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Implementasi Forward Chaining untuk Diagnosa Penyakit Demam Berdarah Dengue

Implementation of Forward Chaining for Diagnosis of Dengue Hemorrhagic Fever

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Abstract

Insects in the form of mosquitoes are transmitting vectors of several types of diseases that are quite dangerous and need to be watched out for because they can be deadly, such as dengue fever mosquitoes, malaria, elephantiasis and the like. Patients suffering from mosquito-borne diseases must be treated immediately to find out the type of disease they are suffering from and their treatment solutions. The era of digitalization that is growing rapidly, including in the field of medical science, makes the use of information technology to help improve quality services for the community. The analysis used in this research is using the forward chaining method, as a comparison of the overall process of the problems obtained in the investigation and developed using the waterfall paradigm. Forward chaining is implemented because the disease diagnosis process begins by observing the symptoms experienced by a patient and then continues with a tracing process that results in conclusions about the dengue fever suffered. While the waterfall method is used in the development of this expert system because the method can accommodate all stages of the system starting from the analysis of functional and non-functional system requirements, system design, coding, expert system testing and the last stage is expert system maintenance. The data used in this study used data from patients infected with mosquito bites at the Maos Health Center, Cilacap Regency in 2021. Testing is carried out using the black box testing method where the expert system is tested on end-users to determine the level of success and usability of the developed system. The questionnaire was given to 76 respondents with the results of the questionnaire: 91.9% indicating the level of user satisfaction, 89.6% indicating the level of effectiveness and 92.2% indicating the level of efficiency of the expert system. The output of this study is the conclusion of the disease suffered by the patient and the solution for handling it. The results of this study were used by the Puskesmas to determine the actions and therapies that were taken and carried out on the patient.

Keywords*: Forward Chaining, Information System, Dengue Hemorrhagic Fever, Diagnosis, Waterfall.*

Introduction

The aedes aegypti mosquito is a type of insect that can carry the dengue virus which causes Dengue Hemorrhagic Fever (DHF) [1]. This disease has long been known in Indonesia as a very endemic disease, especially for children. Cases of this disease in Indonesia are among the largest in the world after Thailand. In Indonesia, DHF emerged as an epidemic for the first time in Surabaya in 1968. DHF has spread widely throughout the province with the number of affected districts/cities continuing to increase [2]. This disease often appears commonly called Extraordinary Cases (KLB) with high morbidity and mortality rates. An outbreak of dengue fever occurred in Indonesia, specifically in Jakarta, in 1998 which reached 15,452 sufferers and a fairly high mortality rate of approximately 134 people. Insects in the form of mosquitoes often interfere in our daily lives [3]. In addition to the sound and its very annoying bite, the mosquito is a carrier of several types of dangerous diseases that can be deadly, such as dengue fever, malaria, elephantiasis [4]. Several types of diseases are caused by ± 2,500 species of dangerous mosquitoes such as aedes aegypti and anopheles malaria.

Dengue fever mostly affects children less than 15 years old, but it can also affect adults. Dengue Hemorrhagic Fever (DHF) is a serious problem in Cilacap Regency, this is evidenced by the fact that there are still cases of DHF scattered in the working area of the Puskesmas in Cilacap Regency. So that it becomes a priority program through the Alert Movement. In 2015 dengue cases in Cilacap Regency reached 1,057 cases spread across 24 sub-districts. There are 283 cases in the UPT Puskesmas Cilacap Tengah 1, from the

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number of cases, 12 people died. It increased rapidly when compared to 2014 when there were 447 cases of dengue fever[5]. The sub-district area with the most cases of dengue fever is 90 cases in North Cilacap District. Of these cases, 6 patients died.

The aedes aegypti mosquito is a type of insect that can carry the Dengue virus which causes Dengue Hemorrhagic Fever (DHF). This disease has long been known in Indonesia as a very endemic disease, especially for children [6]. Cases of this disease in Indonesia are among the largest in the world after Thailand. In Indonesia, DHF emerged as an epidemic for the first time in Surabaya in 1968. DHF has spread widely throughout the province with the number of affected districts/cities continuing to increase. This disease often appears commonly called Extraordinary Cases (KLB) with high morbidity and mortality rates. An outbreak of dengue fever occurred in Indonesia, specifically in Jakarta, in 1998 which reached 15,452 sufferers and a fairly high mortality rate of approximately 134 people. Diseases caused by mosquito bites if not treated early and seriously and even lead to death [7]. The lack of people who lack knowledge about the symptoms of diseases caused by mosquitoes creates queues at the Puskesmas, resulting in patients being served slowly due to the length of time doctors take when examining patients and identifying diseases and treatment solutions [8]. On the other hand, the patient wants to quickly find out the disease he is suffering from and the treatment solution.

