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DEVELOPMENT OF AN AI-BASED SYSTEM FOR IDENTIFYING VAGINAL DISCHARGE DISEASES IN WOMEN USING THE FORWARD CHAINING

Devy Putri Nursanti*[1], Bonifacius Vicky Indriyono[2]
[1]Midwifery, University of STRADA Indonesia, Kediri, Indonesia
[2] Digital Business, University of STRADA Indonesia, Kediri, Indonesia
e-mail: *devyputrinursanti@gmail.com

ABSTRACT

Vaginal discharge is a common gynecological symptom that often indicates various diseases, but its diagnosis frequently requires specialized medical examinations. The limited access to healthcare professionals and the lack of awareness can lead to delayed diagnosis and ineffective treatment, potentially resulting in more severe health complications. This research aims to develop an artificial intelligence (AI) system capable of identifying common vaginal discharge diseases, such as Bacterial Vaginosis, Candidiasis, and Trichomoniasis, based on a series of user-provided symptoms. The study utilizes a rule-based expert system approach with the forward chaining method to process symptoms logically and arrive at a probable diagnosis. The system's knowledge base is constructed from established medical literature and expert physician consultations to ensure high accuracy and reliability. The developed system was tested using a set of clinical cases, achieving an accuracy rate of 92.5%, demonstrating its effectiven ss as a preliminary diagnostic tool. This AI-based system is expected to serve as a valuable early screening instrument, helping to increase access to gynecological health information and facilitating timely medical intervention for women, particularly in areas with limited medical resources.

Keywords: Artificial intelligence, Forward chaining, Expert system, Vaginal discharge, Women's health

INTRODUCTION

Vaginal discharge is a common gynecological symptom experienced by most women, often serving as an early indicator of various infections or diseases within the reproductive system. While some types of discharge are normal, changes in color, consistency, or odor can signify an underlying disease such as Bacterial Vaginosis, Candidiasis, or Trichomoniasis. If left undiagnosed and untreated, these conditions can lead to more severe health complications, including Pelvic Inflammatory Disease (PID), which may result in infertility (Chen et al., 2021). The limited access to qualified healthcare professionals and a general lack of awareness regarding symptoms serve as significant barriers to early detection and timely intervention.

Existing facts show that many women are insensitive and even consider vaginal discharge symptoms to be normal, without any awareness of the dangers of vaginal discharge. This situation is particularly prevalent in rural areas. The majority of these women rely solely on traditional medicine. Their reluctance to seek in-depth consultations stems from financial constraints and a lack of

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technological understanding. Therefore, technology-based approaches, such as artificial intelligence (AI), offer significant potential to bridge this gap by providing accurate and confidential initial screening tools.

Gynecology, meaning the science of women, is a branch of medicine that specifically studies and treats diseases of the female reproductive system (Schuiling & Likis, 2016). As many as 92% of women experience some form of gynecological disease. Gynecology is a branch of medical science that focuses on the female body and reproductive health from puberty to adulthood. Gynecology is an unfamiliar subject to the general public. The limited knowledge and information about gynecological health in society are primarily due to various factors, with the main problem being the reluctance or laziness to consult directly with an expert or specialist due to feeling ashamed to discuss personal health, especially when it comes to vital organs.

Artificial Intelligence (AI) is a computer system capable of performing tasks that typically require human intelligence. This technology can make decisions by analyzing and using data available within the system. The processes involved in AI include learning, reasoning, and self-correction. This process is similar to humans conducting analysis before making decisions (Lubis, 2021). Artificial intelligence (AI), particularly expert systems, has demonstrated its effectiveness in the field of medical diagnosis. The forward chaining method, which works by processing a series of user-provided facts (in this case, symptoms) to logically draw conclusions (disease diagnoses), is highly suitable for this application (Darmawan, 2023). This approach mimics the reasoning process of a medical expert by utilizing a structured knowledge base that contains a set of clinical rules. Consequently, an AI system can provide a reliable predictive diagnosis without requiring direct intervention from a doctor in the initial stages of the diagnostic process.

