

Expert System for Asthma Diagnosis Using the Forward Chaining Method

Ismail ¹, Musyhidah ², Nurul Sukmayana ³

^{1,2,3} Lamappapoleonro University

Jl. Salotungo Soppeng Regency, Indonesia

e-mail: ¹ismail@unipoo.ac.id, ²idahmusyhidah@gmail.com, ³Sukmanurul570@gmail.com

Abstract - Asthma and respiratory disorders are one type of disease that attacks humans. Based on interviews with doctors at the Lung Clinic of Malaka Soppeng Regional Hospital, various types of asthma and respiratory disorders have many similar symptoms, some are even differentiated by only one symptom. Accuracy and sharp analysis are required for a doctor to identify the type of asthma in order to provide appropriate treatment to patients. One way to overcome the above problems is to design a rule-based system for asthma and respiratory disorders. By using facts provided by the user, the system can generate conclusions that are a representation of the forward chaining method to begin tracing existing data or facts towards a conclusion. Based on the results obtained, an expert system for diagnosing asthma and respiratory disorders can assist doctors at the Lung Clinic of Malaka Soppeng Regional Hospital. This system can provide assistance in the form of conclusions about the types of asthma and respiratory disorders as well as the implementation of care and therapy for asthma and respiratory disorder patients.

Keywords: Disease Asthma, Diagnosis disease, system expert in, Development, Forward Chaining

INTRODUCTION

Asthma is a respiratory disease typically characterized by inflammation of the lower airways in response to numerous stimuli. This abnormal condition tends to persist even when no symptoms are felt and lung function is normal. Childhood through adulthood are vulnerable periods when this disease can affect humans. However, it can also develop in all groups, including the elderly. Genetic factors, exposure to an unfavorable (polluted) environment, viral infections, socioeconomic factors such as income level, and even the presence of rodents in the home can contribute to asthma. The Patient Medical Record Information System is designed to assist healthcare providers in managing the medical record process in a structured manner, starting from the collection, recording, storage, and management of patient data. Through this system, the resulting information can be used to support faster, more accurate, and more efficient decision-making (Tahir & Ismail I, 2023).

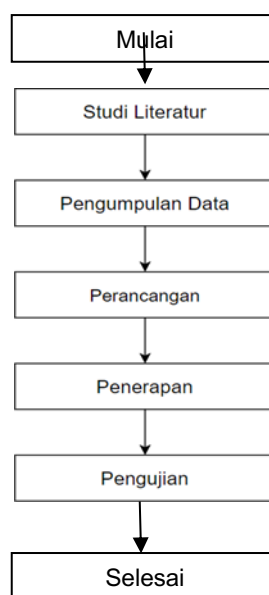
In South Sulawesi, according to data from the 2020 Basic Health Research released by the Ministry of Health of the Republic of Indonesia, the prevalence of asthma among all ages in Indonesia reached 2.4%, with South Sulawesi province among the five provinces with the highest number of asthma sufferers in Indonesia. The percentage of asthma sufferers by environment shows that urban areas contribute a greater percentage (2.6%) compared to rural areas, which are at 2.1%. Given the high percentage of asthma sufferers in Indonesia, the government has implemented several asthma control efforts by implementing a number of programs, including partnerships, counseling, diagnosis, special protection, discovery (including early detection), rapid treatment and referral, and monitoring and assessment. To ensure the smooth running of this government program, it is deemed necessary to create a web-based expert system application that can work like a specialist doctor in helping diagnose the type of asthma based on the symptoms experienced by the sufferer. The expert system is able to identify the name of the disease, its causes, and its treatment. The benefit of the research that has been conducted is that the expert system

built using the forward chaining inference method can help the people of Soppeng Regency and health workers at Malaka Soppeng Hospital in diagnosing asthma.

