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Expert System for Early Diagnosis of Malaria Disease and Its Prevention Using the Forward Chaining Method

Sartika Situmorang[1]*, Patmawati Hasan [2], Rahmat H. Kiswanto[3]
[1]Program Studi Sistem Informasi
[1-3]Universitas Sepuluh Nopember Papua
Corresponding Author: Sartika Situmorang sartikasitumorang24@gmail.com

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ABSTRACT

Malaria is one of the endemic diseases that is a major health challenge in the 3T (Disadvantaged, Frontier, and Outermost) areas, especially in Papua. The limited number of health workers in this area worsens the handling and early diagnosis of malaria. This study aims to design an expert system based on the forward chaining method to detect malaria early based on reported symptoms. The test results show that the system's accuracy level reaches 80%, which is included in the very good category. This system is expected to help the community in carrying out early detection independently before receiving further medical treatment. To improve accuracy, it is recommended to combine the forward chaining method with a certainty factor so that the system can consider the level of certainty in the diagnosis, so that the results provided are more optimal.

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INTRODUCTION

The limited human resources (HR) for health in Kampung Klaisu, Jayapura Regency, Papua, is one of the main obstacles in handling malaria. With the number of cases reaching 150 people in 2024, the available medical personnel are not sufficient to provide optimal services. The local health center must serve a large area with a limited number of staff, so that residents often receive a late diagnosis and treatment. In addition, the lack of training and education for the community regarding malaria prevention worsens the situation. This condition emphasizes the need.

increasing the number and capacity of health workers to effectively deal with the threat of malaria in the region. The lack of human resources (HR) for health in Kampung Klaisu, Jayapura Regency, Papua, makes it difficult to handle malaria quickly and effectively. With the high number of malaria cases, innovative solutions are urgently needed to overcome this limitation. The implementation of technology, such as an artificial intelligence-based expert system, can be a significant tool. This system allows residents to make an initial diagnosis based on the symptoms they experience, so they can determine the initial steps before consulting with medical personnel. This technology not only helps to ease the burden on health workers, but also speeds up the case identification process. In addition, the expert system can be connected to patient data and provide appropriate temporary treatment recommendations. With the implementation of this system, the people of Kampung Klaisu can get faster health services, even though the number of medical personnel is limited, so that the death rate and complications due to malaria can be minimized.

An expert system with the forward chaining method can be an innovative solution to help the people of Kampung Klaisu in dealing with malaria. This method works by analyzing the initial symptoms inputted by the user, such as fever, chills, or body aches, and matching them with programmed rules to produce an initial diagnosis. This process allows the community to get quick information about the possibility of contracting malaria without having to wait for medical personnel. This system not only helps diagnose, but also provides recommendations for initial steps, such as the use of antimalarial drugs or advice to go to a health facility immediately. With easy access, expert systems can ease the burden on health workers while increasing public awareness and response to malaria.

LITERATURE REVIEW

Several studies on expert systems that implement the forward chaining method and other methods to detect malaria include research conducted by Notria Inna Dodo et al., entitled Implementation of the forward chaining method in an expert system to diagnose malaria at the Waimangura health center. In this study, the Expert System was produced to help people who need information on diagnosing malaria. The difference in this study is that in the previous study, the accuracy of the method was not tested, while in this study, the accuracy of the method will be measured.(Dodo et al., 2024) The second study, namely the study conducted by Eka Lia Febrianti et al., is the application of the Forward Chaining method to diagnose malaria. This study concluded

that the forward chaining method can be used for tracing in overcoming malaria. The difference in this study lies in the type of malaria that was detected.(Febrianti & Christi, 2017) The third study is a study conducted by Veronika H et al entitled Expert System for Malaria Disease Diagnosis with Certainty Factor and Forward Chaining. This study concluded with an accuracy result of 83-87%. The difference in the previous study lies in the design using DFD, while the design to be carried out in this study uses use case.(Kalua et al., 2022) The fourth study, namely the Implementation of the Certainty Factor Method to Diagnose Malaria, conducted by Linda Perdana Wanti, Wafa Ulfiyah 2024, the Accuracy of Method Utilization Reaches 90%, the difference in the study lies in the method used in designing the expert system, namely the certainty factor, while the research to be carried out uses the forward chaining method.(Linda Perdana Wanti & Wafa Ulfiyah, 2024) Next, the research entitled Expert System for Malaria Disease Diagnosis with the Naive Bayes method of Waimagura Health Center conducted by Regina Bali Ate, et al. in 2023. This research can provide recommendations for hypotheses of the disease experienced, efficiently and accurately. The difference in the previous research is the implementation of the method in the expert system using Naive Bayes while the method to be used in this study uses the forward chaining method.(Ate, 2023). Expert system for diagnosing diabetes mellitus using forward chaining Depi Trisnawati, Mariana Windarti, et al. in 2022 This study concluded that the use of the Forward Chaining method in this study was successful in detecting diabetes mellitus. The difference in the research that will be carried out lies in the object of the study, namely malaria.(Trisnawati et al., 2022).