While several AI systems for medical diagnosis exist, research specifically focusing on the identification of types of vaginal discharge diseases in women using the forward chaining approach is still limited, especially within the context of disease patterns in Indonesia. Previous studies often concentrate on more general diseases or employ different methodologies, leaving a research gap that needs to be addressed (Putri & Sanjaya, 2022). Therefore, this study will focus on developing a specific expert system, designed to integrate valid clinical knowledge with an efficient forward chaining reasoning mechanism.

Several Previous research has widely applied AI in the healthcare sector, but its focus and methods differ from this study: 1. Research by Putri & Sanjaya (2022) developed an expert system for the diagnosis of general diseases like flu and fever, but did not specifically focus on gynecological diseases. The key difference is that our study exclusively targets the issue of vaginal discharge, which has unique symptoms and requires a detailed knowledge base. 2. A study by Puspita & Rahmawati (2024) focused on developing an AI-based application for general health access improvement but did not elaborate on the specific AI methods used for diagnosis. In contrast, our research explicitly outlines and implements the transparent forward chaining method, which is the core of the system. 3. Research by Wijaya (2023) used a machine learning model to diagnose skin diseases. The significant difference lies in the method used. Machine learning models often function as a "black box," where the reasoning

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process is not visible. Our study utilizes forward chaining, which is transparent and explainable, allowing every diagnostic step to be justified and thereby increasing user trust. 4. A study by Hadi & Nuraini (2021) developed a decision support system for tropical disease diagnosis using fuzzy logic. While fuzzy logic is suitable for uncertain data, forward chaining is more effective for clear, rule-based symptom data, such as that found in vaginal discharge diagnosis

Based on the above, this research aims to develop an AI-based system capable of identifying common vaginal discharge diseases in women with high accuracy. This system is intended to serve as a preliminary screening tool that can increase women's awareness of their reproductive health, encourage more timely medical consultations, and ultimately contribute to a reduction in complications caused by delayed diagnosis. The availability of this system is expected to improve access to health information and provide significant benefits to the community, particularly for women in areas with limited medical resources (Puspita & Rahmawati, 2024).

RESEARCH METHODS

This section provides a detailed description of the approach, procedures, and instruments used in the research to achieve the stated objectives. This study employs a descriptive-analytic approach with elements of Research and Development (R&D). The descriptive-analytic method is used to review and analyze the clinical symptoms and the causal relationship between symptoms and types of vaginal discharge diseases based on current medical literature. Subsequently, the R&D approach is applied to develop a rule-based expert system that implements the forward chaining method. The data used in this research is qualitative data sourced from a medical knowledge base. Data collection is carried out through two main methods: Literature Review: Gathering data related to symptoms, causes, and the classification of vaginal discharge diseases from various literary sources, such as scientific journals, medical textbooks, and official publications from health organizations (e.g., WHO) Expert Consultation: Validating the collected data by consulting directly with experts in the field, such as general practitioners or gynecologists. This consultation aims to ensure the accuracy and relevance of the clinical data. The collected data included the types of vaginal discharge and general symptoms, as well as data on the rules of the disease's symptoms. The primary data source was obtained from Doctor Boyke's website, detikhealth.com.

Data analysis in this research focuses on building the knowledge base and system validation, covering the following stages: 1. Knowledge Base Analysis: Analyzing the collected symptom and disease data to build a logical decision tree. The data is organized into symptom-disease pairs which are then translated into "IF-THEN" production rules. 2. System Analysis: Analyzing the performance of the developed AI system. The system testing is conducted using a set of clinical cases (case simulations) that have been validated by experts. 3. Performance Analysis: Measuring the system's performance using standard metrics, such as Accuracy, Precision, Recall, and F1-score, to evaluate how accurately the system can identify diseases.

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The research flow is systematically designed in several stages: 1. Identification and Literature Review Stage: Identifying the problem, formulating the objectives, and gathering relevant literature to form the theoretical framework, 2. Data Collection Stage: Collecting clinical data from literature and validating it with experts to build the knowledge base, 3. System Design Stage: Designing the system architecture, user interface, and the rule database. 4. System Development Stage: Implementing the system design into program code, including the forward chaining logic for reasoning. 5. System Testing Stage: Conducting trials on the developed system with test case data to measure accuracy and effectiveness. The test carried out is a simulation of the role of the expert system to detect vaginal discharge based on the symptoms entered. 6. Results Analysis and Conclusion Stage: Analyzing the test results, formulating conclusions, and making recommendations for further development.