Based on the background of the problem that occurred, the title of the proposed research is "Web-Based Expert System for Asthma Diagnosis Using the *Forward Chaining Method* ." The use of programming languages and the addition of several new features in the research uses the PHP programming language in a web-based expert system. The research also produced several suggestions including for further research, namely by developing the system into a programming language for expert system application programming, as well as development in terms of features that will later be implemented in the research.

RESEARCH METHODS

1. Research Stages



Literature study, at this stage, scanning or searching in the form of theories obtained from various sources or books to fulfill the concepts and theories that are suitable for use. Data collection, at this stage the researcher obtains information and data from interviews, articles and journals about asthma. Design, at the design stage, the application design is carried out before coding, at which time this process can be started by creating a user interface design that can be understood by users. Implementation, at this stage is the process of implementing the design so that it can become a complete application, namely through the coding process. Testing, at this stage the testing process aims to see if there are any error or bug parts of the application, then analyzed and assessed.

2. Data Analysis

a. Planning

This stage aims to identify and understand emerging problems. Then, determine the purpose of the system and identify whether the existing problems can be resolved.

b. Analysis

At this stage, a literature study is conducted to determine which problems will be used in the system, collect the data needed for the kidney disease diagnosis expert system, and observe if there is a previously running system to lead to the new system.

c. Design

- 1) Prepare a detailed system design.
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- 2) Identify alternative system configurations.
 - 3) Evaluate alternative system configurations.
 - 4) Designing user interface.
- d. Implementation
- 1) Application loading based on system design.
 - 2) Application testing and repair (debugging).

3. System Design

a. System Flowchart

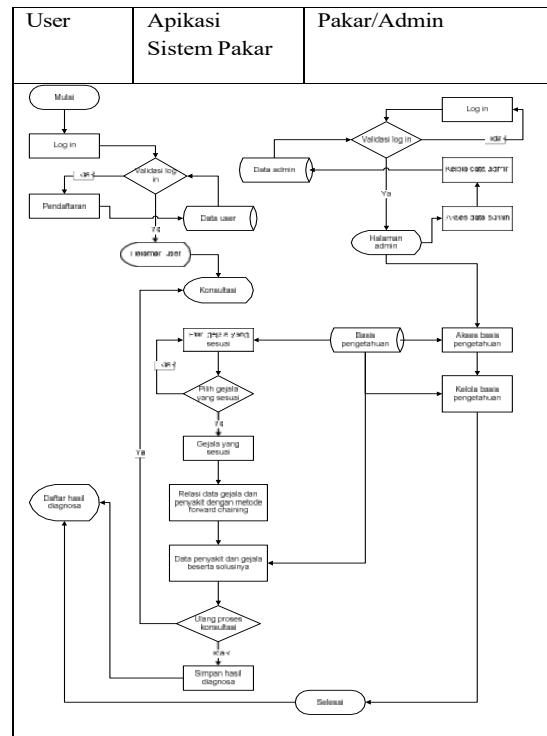
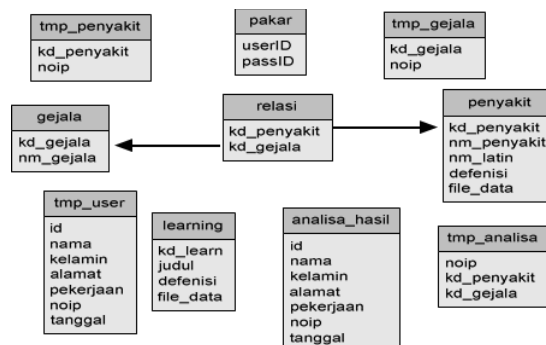


Figure 1. System Flowchart

The system flowchart begins with the patient entering their data. In the second step, the patient selects the symptoms they are experiencing. In the third step, the system calculates a formula using the forward chaining method. The output then provides a diagnosis of the patient's condition.