The era of increasingly rapid digitalization has forced the medical field to take advantage of this technology, thereby helping to improve services that are more comprehensive for the community. The expert system model is very suitable to be applied to a job that requires accuracy, such as the work of a doctor in diagnosing a patient suffering from a disease [9]. One method that is quite reliable is using the forward chaining method. This method can be used to collect data from the existing symptoms, to find out the disease suffered by the patient quickly and correctly [10].

Several studies that have been carried out include research by Siti et al who applied the forward chaining method for early detection of diseases that attack rubber plants. The expert system was developed to control diseases in rubber plants that often appear in the rainy season [11]. The forward chaining method is used to determine diseases that attack rubber plants based on symptoms observed by rubber farmers on rubber plants. The expert in this study is an expert in the field of rubber plants so that expert knowledge can be absorbed and transformed into an expert system. The output of this research is a web-based information system that can be used to conduct consultations regarding diseases that attack rubber plants. Further research was carried out by Randhika who developed an expert system for early detection of dengue hemorrhagic fever. The expert system method used is backward chaining because the method processes the search for diseases starting from the desired facts and then proceeds to a hypothesis [12]. The results of this study are an information system that can carry out the process of early detection of dengue hemorrhagic fever based on android which is useful for the general public who are still unfamiliar with information on dengue hemorrhagic fever and its handling so that people can use it easily. Furthermore, research by Ghina et al implemented the certainty factor method to diagnose dengue hemorrhagic fever. The expert system created can assist the community in providing information and early diagnosis of dengue hemorrhagic fever [13]. The stages of the research carried out began with data collection, system analysis, system implementation and system testing. The output of this research is an expert system that provides initial information about the diagnosis of dengue hemorrhagic fever and its treatment category.

Based on the above background, a computer-based system is needed that helps in diagnosing diseases caused by mosquito bites quickly and accurately [14]. Several studies that have been carried out and become a comparison for research that is being carried out distinguish the implementation of the technology to be applied, and the resulting research outputs. This research utilizes information technology in this case the website to display all information and can help diagnose diseases caused by mosquito bites. In this study, the output of the system will be used by the health centre to decide the action to be taken and the therapy to be given to the patient. The implementation of an expert system is a way and engineering to store and process the knowledge of an expert in a particular case into a database that can be operated using a computer system so that it can make decisions and do reasoning appropriately [15]. The purpose of this study is to optimize the forward chaining method in the disease tracing process, which begins by observing the symptoms that appear in patients and are caused by mosquito bites so that the best treatment solution can be found early. These solutions can help patients and doctors in determining the medical treatment given to patients. The results of this expert system for diagnosing dengue hemorrhagic fever can provide an initial description of the diagnosis of the cause of dengue hemorrhagic fever and the category of initial treatment for patients. The difference between this study and several previous studies is the optimization of the forward chaining method to determine the disease by tracing the symptoms experienced by the patient [16]. This expert system also uses the waterfall method in its development process because the method is

able to accommodate all stages of the process from the beginning until the expert system is implemented [17].

Research Methods

Forward Chaining Method

Expert System

An expert system is a system that uses computers and knowledge of a particular field to solve a problem in that field [18]. The solutions given are the same as those concluded by someone who knows a lot about the problem at hand. Building a good expert system requires several components, including: (a) User Interface; (b) Knowledge Base; (c) Mechanism of Inference (Inference Machine); and (d) Working Memory.

The user interface, an expert system replaces an expert in certain situations, the system must provide the support needed by users who do not understand the problem technically [19]. The expert system also provides communication between the system and the user, which is known as the interface. An effective and user-friendly interface must be user-friendly because it is very important, especially for users who do not understand the field applied to expert systems [20].

The knowledge base is a collection of knowledge in a particular field at the expert level in a certain format. This knowledge is obtained from the accumulation of expert knowledge and other sources of knowledge. In this expert system, the knowledge base is separate from the inference engine [21]. This separation is useful for the development of expert systems that are freely adapted to the development of knowledge [22].