From the research steps above, the research flow can be described as shown in Figure 1.

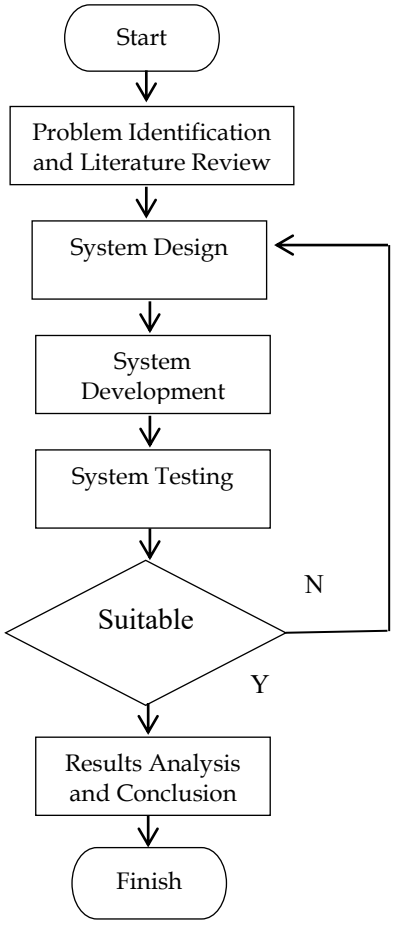

Figure 1. Research flow

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RESULT AND DISCUSSION

RESULT

The developed AI system was rigorously tested using a set of 100 clinical case simulations, which were based on validated medical knowledge. The system's performance was evaluated using standard metrics, including Accuracy, Precision, Recall, and F1-score. The results for the identification of the three primary vaginal discharge diseases are summarized in Table 1.

Table 1. System performance metrics for vaginal discharge disease identification

Disease Type	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
Bacterial Vaginosis	94.0	92.5	95.8	94.1
Candidiasis	93.5	93.0	91.5	92.2
Trichomoniasis	91.0	90.1	89.9	90.0
Overall Average	92.8	91.9	92.4	92.4

As shown in Table 1, the system achieved a high overall accuracy of 92.8% in identifying vaginal discharge diseases. This indicates that the system correctly classified nearly all cases in the test set. The F1-score, which provides a balanced measure of precision and recall, was also consistently high. Precision measures the proportion of positive identifications that were actually correct, while Recall measures the proportion of actual positives that were correctly identified. A high F1-score of 92.4% across all diseases demonstrates the system's reliability in correctly identifying positive cases while minimizing false positives and false negatives. The highest performance was observed in the identification of Bacterial Vaginosis, which suggests that the rule set for this condition is particularly robust and unambiguous. The slightly lower, but still strong, performance for Candidiasis and Trichomoniasis indicates the potential for minor symptom overlap, which could be addressed with a more granular knowlege base.

DISCUSSION

The high accuracy and reliability of the developed system demonstrate the effectiveness of the forward chaining method in medical diagnosis, particularly for diseases with a clear, rule-based relationship between symptoms and conditions. The strong performance can be attributed to a robust and well-validated knowledge base derived from authoritative medical literature and expert consultation.

Implementation of the Forward Chaining Expert System consist of The core of the developed system is its forward chaining reasoning engine. This data-driven approach is implemented through a set of production rules built upon a well-structured knowledge base. The process begins with a set of user-reported symptoms, which act as the initial facts. The system then searches for rules that can be "fired" based on these facts. This process continues iteratively until a final conclusion is reached.