b. Database

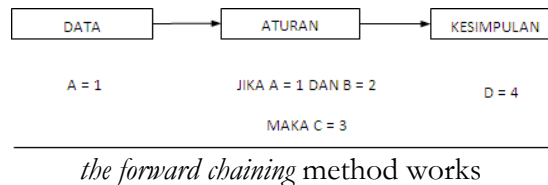


From the disease name table and the symptom table, a decision table can be created to be used as a reference in creating rules that are used to match the information entered by the user

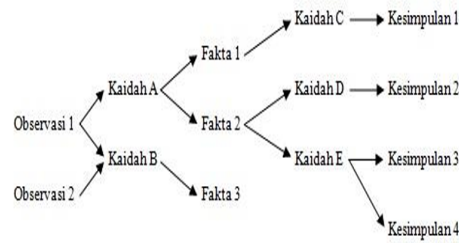
from the knowledge base.

4. Forward Chaining Method

Forward Chaining uses a set of condition-action rules. In this method, data is used to determine which rules to execute, and then those rules are executed. The process may involve adding data to working memory. The process is repeated until a result is found, demonstrating how forward chaining inference works. The following example demonstrates the use of forward chaining: IF a patient has bronchial asthma with a CF between 0.4 and 0.6, THEN administer medication.



In this approach, tracing starts with input information and then tries to draw conclusions. Forward tracing looks for facts that match the IF part of an IF-THEN rule.



Forward chaining is a reasoning method that starts from collecting facts to reach a conclusion.

- 1) Observation 1 covers several parts, namely rule A to Fact 1 and Fact 2, Fact 1 continues to Rule C and finally to Conclusion 1. Meanwhile, Fact 2 continues to Rule D and Rule E, Rule D to conclusion 2, while Rule E to conclusion 3 and conclusion 4.
- 2) Observation 2 Covers one part, namely Rule B with Fact 3.

Forward chaining is a technique A search that starts with known facts, then matches those facts against the IF part of an IF-THEN rule . If a fact matches the IF part, the rule is executed. When a rule is executed, a new fact (the THEN part) is added to the database. Each match starts from the top rule. Each rule can only be executed once. The matching process stops when there are no more rules to execute. The search methods used are *Depth-First Search* (DFS), *Breadth-First Search* (BFS), or *Best First Search*.

5. Data Model

There are 11 clinical symptoms affecting 8 diseases. Each rule consists of only one antecedent. Therefore, for each disease, the weight given to each symptom is determined by the fire strength assigned to the corresponding rule. The final disease risk level is calculated using the weighted average of each rule corresponding to that disease.

Table 1. Data Model

No	Symptom	Disease / Diagnosis
1	IF Fever	THEN Bad Asthma in the Morning
2	IF Chest pain	THEN Bad Asthma in the Morning
3	IF Cough	THEN Asthma With Allergens
4	IF Out of breath	THEN Infrequent Episodic Asthma

5	IF Attacks 3-4 times a year	THEN	Infrequent Episodic Asthma
6	IF Excess mucus production	THEN	Frequent Episodic Asthma
7	IF Cough accompanied by vomiting or nausea	THEN	Hypersecretory Asthma
8	IF Likes to sleep on the affected chest	THEN	Hypersecretory Asthma
9	IF Cough due to heavy physical exercise	THEN	Asthma Due to Physical Load
10	IF Happened at night	THEN	Chronic Asthma
50	IF Growth disorders	THEN	Atelectasis

The knowledge base that shows the relationship between symptoms and diseases is structured using the IF-THEN production rule.