An inference engine is the brain of an expert system in the form of software that performs the task of reasoning inference on an expert system, commonly referred to as a thinking machine [23]. In principle, this inference engine will find a solution to a problem [24]. An inference engine is a computer program that provides a methodology for reasoning about the information on a knowledge base and working memory to formulate some conclusions [25]. This component provides some direction on how to use knowledge from the system by establishing an agenda that manages and controls the steps taken to resolve issues during consultations [26]. Working memory is part of the expert system that stores the facts obtained during the consultation process [27]. These facts will be processed by the inference engine based on knowledge to determine a problem-solving decision [28].

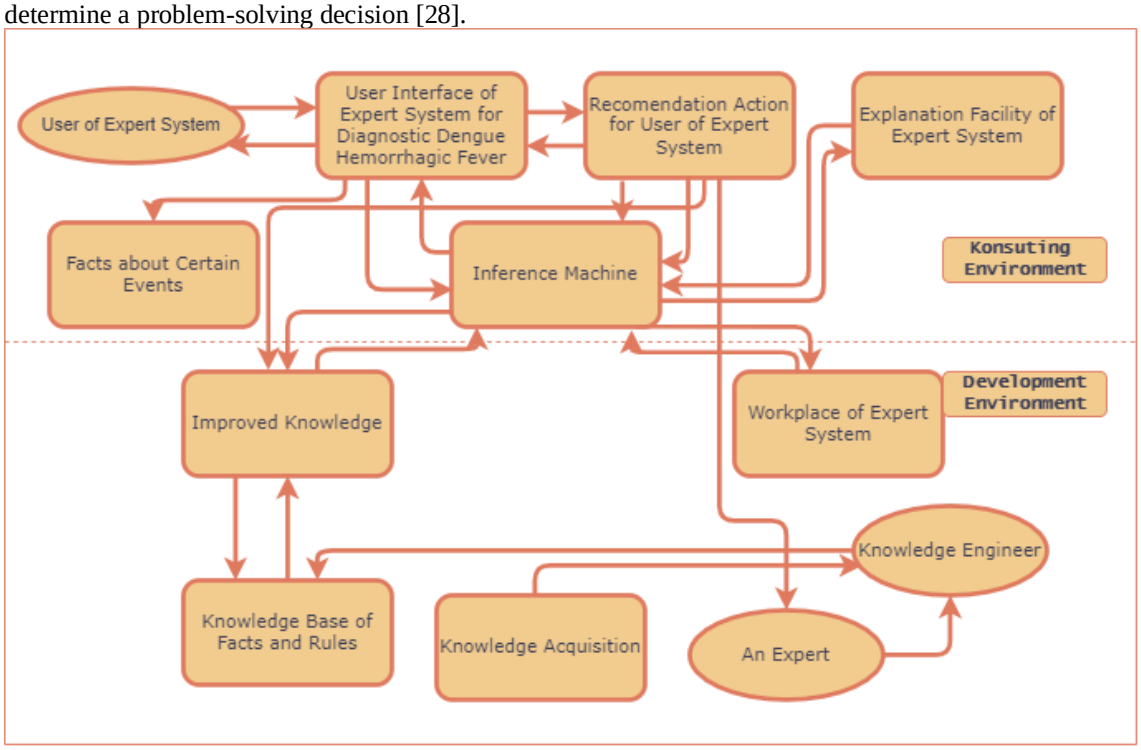

Figure 1. Expert System Structure

Figure 1 describes the structure of the expert system which consists of two scope areas, namely the expert system development environment itself and the consulting environment [29]. In the development

environment, there are several items including expert knowledge acquired to become a knowledge engineer, explanatory facilities, and a knowledge base consisting of facts and rules used to conclude a problem [30]. Meanwhile, the consulting environment consists of several components including the expert system user interface which consists of modules used to conduct consultation sessions, explanation facilities and inference engines [31].

Forward Chaining Algorithm

The forward chaining method is a search method and forward tracking technique starting with existing information and combining rules to produce a conclusion or goal [13]. This forward tracking process is especially good when working with problems that start with an initial recording of information and want to achieve a final resolution [27]. The whole process will be executed sequentially forward. Forward chaining is an inference method that makes reasoning from a problem to find a solution [32]. If the premise clause matches the situation, the value is true, then the process will state the conclusion [33]. Forward chaining is data-driven because inference begins with available information and only then conclusions will be obtained [34]. If an application generates a tree that is wide and not deep [35].

