Available online at https://ejournal.almaata.ac.id/index.php/IJUBI
Indonesian Journal of Business Intelligence
Volume 8 | Issue 1 | June (2025)
ISSN 2621-3915 (PRINT), ISSN 2621-3923 (ONLINE), Published by **Alma Ata University Press**

IJUBI
Indonesian Journal
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Business Intelligence

AUTOMATED ACNE TYPE IDENTIFICATION THROUGH FORWARD CHAINING APPROACH

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Article history: *Received: 4 March 2025; Revised: 17 June 2025; Accepted: 30 June*

Abstract

Acne is a common dermatological issue that poses both physical and psychological challenges. However, timely and accessible diagnosis remains limited, particularly in low-resource settings where access to dermatologists is constrained. To address this gap, this study developed an AI-powered online consultation system that utilizes a forward chaining expert system to identify acne types based on user-reported symptoms, including severity, location, and appearance. The knowledge base was constructed through observation, literature review, and expert interviews to ensure clinical relevance. Developed using a prototype model, the system underwent black-box testing and a System Usability Scale (SUS) evaluation, achieving a high SUS score of 86.5, which indicates strong user acceptance. By enabling real-time, user-centric diagnostics and personalized treatment recommendations, this system demonstrates the potential of AI to enhance the accessibility and accuracy of dermatological care, especially in underserved areas.

Keywords: *Acne Type Identification, Forward Chaining, Expert System, Healthcare, Artificial Intelligence.*

Abstrak

Jerawat adalah masalah dermatologis yang umum dan menimbulkan tantangan baik secara fisik maupun psikologis. Namun, diagnosis yang tepat waktu dan mudah diakses masih terbatas, terutama di daerah dengan sumber daya terbatas di mana akses ke dokter kulit terbatas. Untuk mengatasi kesenjangan ini, studi ini mengembangkan sistem konsultasi online berbasis kecerdasan buatan (AI) yang menggunakan sistem pakar *forward chaining* untuk mengidentifikasi jenis jerawat berdasarkan gejala yang dilaporkan pengguna, termasuk tingkat keparahan, lokasi, dan penampilan. Basis pengetahuan dibangun melalui observasi, tinjauan literatur, dan wawancara ahli untuk memastikan relevansi klinis. Dikembangkan menggunakan model prototipe, sistem ini menjalani pengujian *black-box* dan evaluasi *System Usability Scale* (SUS), dengan skor SUS tinggi sebesar 86,5, yang menunjukkan penerimaan pengguna yang kuat. Dengan memfasilitasi diagnosis real-time yang berpusat pada pengguna dan rekomendasi pengobatan yang dipersonalisasi, sistem ini menunjukkan potensi AI untuk meningkatkan aksesibilitas dan akurasi perawatan dermatologis, terutama di daerah yang kurang terlayani.

Kata Kunci: *Identifikasi Jenis Jerawat, Forward Chaining, Sistem Pakar, Kesehatan, Kecerdasan Buatan.*

Introduction

Acne is a prevalent inflammatory skin condition that affects various parts of the body, including the face, neck, chest, and back. While not considered life-threatening, acne can often lead to permanent scarring, making it difficult to restore the skin's original appearance. Beyond its physical manifestation, acne can also have profound psychological consequences, significantly impacting an individual's self-esteem and mental well-being. Despite being a non-fatal condition, acne is a highly disruptive and distressing issue for many people, both physically and emotionally [1].

This widespread condition is not confined to any specific age group but is particularly common among adolescents, with hormonal changes being a primary trigger for the onset of acne vulgaris [2]. However, the development of acne can be influenced by numerous factors, including dietary habits, physical activity, cosmetics, stress, environmental conditions, and even genetics. The complex nature of acne's causes makes it challenging to manage, further exacerbating its impact on individuals, especially teenagers and young adults.

The growing presence of technology in our daily lives has transformed multiple sectors, including healthcare. Technology has revolutionized medical research, simplified healthcare processes, and improved diagnostic accuracy [3]. In particular, the rise of online consultation services offers patients an accessible platform to seek professional advice and receive diagnoses without geographical constraints [4]. This shift towards digital healthcare is essential, especially in an era where convenience and accessibility are critical in managing public health issues.