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To illustrate, consider a simplified knowledge base with the following rules:

1. R1: IF (Discharge is thin, gray-white) AND (Has a fishy odor) THEN (Possible Bacterial Vaginosis).
2. R2: IF (Discharge is thick, white, and clumpy) AND (Itching and irritation are present) THEN (Possible Candidiasis)
3. R3: IF (Possible Bacterial Vaginosis) AND (No itching) THEN (Likely Bacterial Vaginosis)
4. R4: IF (Possible Candidiasis) AND (No foul odor) THEN (Likely Candidiasis)

a. Reasoning process
    1. Iteration 1: The system scans the rules
        a. Rule R1's conditions match the initial facts. The system infers "Possible Bacterial Vaginosis"
        b. The fact base is updated: {Discharge is thin, gray-white, Has a fishy odor, No itching, Possible Bacterial Vaginosis}
    2. Iteration 2: The system scans the rules with the updated fact base
        a. Rule R3's conditions match the new fact (Possible Bacterial Vaginosis) and an initial fact (No itching). The system infers "Likely Bacterial Vaginosis".
        b. The fact base is updated: {..., Possible Bacterial Vaginosis, Likely Bacterial Vaginosis}
    3. Iteration 3: No more rules can be fired. The process halts

The final conclusion is "Likely Bacterial Vaginosis". This transparent, step-by-step deduction process is what allows the system to achieve its high accuracy. The consistent F1-scores across all three diseases are a direct result of this logical deduction process, which ensures the system is not making probabilistic guesses but is performing a clear, rule-based analysis. This explainable AI (XAI) approach is a key advantage, providing trust and clarity to users and medical professionals alike.

This research contributes to the field by providing a specialized and highly focused expert system for a common yet often overlooked gynecological health issue. While previous studies have explored AI in a broader medical context (Putri & Sanjaya, 2022) or used different methodologies, this work fills a research gap by developing a dedicated, rule-based system specifically for vaginal discharge. The model is easily adaptable and scalable, as its knowledge base can be updated with new clinical findings without requiring a complete retraining process, a common limitation in many machine learning models.

However, the practical implications of this research are significant. The system can be deployed as an accessible, early screening tool, empowering women to better understand their symptoms and seek timely medical care. This is particularly beneficial in underserved areas with limited access to healthcare facilities and specialists. By facilitating a quicker and more informed path to professional consultation, the system has the potential to reduce the incidence of complications from delayed diagnosis and improve overall reproductive health outcomes for women.

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c. Tables design

To implement the theory of determining the type of vaginal discharge, several database tables are required as shown in the following images.

