]\} \]  \hspace{1cm} (7)

3.2. Daily Calorie Needs

**BMR (Basal Metabolic Rate)**

The formula for calculating the Basal Metabolic Rate for Men is [5]:

\[ \text{BMR} = 66 + (13.8 \times \text{BW}) + (5 \times \text{H}) - (6.8 \times \text{A}) \]  \hspace{1cm} (9)

The formula for calculating the Basal Metabolic Rate for Men is:

\[ \text{BMR} = 65.5 + (9.6 \times \text{BW}) + (1.8 \times \text{H}) - (4.7 \times \text{A}) \]  \hspace{1cm} (10)

with:

- BMR = Basal Metabolic Rate
- BW = Body Weight in kilograms (kg)
- H = Height in centimeters (cm)
- A = Age in years

**Physical Activity**

To calculate the final BMR, physical activity factors are needed. Physical activity for patients with heart disease can be divided into 2 types of activities [6].

| Type of Activity          | Activity Factor |
|--------------------------|-----------------|
| Rest in bed              | 1.2             |
| Not tied in bed          | 1.3             |

The formula for calculating the final BMR:

\[ \text{Final BMR} = \text{BMR} \times \text{activity factor} \]  \hspace{1cm} (11)

4. System Analysis

The following are 6 processes used in the expert system for diagnosing heart and cardiovascular diseases: (1) Symptom management process; symptom management in expert systems aims to perform data processing of symptoms, such as: deleting, editing and adding symptoms. (2) Rule management process; rule management process aims to do data processing rules, namely adding, deleting and editing rule data. (3) Disease management process; disease management process aims to perform data processing, namely disease, adding, deleting and editing data illness. (4) Consultation process; The consultation process in this system aims to consult a diagnosis of cardiovascular disease. In this process, the patient will enter the personal data and symptoms experienced by the patient. (5) The food menu management process; Food menu management process aims to perform data processing, namely food
menu, edit the data diet. (6) Patient management process; Patient management process aims to make a patient's data processing, delete and view patient data in detail.

The Inference Process is a process to produce conclusions from facts that are known or assumed. Inference is a logical conclusion or implication based on available information. There are 2 methods of reasoning that can be used to produce conclusions, but according to Ignizio says that if there are problems that have a premise less than conclusions then the strategy offered is Forward Chaining, but if the opposite the right solution is forward chaining [7].

Sources of disease data and symptoms were obtained from interviews with cardiologist at Jogja International Hospital (JIH), namely a specialist heart and blood vessels, while knowledge about diet for the cardiovascular disease diet by nutrition specialist. Knowledge base results are shown in tables 2 and 3.

| Disease Code | Disease Name         | Definition                                                                                                                                                                                                 |
|--------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P01          | Coronary heart       | Coronary heart disease is caused by narrowing of small blood vessels that supply blood and oxygen to the heart.                                                                                             |
| P02          | Arrhythmia           | Arrhythmia is a problem with the heart rhythm when the organ beats too fast, too slow or irregularly. An arrhythmia occurs due to the malfunctioning of electrical impulses that regulate heart rate. |
| P03          | Cardiomyopathy       | Cardiomyopathy occurs because the myocardium cannot pump and send blood throughout the body.                                                                                                             |
| P04          | Heart valve          | Heart valve disease arises due to abnormalities or disturbances in one or more of the four heart valves, so that blood is difficult to flow into the room or blood vessels.                                     |
| P05          | Ventricular Sentiment| This is an abnormality in the heart wall. There is a hole in the ventricular septum, which is the wall that separates the right ventricle and left ventricle. This can cause oxygen not to be pumped to the entire body, but to re-enter the lungs. |
| P06          | Pericarditis         | This is a problem caused by injury and inflammation of the pericardium, the membrane lining the heart. The function of this membrane is to maintain the location of the heart.                                |
| P07          | Endocarditis         | Endocarditis is an infection of the inner lining of the heart caused by bacteria attached.                                                                                                                  |