Despite these advances, traditional healthcare systems may still be slow to address the widespread need for timely acne diagnosis and treatment [5]. Many individuals lack immediate access to dermatologists, and increasing demand for healthcare services frequently causes delays. Unfortunately, untreated acne can worsen over time, leading to more serious physical and psychological consequences. Therefore, there is an urgent need to develop alternative methods that offer faster and more efficient access to acne diagnosis and management.

This research aims to address these concerns by utilizing Artificial Intelligence (AI), specifically an expert system powered by forward chaining, to provide an innovative solution for acne diagnosis. AI has already demonstrated its potential in various industries, and its application in healthcare, particularly dermatological conditions like acne, could be transformative [6]. The expert system stores dermatologists' knowledge and expertise, enabling it to diagnose acne based on user input. This AI-driven approach offers a significant advantage in terms of speed, accessibility, and accuracy, making it a crucial development for acne patients.

One of the main advantages of forward chaining is its ability to process information sequentially, moving from available facts toward logical conclusions [7]. This method enables the system to accurately identify acne types based on user-provided data, providing a more personalized and efficient solution than conventional online consultations. As a result, the system's approach can bridge the gap between patients and dermatologists, delivering real-time, reliable diagnoses and recommendations that could otherwise take weeks to obtain in a traditional consultation setting [8].

Moreover, including product recommendations within this system is crucial in addressing the diverse needs of individuals dealing with acne. Not all acne is the same; different types require different treatments, and the wrong product can sometimes exacerbate the problem [9]. By incorporating tailored product recommendations, this system identifies the type of acne. It guides users toward appropriate treatments and skincare products, thereby reducing the trial-and-error process that many individuals undergo when managing acne.

The urgency of this research is also highlighted by the fact that acne is a leading cause of distress for many individuals, particularly among younger populations. The psychological toll of acne, including its impact on self-confidence and social interactions, can significantly affect an individual's quality of life. The timely identification and appropriate treatment of acne can mitigate these effects and prevent long-term physical and emotional consequences [10]. By developing a system that can quickly and accurately identify acne types and recommend suitable treatments, this research can play a crucial role in alleviating the burden of acne on individuals [11].

Unlike prior AI-based dermatology tools, which predominantly rely on image-based analysis through deep learning models [11], [12], [13], this study introduces a novel rule-based expert system that emphasizes symptom-driven diagnosis using a forward chaining inference method. This approach enables accurate acne classification even in environments where image capture quality may be inconsistent or unavailable, such as in low-bandwidth or resource-constrained settings. Moreover, the incorporation of personalized product recommendations based on expert knowledge adds practical value beyond diagnosis, supporting direct self-care for users.

Recent advances in AI-based dermatology have underscored the importance of not only diagnostic accuracy but also fairness and transparency. Schaekermann et al. [14] proposed the HEAL framework to evaluate the equity of AI model performance across subpopulations, applying it to a dermatology use case that includes acne and other skin conditions. Their results emphasized the importance of ensuring that AI systems do not exacerbate health disparities. Furthermore, Stutz et al. [15] addressed the issue of uncertainty in medical AI evaluation by introducing a probabilistic framework that captures expert disagreement and ground truth ambiguity. These studies underscore the necessity of interpretable and accessible systems—such as the rule-based forward chaining approach in this research—for supporting early and equitable dermatological screening.

Additionally, implementing AI-driven systems for acne diagnosis offers a scalable solution to an ever-growing global problem [12]. Acne affects millions of people worldwide, and many do not have the luxury of immediate access to medical professionals. With the increasing reliance on smartphones and the internet, an online consultation system powered by AI has the potential to reach a broad audience, particularly in underserved or remote areas. This ability to provide accessible, affordable, and timely care is essential in addressing a widespread health issue.

This research represents a significant leap toward integrating AI and healthcare, which could pave the way for future innovations in medical diagnostics [13]. As AI technology advances, the potential applications for diagnosing and treating various conditions, including acne, are vast [16]. By exploring and refining this technology for acne diagnosis, this research could contribute to the development of similar systems for other dermatological conditions, thereby broadening its impact.