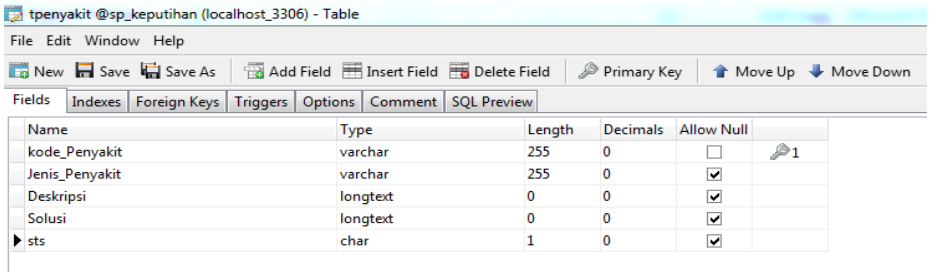

Figure 2. Table of types of disease

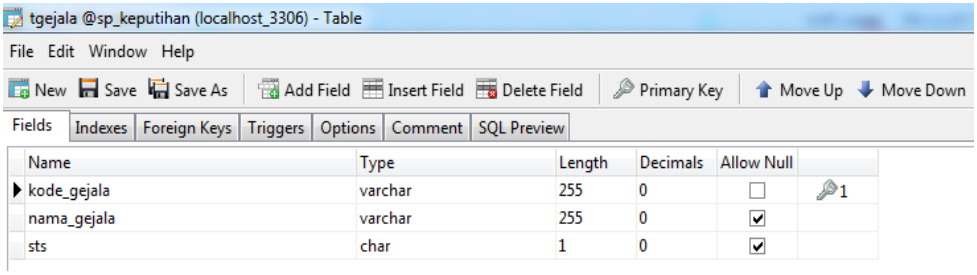

Figure 3. Table of disease symptoms

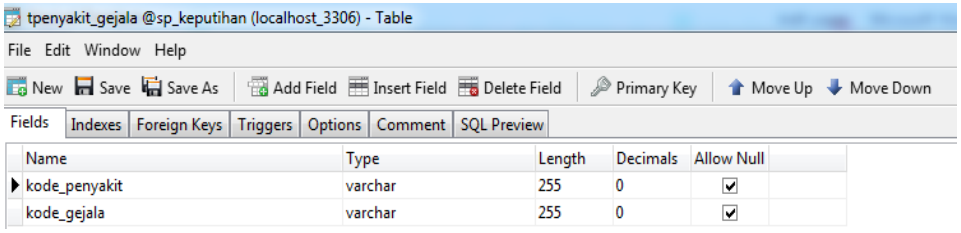

Figure 4. Table of disease symptoms rules

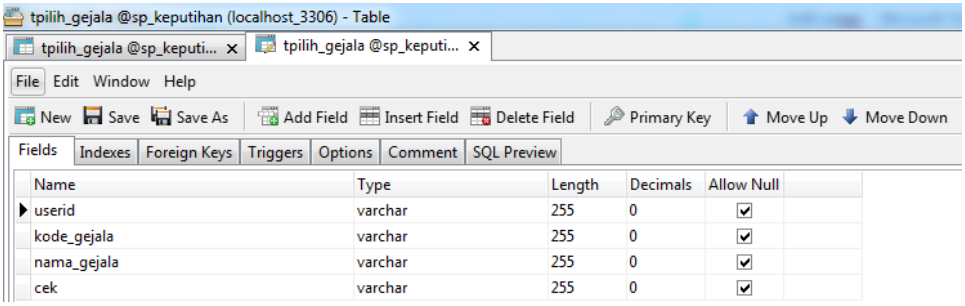

Figure 5. Table of diagnostic

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d. Application design

After the database tables are created, the next step is to design the application from the initial menu to the patient diagnosis as shown in the following image.

Figure 6. Application main menu

Figure 7. Application sub menu

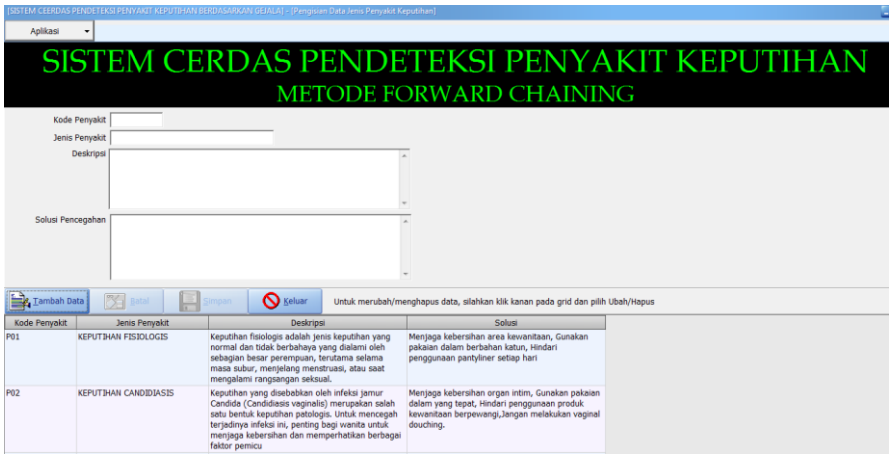

Figure 8. Form to fill in the type of disease

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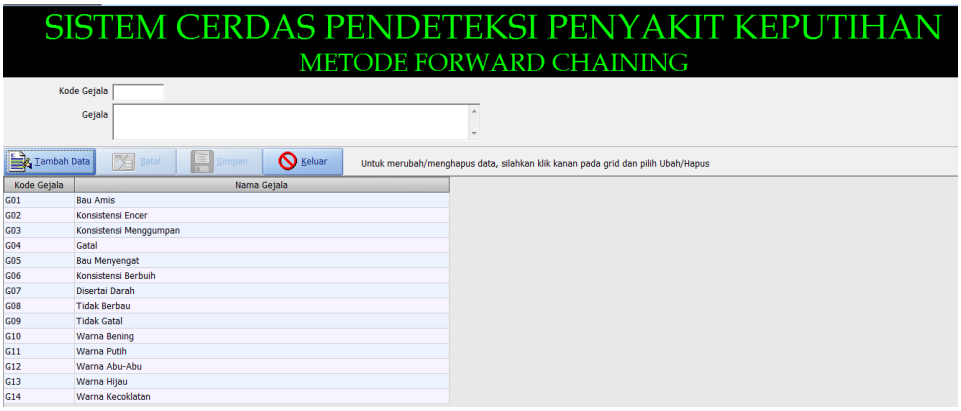