| Disease Code | Disease Name         | Definition                                                                                                                                  |
|--------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| G01          | coughing continuously|                                                                                                                                              |
| G02          | reduced weight       |                                                                                                                                              |
| G03          | weight gain          |                                                                                                                                              |
| G04          | the white spot in the eye, or mouthparts inside |                                                                                                                                              |
| G05          | red blotsches on the skin |                                                                                                                                              |
| G06          | excessive sweating   |                                                                                                                                              |
| G07          | sweating at night    |                                                                                                                                              |
| G08          | sweating while eating or crying |                                                                                                                                              |
| G09          | spots on the skin of the fingers |                                                                                                                                              |
| G10          | chest tightness during activities |                                                                                                                                              |
| G11          | blood in the urine   |                                                                                                                                              |
| G12          | high fever           |                                                                                                                                              |
| G13          | heart rate faster than normal |                                                                                                                                              |
| G14          | heart rate is slower than normal |                                                                                                                                              |
| G15          | irregular heartbeat  |                                                                                                                                              |
| G16          | edema (swelling in the ankle) |                                                                                                                                              |

Table 3. Symptoms of cardiovascular disease

| Disease Code | Disease Name         | Definition                                                                                                                                  |
|--------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| G17          | nervous and anxious  |                                                                                                                                              |
| G18          | hypertension (high blood pressure) |                                                                                                                                              |
| G19          | loss of appetite     |                                                                                                                                              |
| G20          | pale face            |                                                                                                                                              |
| G21          | Nausea               |                                                                                                                                              |
| G22          | easy fatigue         |                                                                                                                                              |
| G23          | dizziness/ a headache |                                                                                                                                              |
| G24          | short breath         |                                                                                                                                              |
| G25          | pain in the joints   |                                                                                                                                              |
| G26          | pain in the chest    |                                                                                                                                              |
| G27          | frequent respiratory infections |                                                                                                                                              |
| G28          | often fainted        |                                                                                                                                              |
| G29          | Breathless           |                                                                                                                                              |
| G30          | hard to focus        |                                                                                                                                              |
| G31          | Insomnia             |                                                                                                                                              |

5. Experimental Result
5.1. Implementation System

The purpose of this implementation phase is to find out the feasibility of a system that has been previously designed. Based on previous studies that discuss the expert system for nutritional diagnosis with rule base reasoning as conducted by Chen [8], Van der Merwe [9], Al-Dhuhi [10] and the next is a little different, namely applying uncertainty in the implementation of expert systems [11], and linear programming in the implementation [12-14]. Other studies that map a person's nutritional status using food diaries and by
comparing the level of nutritional intake with the validation of the Fuzzy model recommended by the expert [15], this study is very similar to the concept of the research conducted now.

In addition there are several studies that focus on the expert system of special nutrition care for the elderly [16] and in contrast there is a focus on special nutrition for children [17] others have developed expert systems for mobile-based nutrition needs [18]. The results of the implementation of the design that had been made consisted of patient self-data including age, height, weight, sex, activity and symptoms. some data needed based on previous research is almost the same.

5.2. Testing System

System testing is carried out to determine the similarity of the final results in the form of possible diseases and food menu recommendations produced by the system with those produced by experts. Based on manual calculations, the highest CF value is 0.7022 with ventricular septum defect disease (Figure 2). Then the system calculation is done by entering the same symptoms. The system also produces the possibility of a ventricular centum defect disease.

![Figure 2. System Testing Result](image)

6. Conclusion

Based on the results of research that has been done, it can be concluded:

a. A cardiovascular expert system with Certainty Factor method is able to diagnose and provide the possibility of a cardiovascular disease based on symptoms.

b. Based on the results of the tests that have been carried out, the system can provide the results of consultations in accordance with expert knowledge.

c. Based on the results of testing calculations have been done, the results of the calculation system in accordance with the results of manual calculations.

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