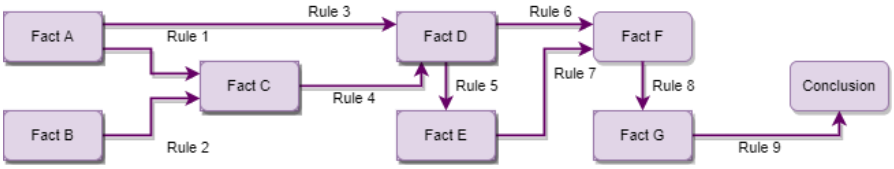

Figure 2. Forward Chaining Algorithm

Waterfall Method

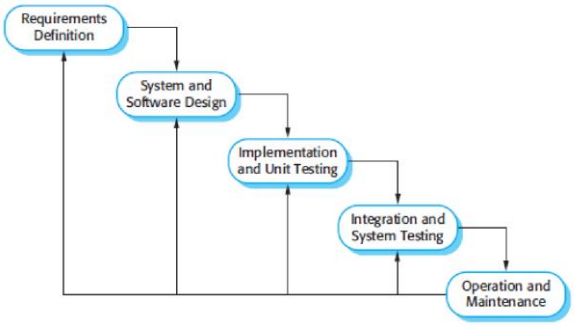

Figure 3. Waterfall Method

The first stage in the waterfall method is to define needs. The process is carried out in analyzing system requirements, diagnosing diseases caused by mosquito bites to be built [36]. Collecting complete needs including the name of the disease, symptoms of the disease, solution for handling the disease and then heading to the analysis stage. The process of collecting system information needs through interviews with sections related to the problem of the system to be built such as with doctors, collecting disease data and symptoms of the disease needed. After defining all the requirements, the next step is to design the developed expert system, starting with designing the data flow, designing the relationships between tables on the expert system base, designing activities that can be carried out by end-users [37]. This design stage is given a clear general description to the user and a complete design of the system in question. Users who will take advantage of the system that has been designed are patients and doctors. The next stage is the implementation of each design into program codes and testing each module on the expert system [38]. At this stage, the system components are made using program logic modules. Unify the interface with the designed database. The next stage is to integrate each module that has been made and test the expert system as a whole [39]. System testing is carried out using the black box testing method, to find out the overall system that has been developed meets the requirements according to user needs and functions in the system such as symptom data management functions, disease data management, relationship management. After the last stage of testing, namely the maintenance of an expert system to diagnose diseases caused by mosquito bites, in the treatment stage it is useful to correct whether the system can run smoothly without any problems and to update diseases, symptoms, relationships or relationships between diseases and their symptoms [40].

Result and Discussion

Requirements Definition

Data collection was carried out by observation and interviews at the Maos Health Center, Cilacap Regency to find out data on patients who were infected by mosquito bites during the past year. The data are classified to identify the symptoms experienced by patients who refer to certain diseases. This stage also defines the software requirements for developing an expert system for diagnosing dengue fever that optimizes the forward chaining method. The functional and non-functional requirements of the system are as follows [41]:

1. The functional requirements of the expert system consist of three main modules, namely data management of disease symptoms due to mosquito bites which can be added, modified and deleted data, the second module is a disease data management module which can also be added, changed and deleted data and the last module is a relationship management module that is also dynamic, adapted to future organizational needs.
2. Non-functional requirements for expert systems include hardware and software requirements used for expert system development.

System and Software Design

Figure 4 (a) shows the data flow at level 0 in the process of diagnosing diseases caused by mosquito bites, where experts, namely doctors, can perform symptom data processing, disease data processing and relational data processing to take their knowledge and serve as a knowledge base for expert systems. While Figure 4 (b) shows the flow of data at level 1 in the consultation process carried out by patients using an expert system. After the doctor transfers knowledge about the symptoms that are usually experienced by the patient and concludes these symptoms to a disease, the knowledge is stored in the form of facts and rules in the knowledge base of the expert system. On the patient side, after conducting a consultation by selecting the symptoms that are adjusted to the symptoms experienced, the patient can see the results of the expert system analysis through the user interface provided by the expert system.