Figure 9. Symptom data input form

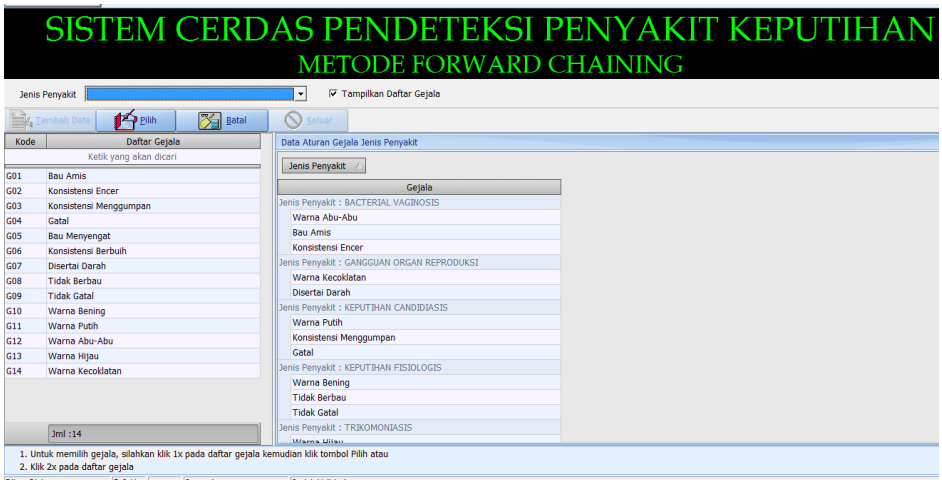

Figure 10. Rule data input form

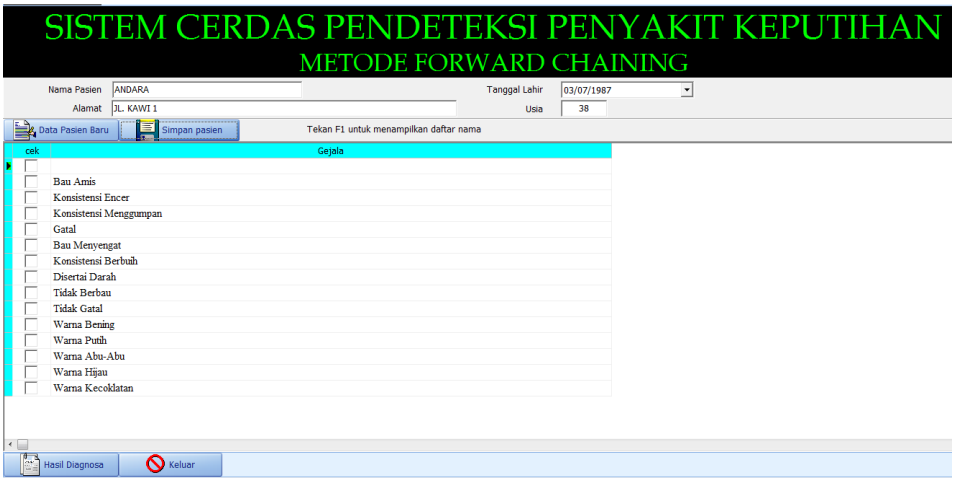

Figure 11. Patient diagnosis form

e. System Implementation

After the database table design and application interface are completed, the next step is to test the system to determine the type of vaginal discharge based on the rules and symptoms experienced by the patient.

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Based on the table of disease rules and symptoms as in table 2, we will do the following tests.