METHODOLOGY

The Waterfall model is one of the most classic and widely used software development models. This model follows a linear and sequential approach, where each stage must be completed before moving on to the next stage. In this method, software development is carried out in stages with a clear sequence.

1. Needs Analysis

The first stage in the waterfall model is needs analysis. At this stage, software developers together with users or clients collect and document all functional and non-functional requirements of the system to be developed. The information collected includes what is expected from the system, how the system should work, and system specifications and limitations.

2. Design (System Design)

After the system requirements are clearly determined, the next stage is system design. At this stage, the system architecture is designed based on the needs that have been collected. This design involves specifications regarding hardware and software, data structures, algorithms, user interfaces, and how system components will be implemented and integrated.

3. Implementation (Development/Coding)

At this stage, based on the design documents that have been created, developers begin implementing the system in the form of program code. This stage is often referred to as coding. Each module or part of the system is developed and tested individually.

4. Testing (Testing)

After all parts of the system have been developed, the next stage is integration and testing. At this stage, the modules that have been implemented are integrated into a complete system. Testing is performed to ensure that the system functions according to predetermined specifications.

RESEARCH RESULT

1. Malaria Disease and Symptoms

The list of symptoms that will be used in this study, furthermore, for the list of disease categories can be seen in table 1.

Table 1. Disease codes and names

Symptom Code	Symptom Name
P01	Malaria tertiana
P02	Malaria Tropika
P03	Malaria Quartana
P04	Malaria Ovale

The symptoms used in this study can be seen in table 2. Symptom

Table 2. Symptom

Symptom Code	Symptom Name
G01	Fever
G02	Chills
G03	Sweating
G04	Headache
G05	Loss of Consciousness
G06	Anemia
G07	Nocturnal Pulse
G08	Spots Appear
G09	Body lethargy / weakness
G10	Red face
G11	Vomiting
G12	Diarrhea
G13	Aches and pains
G14	Convulsions
G15	Fever

G16	Chills
G17	Sweating
G18	Headache
G19	Loss of Consciousness
G20	Anemia

1. Rules Forward Chaining

Next, rule making uses the forward chaining method based on the first step in making rules for diagnosing disease. (Tobing et al., 2019)(David, 2014). Malaria disease is carried out by creating a knowledge base based on knowledge about malaria disease which is included in the rules table Table 3.

Tabel 3. Rules

Symptom	Disease
IF G01 (0,8) AND G02 (0,6) AND G03 (0,7) AND G10 (0,3) AND G13 (0,4) AND G20 (0,5) THEN P01	Malaria tertiana
IF G01 (0,8) AND G02 (0,6) AND G05 (0,6) AND G06 (0,7) AND G07 (0,4) AND G11 (0,8) AND G12 (0,6) AND G13 (0,4) AND G14 (0,8) AND G15 (0,4) AND G17 (0,8) AND G18 (0,3) AND G20 (0,5) THEN P02	Malaria Tropika
IF G01 (0,8) AND G02 (0,6) AND G04 (0,8) AND G05 (0,6) AND G09 (0,7) AND G13 (0,4) AND G14 (0,8) AND G16 (0,4) AND G19 (0,3) AND G20 (0,5) THEN P03	Malaria Quartana
IF G01 (0,8) AND G03 (0,7) AND G05 (0,6) AND G06 (0,7) AND G08 (0,6) AND G13 (0,4) AND G16 (0,4) AND G20 (0,5) THEN P04	Malaria Ovale

2. User Interface

The expert system application created is a type of website-based application created using the PHP programming language and a MySQL database. The expert system application consists of several main modules, namely home, symptom data, Diseases Data, Rules Data, Diagnosis, Admin Data, Change Password and Logout. The Home menu can be seen in Figure 1.

Figure 1. Home

The home menu displays access to several main modules that can be clicked by the admin, such as the diagnosis process, then the symptom form can be seen in Figure 2.