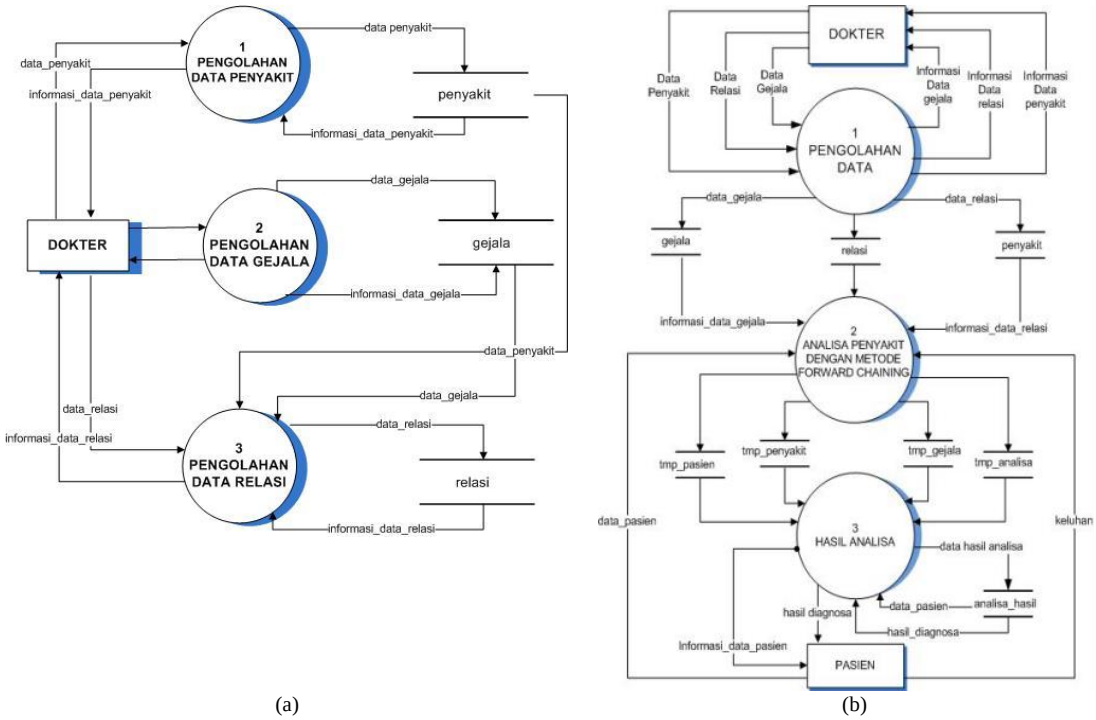

Figure 4. (a) DFD Level 0 Diagnosing Diseases Due to Mosquito Bites, (b) DFD Level 1 Expert System Diagnosing Diseases Due to Mosquito Bites

Implementation and Unit Testing

Figure 5 describes the flow of the expert system designed by optimizing the forward chaining method. The first step that must be done by the end-user is to choose the method used because there are two choices of methods. The first is the forward chaining method, which is for symptom questions or

consultations and the second option is the backward chaining method to find out the symptoms of the disease you want to know. At the time of consultation, the user will answer questions with the answer "YES" or "NO". If the user answers "YES" then the system will check until the last question to get the diagnosis results from the disease report. If the user answers "NO" the system will continue to look for the next symptom question until the system checks the last question and gets the diagnosis result from the disease report.

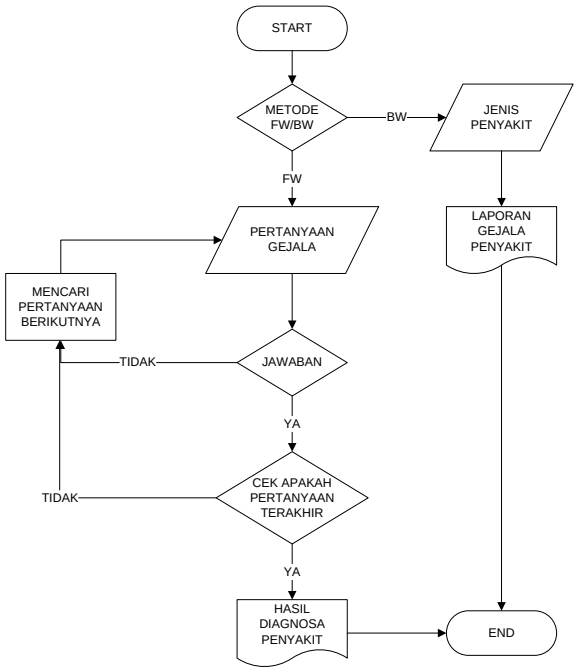

Figure 5. Flowchart of Expert System Optimizing Forward Chaining Method

Several types of diseases caused by mosquito bites and their symptoms can be seen in table 1. Table 1 shows disease data symbolized by D01 to D05 and the symptoms experienced symbolized by S01 to S34.