The urgency of this research is underscored by the widespread prevalence of acne, its physical and psychological impacts, and the potential for AI-driven solutions to provide timely and effective care. By developing an online consultation system that uses AI and forward chaining for acne diagnosis, this research aims to improve accessibility, accuracy, and convenience for individuals seeking effective acne treatment. Integrating personalized product recommendations further enhances the system's value, ensuring individuals receive appropriate care tailored to their needs. Given the growing demand for efficient healthcare solutions, the findings of this study could be a significant step forward in the evolution of digital health and AI-assisted diagnostics.

Method

In this research, the system development approach employed is the prototype model. This method is designed to facilitate the iterative creation of the system, where each component is developed and integrated into a working model [17]. The system is continually evaluated, enabling improvements and refinements at each stage of development. This iterative process helps to ensure that the final system meets the users' needs and expectations, making it a practical approach for developing complex systems.

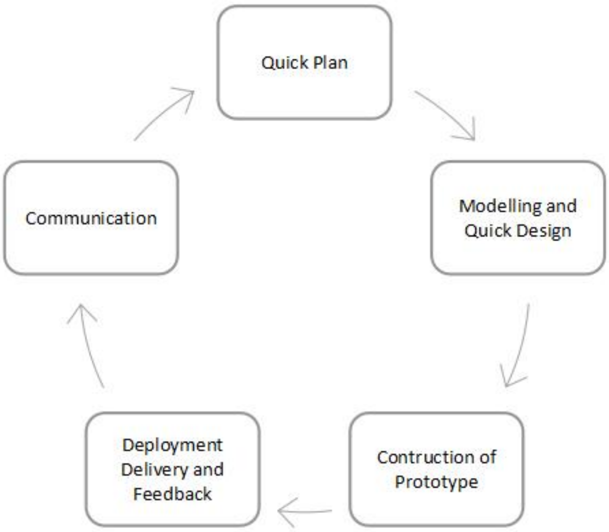

Figure 1. Prototype Development Lifecycle for the Acne Diagnosis Expert System

The core strength of the prototype method lies in its flexibility to accommodate changes during the development cycle [18]. User feedback and testing can be incorporated as the system is built, leading to a more refined and functional prototype. This adaptability is crucial in achieving an optimal design that aligns with the initial requirements and evolves based on practical insights gained during the development process.

Ultimately, the prototype model aims to deliver a functional and user-friendly system. By the end of the development cycle, the prototype will have undergone sufficient testing and evaluation to ensure it is ready for implementation [19]. The model provides an invaluable preview of how the system will operate in real-world conditions, helping users and developers understand its functionalities and identify potential issues before the final deployment. Figure 1 illustrates the prototype model used in this research [20].

The prototype model has a cyclical diagram that illustrates the iterative process of system development [21]. This process begins with the Communication step, where data and requirements are gathered from the user [22]. The information collected during this phase is then used to develop a Quick Plan outlining the system's functional and non-functional requirements.

Following the planning phase, the Modeling Quick Design step is initiated, where the system's design and structure are laid out. This step involves creating visual representations, such as use cases and activity diagrams, to depict the system's workflow. After the design phase, the prototype is constructed, and the system is developed into a functional prototype that can be tested and evaluated.

Once the prototype is constructed, it is ready for Deployment, Delivery, and Feedback. This step involves delivering the prototype to the user for feedback and validation. The system is then refined based on user input, and the process loops back to the Communication step, where additional requirements or modifications are discussed, leading to further iterations of the system. This continuous feedback loop ensures the system evolves and improves with each cycle, resulting in a fully functional and user-approved information system.

Discussion

Communication

Communication is the stage in the system development process where user data or information is collected [23]. This step is crucial because it serves as the foundation for designing the system based on the needs and experiences of the users. Several methods have been used to gather the necessary data. The first method is Observation, which involves collecting data by observing individuals with acne. This method enables the researcher to identify patterns or visible symptoms associated with different types of acne. More accurate and relevant data can be gathered by directly observing the users, which is vital for understanding the various manifestations of acne.

The second method for gathering data is a literature review, where data is obtained through extensive reading, analysis, and the conclusion of various credible and relevant sources [24]. This method is essential to ensure the system is based on proven knowledge, offering insights from previous research and expert opinions. A thorough literature review helps identify existing systems, technologies, and approaches that can be incorporated into the development of the acne identification system [25]. It also serves as a means of validating the findings and ensuring that the system aligns with the latest advancements in the field.