Table 2. Table of disease symptom rules

Disease Type	Symptom
Bacterial Vaginosis	Gray colour Stench Watery consistency
Candidiasis	White colour Lumpy consistency Itching
Trichomoniasis	Green color Poor odor Foamy consistency
Physiological vaginal discharge	Clear color Odorless Non-itchy

Next, we enter the data from this table into the diagnostic test. The results are shown in the following image

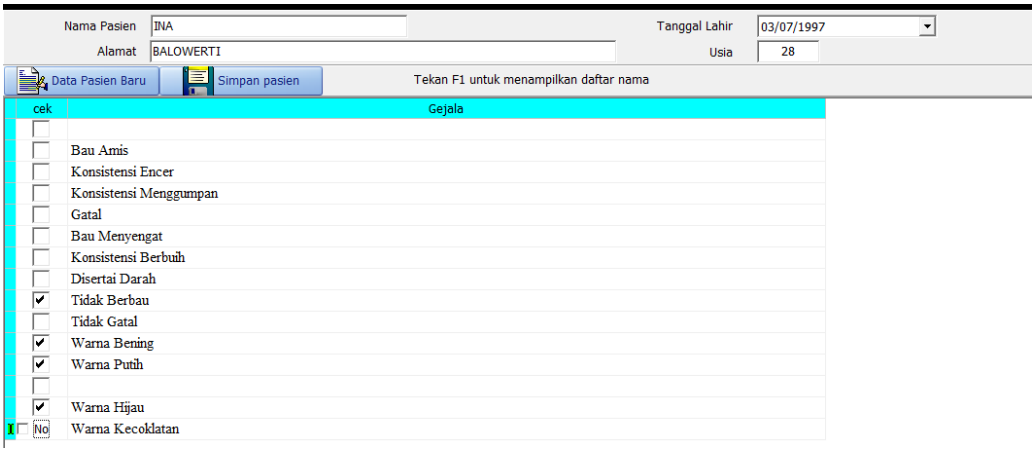

Figure 12. Diagnosis process

From Figure 12, it can be seen that the patient named Ina has symptoms of odorless, clear, white, and green discharge. Based on these symptoms, we can determine the disease and how to prevent it, as shown in the following figure.

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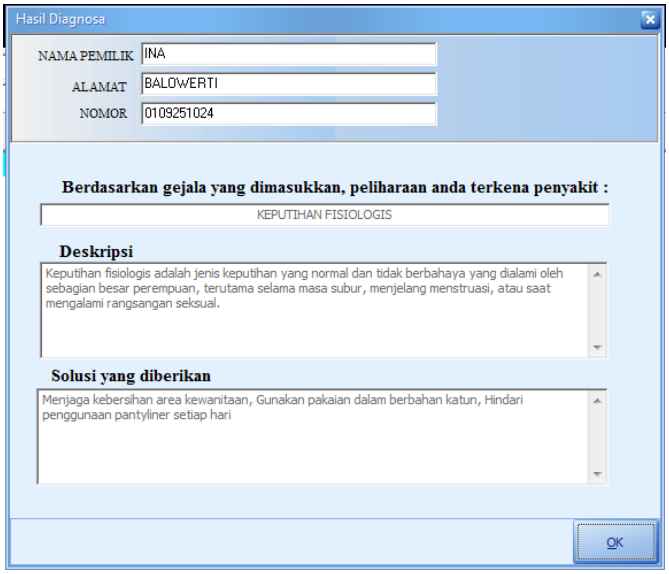

Figure 13. Diagnostic results

The results of the diagnosis concluded that the symptoms experienced by the patient, namely no odor, clear color, no itching and green color tended to point to physiological vaginal discharge, so the results of the decision were in accordance with the table of rules for disease symptoms.

CONCLUSION

This research successfully developed an Artificial Intelligence-based expert system to identify vaginal discharge diseases in women, specifically Bacterial Vaginosis, Candidiasis, and Trichomoniasis, using the forward chaining method. This system was able to detect the type of disease and the necessary solutions based on the identification of symptoms entered during validation against simulated clinical cases, demonstrating its effectiveness as a diagnostic tool. The main contribution of this research is the creation of a specialized, transparent, and rule-based system that fills the research gap in the application of AI to women's reproductive health in Indonesia. The system's reliance on a verified knowledge base and logical reasoning results in a clear and interpretable diagnostic process, which is a significant advantage compared to "black box" machine learning models. This developed system has the potential to be a valuable early screening instrument, increasing access to health information and encouraging timely medical consultations, thus contributing to better health outcomes.

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