Table 1. Diseases and Symptoms

No	Disease and Code	Symptoms and Code
1	Dengue Hemorrhagic Fever (D01)	✓ (S01) Sudden high fever (38-40 C) ✓ (S02) Fever suddenly dropped ✓ (S03) Leakage of blood vessels ✓ (S04) Headache ✓ (S05) Muscle pain and rash ✓ (S06) Stomach pain (nausea and vomiting) ✓ (S07) Happens pretentious ✓ (S08) Breathing breath ✓ (S09) Fast but weak heart rate ✓ (S10) Cold and bluish skin ✓ (S11) Mental changes like a daze ✓ (S12) Body Shiver ✓ (S13) Red spots on hands and feet ✓ (S14) Pain in the joints of the knees, wrists, and feet ✓ (S15) Pain in the throat ✓ (S16) Black and hard bowel movements
2	Malaria (D02)	✓ (S01) Sudden high fever (38-40 C) ✓ (S17) Severe headache ✓ (S18) Muscle pain and rash ✓ (S19) Stomach ache ✓ (S20) Shiver ✓ (S21) Bone pain ✓ (S22) Cough ✓ (S23) Palms that feel cold and moist ✓ (S24) The liver is often enlarged ✓ (S25) Sore throat ✓ (S26) Tired ✓ (S27) Less blood ✓ (S28) The yellow color on the skin/eyelids

3	Chikungunya (D03)	✓ (S01) Sudden high fever (38-40 C) ✓ (S17) Severe headache ✓ (S06) Stomach pain (nausea and vomiting) ✓ (S29) Swollen lymph nodes ✓ (S13) Red spots on hands and feet ✓ (S14) Pain in the joints of the knees, wrists, and feet ✓ (S30) Red eyes
4	Elephantiasis (D04)	✓ (S01) Suddenly high fever (38-40 C) ✓ (S29) Swollen lymph nodes ✓ (S31) Inflammation of the lymph node ducts ✓ (S32) Enlargement of legs, arms, breasts ✓ (S33) The testicles look slightly red and feel hot
5	Yellow Fever (D05)	✓ (S01) Suddenly high fever (38-40 C) ✓ (S02) Fever suddenly dropped ✓ (S17) Severe headache ✓ (S18) Muscle pain and rash ✓ (S06) Stomach pain, nausea and vomiting ✓ (S09) Fast but weak heart rate ✓ (S34) Loss of appetite

Figure 6 describes the process of tracing diseases caused by mosquito bites by optimizing the forward chaining method. This method is optimized because the tracing process starts from selecting the symptoms experienced by the patient, in this case, the symptoms experienced will be stored in the knowledge base of the expert system as facts that occurred. Meanwhile, the rules that bind each symptom and are concluded to lead to disease are also stored in the knowledge base of the expert system in the developer environment. The types of diseases caused by mosquito bites are very diverse and almost all of them are dangerous. This type of disease attacks the most important organs in the human body. So that the type of mosquito that bites must be detected immediately and must be handled specifically.