The third method is Interviews with experts in the field, such as dermatologists or skincare specialists [26]. This data collection method is highly valuable because it provides direct insights from professionals with practical experience and specialized knowledge in diagnosing and treating acne [27]. Through interviews, the researcher can gather expert opinions and advice on the most effective ways to identify acne types and recommend treatments [28]. Combining these three methods—observation, literature review, and expert interviews—ensures the system is built on comprehensive, accurate, and user-centered data, forming a solid basis for developing the acne identification system.

Table 1. Parameters of Identified Symptoms

No	Code of Parameter	Symptom
1	A11	Whitehead
2	A10	Irritation around the acne
3	A09	Pain
4	A08	Itchy
5	A07	White in color
6	A06	Hurtful
7	A05	Inflamed
8	A04	Large bump
9	A03	Redness
10	A02	Pus/Fluid-filled
11	A01	Small bump

The next step involves defining the key parameters guiding the system's decision-making process [29]. The parameters of this study are based on the symptoms, as listed in Table 1, and the types of acne, as outlined in Table 2. The data collected through observation, literature review, and interviews are categorized into two main sets: symptom data and acne-type data. These parameters form the core of the knowledge base, allowing the system to accurately diagnose and classify different types of acne based on user input.

Table 2. Type of Acne

No	Disease Code	Type of Acne
1	J05	Cystic (Severe Acne)
2	J04	Papule
3	J03	Whitehead
4	J02	Nodular
5	J01	Pustule

The symptom data encompasses a range of key characteristics, including the visual appearance, anatomical location, and severity of the acne lesions. These features are critical for accurately identifying and classifying the acne condition. The data may include attributes such as comedones, pustules, papules, or cysts and any associated signs of inflammation, pain, or irritation. On the other hand, the acne type data provides more detailed classifications that differentiate between various forms of acne, such as comedonal acne, inflammatory acne, and cystic acne. Each type of acne is defined by distinct morphological features and underlying pathophysiological mechanisms.

Table 3 presents the data detailing the solutions or product recommendations corresponding to each type of acne. It categorizes the various types of acne, offering tailored treatments or product suggestions based on the specific characteristics and severity of each type. This table serves as a reference to guide appropriate treatment choices for individuals with different acne conditions, ensuring that the recommended solutions align with the nature of the acne and its unique symptoms.

Table 3. Expert- and Experience-Based Product Recommendations for Different Acne Types

No	Type of Acne	Solution
1	Papule	Safi Expert Oil Control & Anti Acne Two in One Cleanser and Toner.
2	Whitehead	FREEMAN Oil Absorbing Mint + Lemon Clay Mask and Somethinc Peeling Solution.
3	Nodular	Avoskin Your Skin Bae Alpha Arbutin + Grapseed, and Skin Game Acne Warior,
4	Pustule	Somethinc Niacinamide + Moisture Beet Serum, Avoskin Miraculous Refining Toner, and Some by Mi AHA BHA PHA Miracle Toner.
5	Cystic	Neutrogena Oil-Free Acne Wash, and COSRX BHA Blackhead Power Liquid, and Kiehl's Breakout Control Targeted Blemish Spot Treatment.

These parameters, both symptom-related and type-based, are integral to the decision-making process within the forward chaining expert system. Forward chaining, an inference technique, utilizes these parameters to analyze the input data sequentially, applying predefined rules to generate possible outcomes [30]. As the system progresses through the rules, it narrows the potential diagnoses and recommends appropriate treatment options. The combination of symptom and acne-type data triggers the logical progression of the decision-making process, ensuring that the diagnosis is accurate and tailored to the severity and type of acne present. This approach aims to provide a comprehensive and evidence-based recommendation for acne management, thereby supporting healthcare professionals or patients in making informed treatment decisions.