6. Data Analysis

The rules used in creating an expert system based on the results of the knowledge representation presented:

Table 2. Expert System Rules

Code of Rules	Rules
R01	IF G01 <i>true</i> AND G02 <i>true</i> AND G03 <i>true</i> AND G05 <i>true</i> AND G09 <i>true</i> THEN P01
R02	IF G01 <i>true</i> AND G02 <i>true</i> AND G03 <i>true</i> AND G05 <i>true</i> AND G010 <i>true</i> THEN P02
R03	IF G01 <i>true</i> AND G02 <i>true</i> AND G03 <i>true</i> AND G05 <i>true</i> AND G011 <i>true</i> THEN P03
R04	IF G01 <i>true</i> AND G02 <i>true</i> AND G04 <i>true</i> AND G05 <i>true</i> AND G09 <i>true</i> THEN P04
R05	IF G01 <i>true</i> AND G02 <i>true</i> AND G04 <i>true</i> AND G05 <i>true</i> AND G10 <i>true</i> THEN P05
R06	IF G01 <i>true</i> AND G02 <i>true</i> AND G04 <i>true</i> AND G05 <i>true</i> AND G011 <i>true</i> THEN P06

R07	IF G03 <i>true</i> AND G06 <i>true</i> AND G07 <i>true</i> AND G08 <i>true</i> AND G09 <i>true</i> THEN P07
R08	IF G03 <i>true</i> AND G06 <i>true</i> AND G07 <i>true</i> AND G08 <i>true</i> AND G10 <i>true</i> THEN P08 <i>true</i>

There are several rules, namely 8 rules which will be the rules in the next forward chaining calculation.

RESULTS AND DISCUSSION

1. Data collection

Based on interviews with doctors at Malaka Soppeng Hospital, several illnesses whose primary symptom is shortness of breath include:

a. Bronchitis

Bronchitis is an inflammation of the bronchi (the airways leading to the lungs). Symptoms include shortness of breath, fever, chest pain, a productive cough, a cough that lasts more than two weeks, and coughing up blood.

b. Pneumonia

Pneumonia is an inflammation of the lung parenchyma distal to the terminal bronchioles, including the respiratory bronchioles and alveoli, and causes consolidation of lung tissue and impaired local gas exchange. Symptoms include shortness of breath, fever, chest pain, cough with phlegm, chest wall retraction during breathing, and recurrent upper respiratory tract infections.

c. Pulmonary tuberculosis

Pulmonary tuberculosis is a directly infectious disease caused by the TB germ, *Mycobacterium tuberculosis*. Symptoms include shortness of breath, fever, a productive cough, a cough with phlegm lasting more than two weeks, a cough accompanied by fresh blood, and weight loss.

d. Asthma

Asthma is a heterogeneous disease, always characterized by chronic inflammation of the airways. Symptoms include shortness of breath, frequent wheezing, worsening at night, shortness of breath triggered by certain factors (allergen exposure, smoke, dust, weather changes, or similar), and recurrent upper respiratory tract infections.

e. Injury to the ribs

A rib fracture is a condition that can result in broken or cracked ribs. This is a common injury that occurs due to chest trauma, such as from falls, motor vehicle accidents, or impacts during sports.

2. Forward Chaining Method Implementation Model

The forward chaining method and system functionality testing utilize black-box testing. Black-box testing is a testing method that approaches the system's visualization with the goal of observing its flow to ensure it aligns with the initial plan. Black-box testing is performed by

observing the functionality of the application being built without needing to delve into the detailed processes within it. Through this testing, any deficiencies discovered are then evaluated to produce the desired output.

a. Implementation of the forward chaining method

System testing after applying the forward chaining method is conducted by answering questions to ensure the system's diagnostic results align with the established rules. System testing is conducted three times to ensure the system delivers the desired output according to the applicable rules.

b. Example of System Implementation 1

System test 1 was conducted to determine mild chronic asthma (P04). The test was conducted by responding "Yes" to the system for symptoms associated with the mild chronic asthma rule.