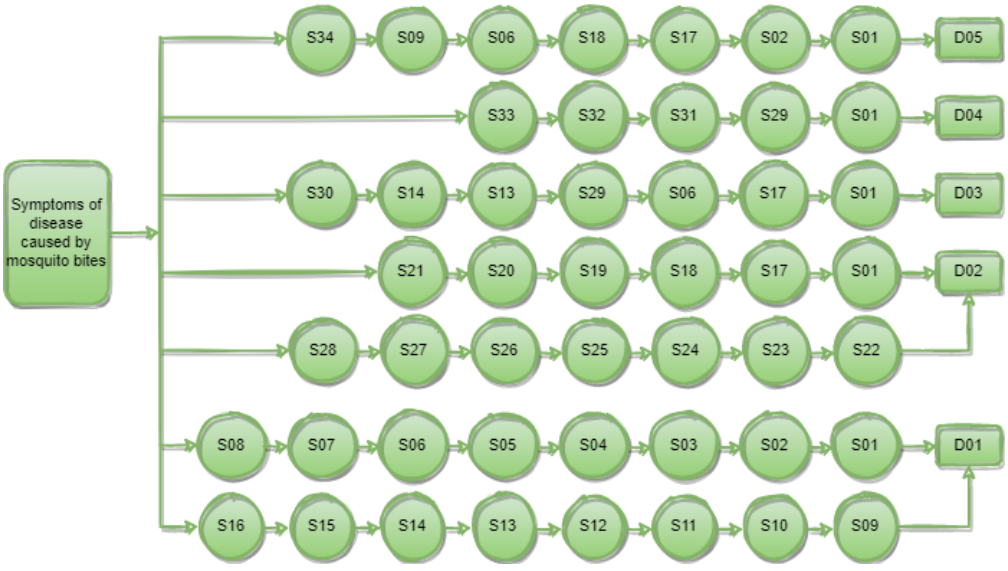

Figure 6. Rule Base Expert System Optimizing Forward Chaining Method

The next process is to design rules based on expert knowledge that has been obtained. The results of the rules formed are represented in table 2 below:

Table 2. Expert System Rules

Rule	
Rule 1 :	If S01 AND S02 AND S03 AND S04 AND S05 AND S06 AND S07 AND S08 AND S09 AND S10 AND S11 AND S12 AND S13 AND S14 AND S15 AND S16 THEN D01
Rule 2 :	IF S01 AND S17 AND S18 AND S19 AND S20 AND S21 AND S22 AND S23 AND S24 AND S25 AND S26 AND S27 AND S28 THEN D02
Rule 3 :	IF S01 AND S17 AND S06 AND S29 AND S13 AND S14 AND S30 THEN D03
Rule 4 :	IF S01 AND S029 AND S31 AND S32 AND S33 THEN D04
Rule 5 :	IF S01 AND S29 AND S31 AND S32 AND S33

The reasoning process begins by taking facts from expert system users to be used in proving the rules that have been made previously. Based on the results that have been done, the facts used in this reasoning process can be seen in table 3 below:

Table 3. User Consultation Results

Symptoms Code	User Feedbacks
S01	Yes
S17	Yes
S18	Yes
S19	Yes
S20	Yes
S21	No
S22	No
S23	Yes
S24	Yes
S25	Yes
S26	No
S27	Yes
S28	Yes

Based on table 2 above, it can be proven that the facts used are S01, S17, S18, S19, S20, S23, S24, S25, S27, S28. In the reasoning process by optimizing the forward chaining method, the process occurs repeatedly more than once and is known as iteration. In the iteration process, if the reasoning process has found a goal/result, the reasoning process will be stopped, but on the other hand, if no goals/results are found in the process, the reasoning process will also be stopped.

Integration and System Testing

At this stage, the expert system for diagnosing diseases caused by mosquito bites has been completed and is ready to be tested on end-users. Figure 7 (a, b, c, d) shows several module pages on the expert system. These modules include modules for adding disease data, modules for displaying symptom data, modules for adding relationships and modules for diagnostic results that have been carried out.