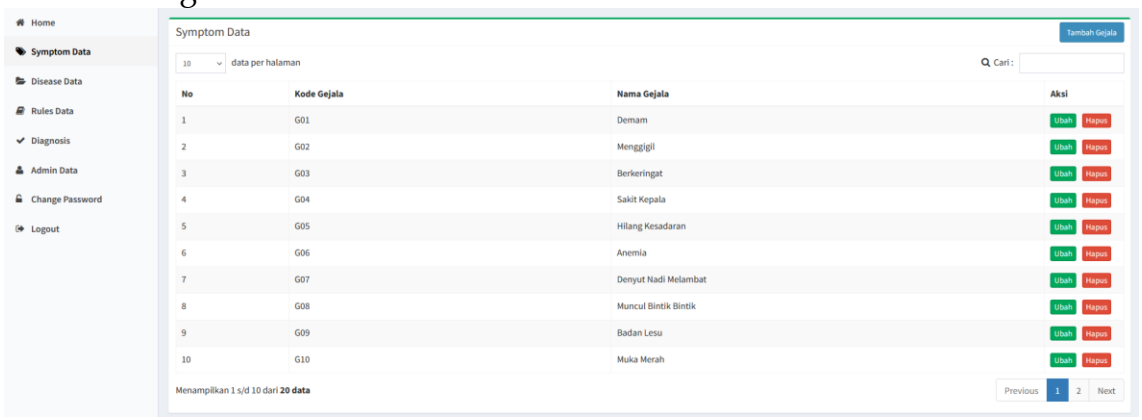

Figure 2. Symptom data form

In figure 4 is a form to access malaria disease symptom data, this form also has functions to edit, search, add and delete disease symptoms. Next in figure 3 is a disease data form.

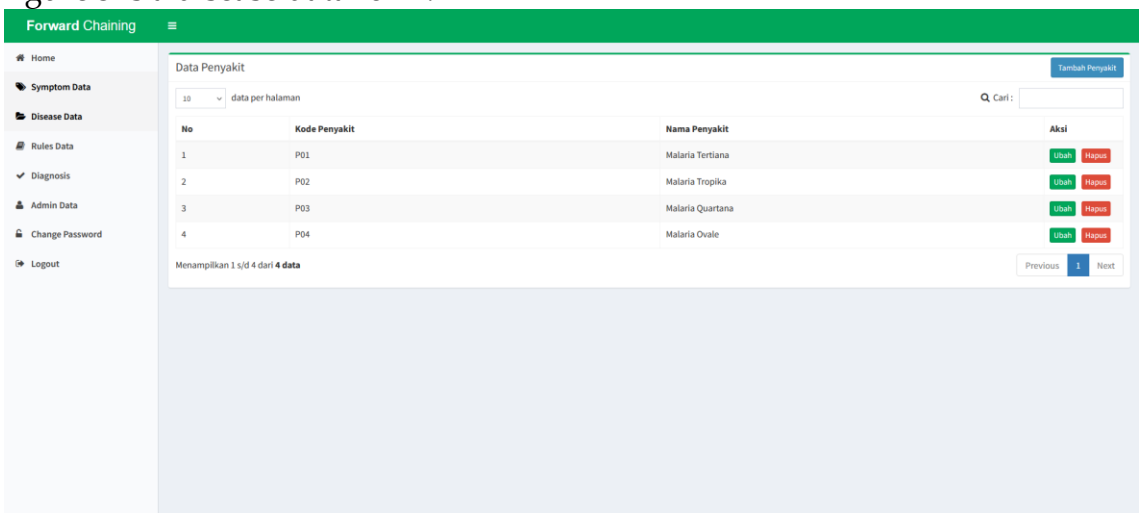

Figure 3. Disease data form

Figure 3 is a form for accessing disease data in the expert system application, this form is also useful for adding, searching, updating and deleting disease data. Next, in Figure 4 is the data rules form.

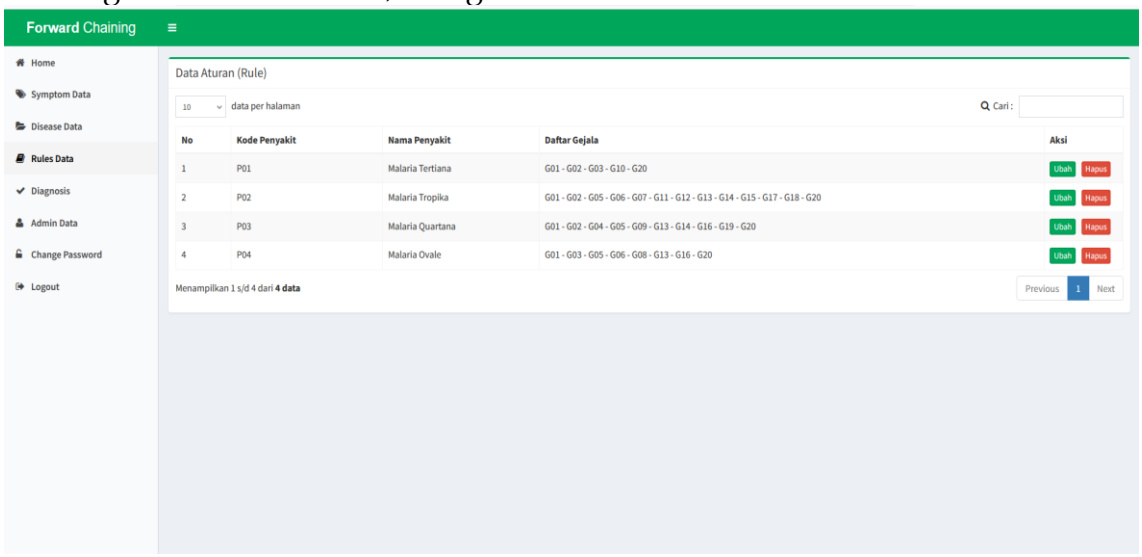

Figure 4. Data rules form

Figure 4 is a form that is useful for searching, adding, updating and deleting data rules in expert system applications. Figure 5 is a diagnosis form.