Table 3. Example of Implementation Table

Name: Musyidah			
Symptom Code	Symptom Name	Yes	No
G01	Experiencing shortness of breath	✓	
G02	Having a family history of asthma (especially parents)	✓	
G03	Shortness of breath occurring in the last 6 months	✓	
G04	Last shortness of breath occurred more than 6 months ago		✓
G05	Have allergies to one or more of the following: cold temperatures/air, dust, cigarette smoke, animal hair, pollen/cotton, food	✓	
G06	Shortness of breath occurs when you are emotional or stressed.		✓
G07	Shortness of breath occurs while working		✓
G08	Have a history of lung infections		✓
G09	Feeling short of breath when breathing normally but no wheezing or "ngik-ngik" sounds can be heard from outside	✓	
G10	Making a wheezing or "ngik-ngik" sound when breathing, especially when exhaling or exhaling		✓
G11	Breathing feels difficult and short, accompanied by a loud wheezing or "whimpling" sound		✓
Diagnostic Results:			
Mild Chronic Asthma			

3. Discussion of Methods

Calculation table to determine the results of the forward chaining method application model:

Table 4. Worse Asthma in the Morning

Symptom Clinical	Which Selected
Fever	✓
Myeri on chest	✓
Breathing fast And shallow	
Happen lobe nose	
Happen cyanosis (bluish) around nose	
Temperature body around 39-40 degrees Celsius	
Congested breath	

Calculation: $\frac{2}{7} \times 100 = 28,57$

Table 5. Asthma with Allergens

Symptom Clinical	Which Selected
Cough	√
Wheezing	√
Production mucus excessive	
Breath	
Age >12 year	
ARI	

Calculation: $\frac{2}{6} \times 100 = 33,33$

Table 6. Asthma Due to Physical Load

Symptom Clinical	Which Selected
Congested breath happen 24 O'clock after operation	
Cough Because exercise physical Which heavy	
Happen in Evening day	
Age > 12 Year	
Congested breath	
Wheezing	√
Sneeze	
Cough	√
Disturbance growth	√

Calculation: $\frac{3}{9} \times 100 = 33,33$

Table 7. Chronic Asthma

Symptom Clinical	Which Selected
Wheezing	√
Production mucus excessive	
Congested breath	
Happen evening	
Age 12 Year	
Offerings breath happen 24 O'clock after operation	
Disturbance growth	√

Calculation: $\frac{2}{7} \times 100 = 28,57$

Some of the tables above are tables used to find out the results of the forward chaining method which has several selected symptoms and there are also formulas that will help with the calculation of the forward chaining method.

```
// Diagram algoritma forward chaining
private fun showResult() {
    if (checkSymptoms[0] && checkSymptoms[1] && checkSymptoms[2] && checkSymptoms[4] && checkSymptoms[8]) {
        showDiagnosticResult(rules[0].id.type, rules[0].description)
    } else if (checkSymptoms[4] && checkSymptoms[1] && checkSymptoms[2] && checkSymptoms[4] && checkSymptoms[9]) {
        showDiagnosticResult(rules[1].id.type, rules[1].description)
    } else if (checkSymptoms[0] && checkSymptoms[1] && checkSymptoms[2] && checkSymptoms[4] && checkSymptoms[10]) {
        showDiagnosticResult(rules[2].id.type, rules[2].description)
    } else if (checkSymptoms[0] && checkSymptoms[1] && checkSymptoms[3] && checkSymptoms[4] && checkSymptoms[8]) {
        showDiagnosticResult(rules[3].id.type, rules[3].description)
    } else if (checkSymptoms[0] && checkSymptoms[1] && checkSymptoms[3] && checkSymptoms[4] && checkSymptoms[9]) {
        showDiagnosticResult(rules[4].id.type, rules[4].description)
    } else if (checkSymptoms[0] && checkSymptoms[1] && checkSymptoms[3] && checkSymptoms[4] && checkSymptoms[10]) {
        showDiagnosticResult(rules[5].id.type, rules[5].description)
    } else if (checkSymptoms[2] && checkSymptoms[5] && checkSymptoms[6] && checkSymptoms[7] && checkSymptoms[8]) {
        showDiagnosticResult(rules[6].id.type, rules[6].description)
    } else if (checkSymptoms[2] && checkSymptoms[5] && checkSymptoms[6] && checkSymptoms[7] && checkSymptoms[9]) {
        showDiagnosticResult(rules[7].id.type, rules[7].description)
    } else if (checkSymptoms[2] && checkSymptoms[5] && checkSymptoms[6] && checkSymptoms[7] && checkSymptoms[10]) {
        showDiagnosticResult(rules[8].id.type, rules[8].description)
    } else if (checkSymptoms[0] && checkSymptoms[1] && checkSymptoms[2] && checkSymptoms[3] && checkSymptoms[4] &&
        showDiagnosticResult(rules[9].id.type, rules[9].description)
    } else {
        showDiagnosticResult("Penyakit tidak ditemukan", null)
    }
}
```