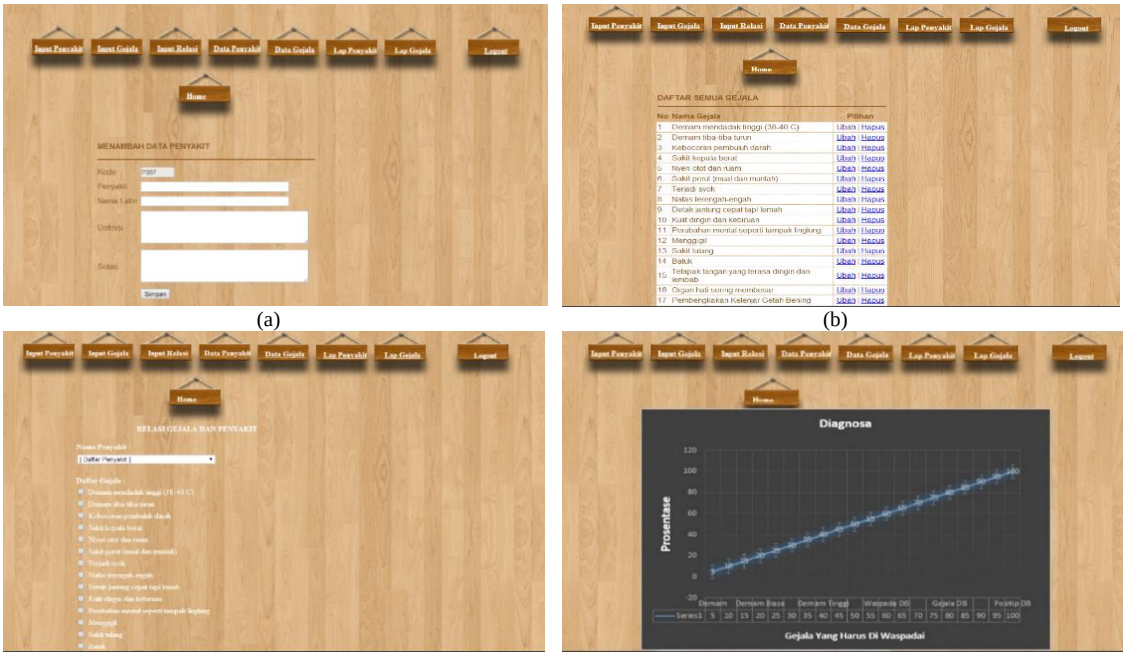

Figure 7. (a) Modules for Adding Disease Data, (b) Modules for Displaying Symptom Data, (c) Modules for Adding Relationships, (d) Modules for Diagnostic Results

The expert system was tested using the black box testing method. This method serves to assess the level of system usability which includes the level of effectiveness and efficiency of the expert system [42]. The level of effectiveness includes the overall appearance of the expert system, the colours used in each module in the expert system, and the images and materials in each module. The level of efficiency includes the function of each button or link contained in the modules in the expert system. To assess the level of

usefulness, the questionnaire was given to 76 respondents. The results of the questionnaire include five evaluation elements, namely: (a) Scenarios for access to each module in the expert system; (b) Scenarios of adding, changing and deleting disease data; (c) Scenarios for adding, changing and deleting symptom data; (d) Scenarios to see and understand the expert system diagnostic results; and (e) Scenarios to complete all activities in the expert system modules. Figure 8 shows a graph of the level of system usability from the perception of the end-user satisfaction, the level of effectiveness of the developed expert system and the level of efficiency of the expert system for diagnosing diseases caused by mosquito bites by optimizing the forward chaining method.

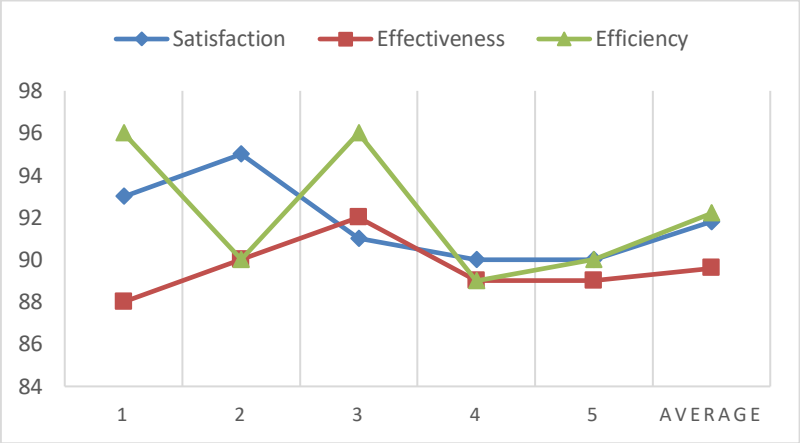

Figure 8. Usability Test Results Graph

Operation and Maintenance

At this last stage, the expert system is ready to be implemented because it has been tested in the previous stage to find out the deficiencies and improvements needed based on input from the end-user [38]. At this stage, maintenance of the expert system is also carried out if in the future the expert system undergoes further repairs that are adapted to changing circumstances [39]. The expert system for diagnosing diseases caused by mosquito bites has been made as dynamic as possible, such as having functions to add and reduce symptoms and diseases, to avoid changes to the expert system modules.

Conclusion

The forward chaining method has been successfully optimized into an expert system for diagnosing diseases caused by mosquito bites through a tracing process that begins with selecting the symptoms experienced by the patient. The reasoning process using the forward chaining method can prove the truth of the rules formed in the process of diagnosing diseases caused by mosquito bites. The expert system produces conclusions about the disease suffered by the patient and the solution for handling it. The purpose of this study was achieved, namely to prove the truth that the forward chaining method was successful in identifying the type of disease caused by mosquito bites. The waterfall method has been successfully implemented at every stage of developing an expert system to diagnose diseases caused by mosquito bites. Based on the results of system testing using the black-box testing method, the results of the questionnaire show the end-user satisfaction level of 91.8%, the effectiveness level is 89.6% and the efficiency level is 92.2%.

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