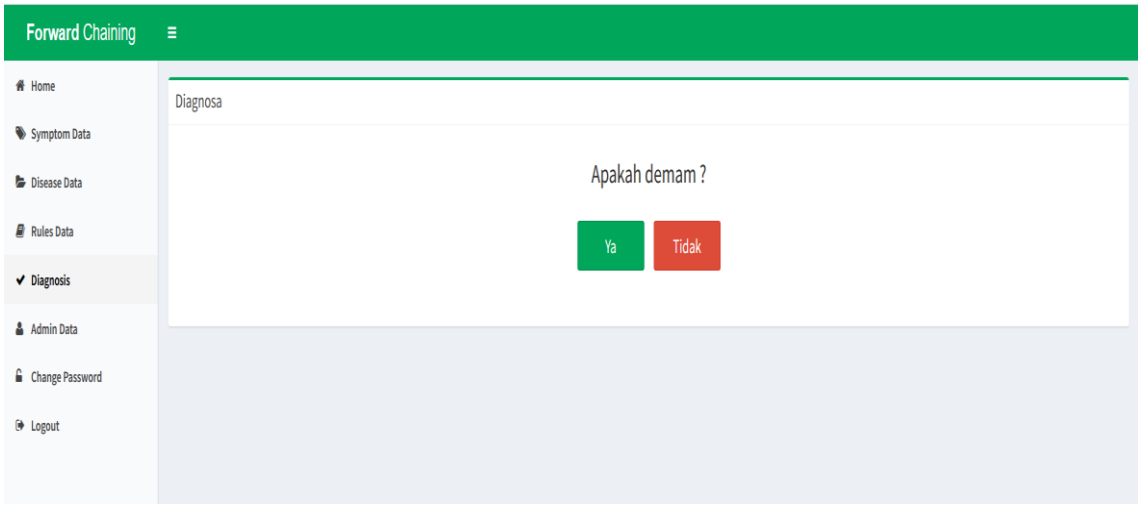

Figure 5. Diagnosis form

Figure 7 is a form for diagnosing a disease. Users can select symptoms according to what is seen or felt by the patient.

3. Output Testing

This system is tested based on expert opinions by comparing diagnoses based on expert knowledge and symptoms inputted based on rules in the forward chaining method. The test results can be seen in table 4.

Table 4. Test Results

Case	Rules	Result by System	By Expert	Remarks
Case 1	G01 - G02 - G05 - G06 - G07 - G11 - G12 - G13 - G14 - G15 - G17 - G18 - G20	Malaria Tropika	Malaria Tropika	Valid
Case 2	G01 - G02 - G04 - G05 - G09 - G13 - G14 - G16 - G19 - G20	Malaria quartana	Malaria Quartana	Valid
Case 3	G01 - G02 - G03 - G10 - G20	Malaria Tertiana	Malaria Tertiana	Valid
Case 4	G02 - G01 - G03 - G10 - G20	Malaria Tertiana	Malaria Tertiana	Valid
Case 5	G01 - G02 - G05 - G06 - G07 - G11 - G12 - G13 - G14 -G17 - G18	Not found	Malaria Tropika	Invalid

Based on the above test, there were 5 cases and a very good level of conformity was obtained, namely 80%.

DISCUSSION

Malaria is an infectious disease caused by the Plasmodium parasite, which is transmitted through the bite of the Anopheles mosquito. In Papua, malaria is a major health problem with the dominant types being tropical malaria (Plasmodium falciparum), tertian malaria (Plasmodium vivax), quartan malaria (Plasmodium malariae), and ovale malaria (Plasmodium ovale). Tropical malaria often causes severe complications such as anemia and organ damage. Tertian malaria has a fever pattern every two days with a risk of relapse. Quartan malaria, although rare, has a fever cycle every three days. Meanwhile, ovale malaria, relatively milder, often attacks local residents with low immunity. Prevention through bed nets, antimalarial drugs, and increasing access to health care is essential.

CONCLUSIONS AND RECOMMENDATIONS

The application of the forward chaining method in the expert system is very suitable, in utilizing this method which has been tested several times and the success rate reaches 80%. To increase the accuracy of the results, the forward chaining method should be combined with other methods such as certainty factor.

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