Figure 2. Source code for implementing the forward chaining method

The showResult() method is used to implement the forward chaining method in this study. This method contains steps that will produce output in the form of the type of disease suffered by the user based on the symptoms entered during the consultation session. The value of the checkSymptoms property is a list of Boolean data (true and false) that will add a true value when the user presses the "yes" button and a false value when the user presses the "no" button.

Example case: If the checkSymptoms value at index 0 (symptom G01) = true, index 1 (symptom G02) = true, index 2 (symptom G03) = true, index 4 (symptom G05) = true, and index 8 (symptom G09) = true, then the diagnosis results will show a certain type of disease along with its description according to the specified rule. Based on the example above, if there is one or more indexes that do not match (value false) then the system will check again whether there are other rules that match the input or not. If not, the system will display a message that the disease was not found.

4. System Implementation

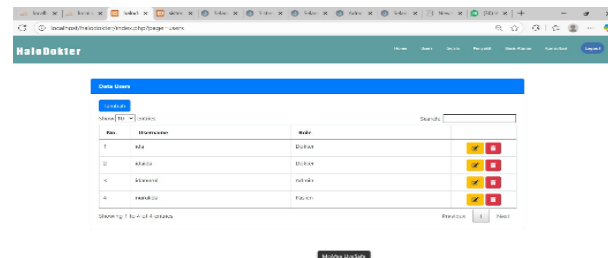


Figure 3. User Page

The image above shows the main visitor page of an expert system program for diagnosing asthma. The display contains a user image.

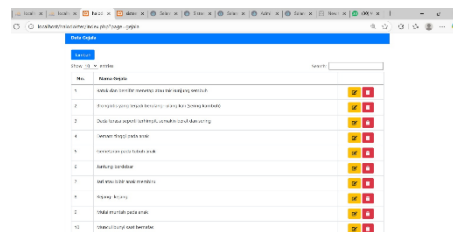


Figure 4. Symptom Data Page

On the symptom data page display, there is an add symptom data menu where this menu inputs a list of symptoms currently being experienced and then processes it so that you can get the appropriate results on the next page list.

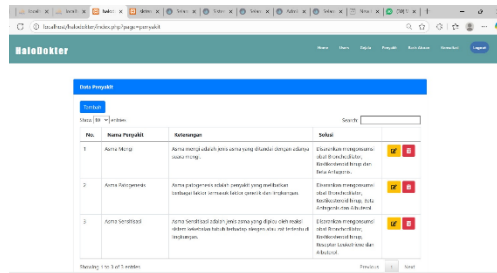


Figure 5. Disease Data Page

On the disease data page display, there is an add disease data menu where this menu inputs a list of diseases currently being experienced and then processes it so that you can get the appropriate results on the next page list.

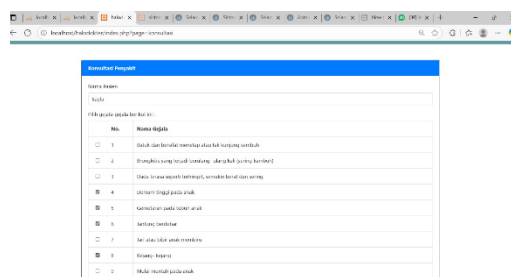


Figure 6. Consultation data page

On this consultation data page display, this is a display to determine the final results in the expert system for diagnosing asthma.

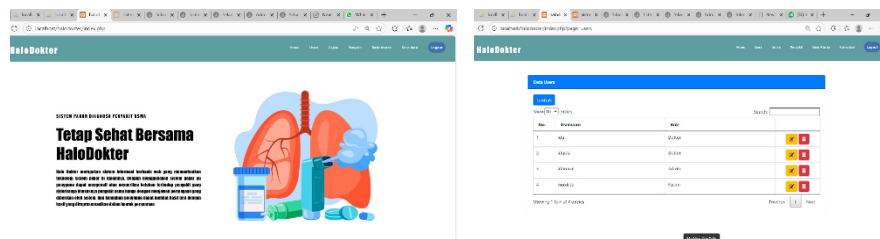


Figure 7. Web Design

The dashboard page is the initial display before entering the login page that will be accessed by the user. The user page is the display that will be accessed when the user wants to visit the menu on the expert system created to diagnose asthma.

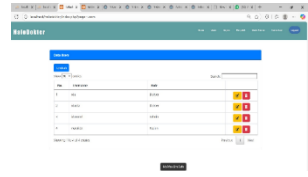
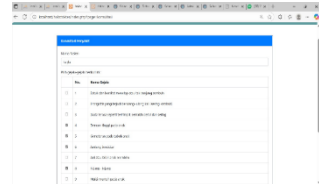
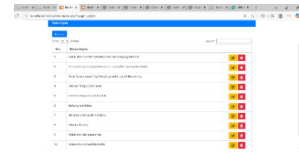
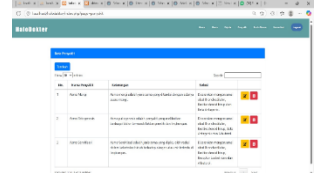
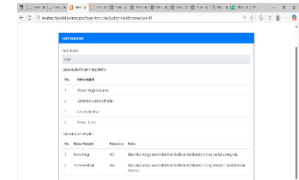
5. System Testing

a. Blackbox Testing

System testing using the forward chaining method is designed to diagnose asthma. This system testing applies black box testing, which specifically focuses on the functional aspects of the software and evaluates the decisions generated by the software.

Table 8. Blackbox Testing

Data	Results	Response	Conclusion
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User Menu	The system displays the User menu page.	As Expected	Succeed 
Consultation Menu	The system displays the consultation menu page.	As Expected	Succeed 
Symptoms Menu	The system displays the symptoms menu page.	As Expected	Succeed 
Disease Menu	The system displays the disease menu page.	As Expected	Succeed 
Diagnostic Consultation Results	The system displays the diagnostic consultation results page.	As Expected	Succeed 

b. Beta Testing

Beta testing is conducted by end users without the presence of developers. Users try the software in a real-world operational environment, then record any issues and report them to developers for further improvement.

No	Test Case	Skenario Pengguna	Feedback dari End User	Status
1	Akses Sistem	Pengguna mencoba mengakses sistem di berbagai perangkat	Sistem dapat digunakan di <i>mobile</i> dan dengan baik	Berhasil
2	Kemudahan Penggunaan	Pengguna mencoba memahami cara kerja sistem tanpa panduan	Sebagian benar pengguna dapat memahami cara kerja sistem dengan mudah	Berhasil
3	Akurasi Diagnosis	Pengguna membandingkan hasil diagnosis dengan kondisi nyata tanaman	Hasil diagnosis sesuai dengan gejala yang diinput	Berhasil

CONCLUSION

Based on the discussion and explanations in the previous chapters, it can be concluded that a website-based expert system application can be designed and built to diagnose asthma symptoms and determine the severity of the disease. Using the forward chaining method, the expert system application can generate an asthma diagnosis based on the severity of the symptoms through

calculations of the symptoms experienced. Data about asthma on this expert system website can be easily added and updated.

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