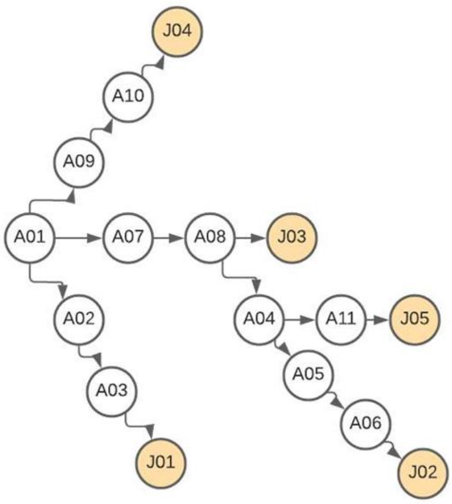

Figure 2. Decision Tree Representation of Acne Classification and Outcomes

A decision tree consists of nodes and branches representing decisions or outcomes, as shown in Figure 2. The primary advantage of using a decision tree is its ability to simplify the knowledge acquisition process. Based on expert input, a decision tree was developed to predict the type of acne. The tree starts with the most prominent symptoms, which serve as the initial point for the consultation. Users then select symptoms by checking the relevant options, progressively narrowing down the possibilities until a final diagnosis is reached. This method allows for a structured and systematic approach to identifying acne types based on the user's input.

Table 4. Symptom-Based Rules for Acne Diagnosis

Code	Rules
R01	IF A01 AND A02 AND A03 THEN J01
R02	IF A04 AND A05 AND A06 THEN J02
R03	IF A01 AND A07 AND A08 THEN J03
R04	IF A01 AND A09 AND A10 THEN J04
R05	IF A08 AND A04 AND A11 THEN J05

Table 4 presents the rules generated by the decision tree, which are derived from the input symptoms provided by the user. These rules serve as the logical framework for classifying the type of acne based on the user's selections. Each rule is a conditional statement that links specific symptom combinations to particular classifications of acne. Following these rules, the system can efficiently determine the most likely type of acne and provide an accurate diagnosis. The table includes all possible combinations of symptoms and their corresponding outcomes, ensuring a transparent and reliable decision-making process. These rules are essential for guiding the system's forward chaining process and enabling it to suggest appropriate treatments based on the identified acne type.

The formulation and validation of the symptoms and rules in Table 4 involved a multi-step process. Initially, symptom patterns were compiled through direct observation of acne cases and a comprehensive literature review. These initial rule sets were then reviewed and refined in consultation with two certified dermatologists practicing in clinical dermatology. The dermatologists provided input on the logical flow of the decision tree and confirmed whether the symptom combinations aligned with actual clinical diagnostic reasoning. Feedback from these experts helped adjust rule conditions and improve the specificity of each acne type classification. This expert validation ensured that the rule-based system was not only technically sound but also clinically relevant.

One potential source of bias in the system lies in its reliance on symptom descriptions that may not fully capture how certain conditions manifest across diverse skin tones. For example, redness or inflammation may appear differently on darker skin, potentially leading to misclassification if rules are built primarily on observations from individuals with lighter skin. Since the current knowledge base was constructed using a limited range of clinical observations and expert inputs, there is a risk that the system may underperform for users with underrepresented skin tones. To address this, future development should incorporate feedback and data from more diverse populations, ensuring that the symptom definitions and diagnostic rules account for variations in skin presentation across ethnic and racial groups.

Quick Plan

The Quick Plan stage in the prototype model plays a crucial role in determining the system's key functionalities and non-functional requirements [31]. During this phase, the focus is on outlining the essential features and technical specifications to ensure the system operates effectively. In the case of the acne type identification system, the functional requirements include the ability to input personal data, symptoms, and diagnosis results. These features form the system's backbone, ensuring that users can provide the necessary information that allows the system to accurately diagnose the type of acne.

Additionally, the system must generate accurate diagnoses based on the user's symptom history. This allows for a more personalized and tailored experience for each user. Using predefined rules and decision trees, the system analyzes the user's symptoms and offers a diagnosis corresponding to the type of acne they are likely experiencing. Moreover, the system will provide skincare product recommendations tailored to the diagnosed acne type, helping users select the most suitable treatment. Another critical aspect of the system's functional requirements is the ability to generate patient consultation history reports. This feature lets users track their past consultations, including their reported symptoms and subsequent diagnoses. It can benefit users who wish to monitor their progress over time and healthcare providers who may need to reference previous consultations for follow-up care.

The system's non-functional requirements include hardware and software specifications to ensure smooth operation. The hardware requirements are relatively standard, with the system needing a Core i5 processor to handle the necessary computations. On the software side, the system will be developed using XAMPP for the server environment, Sublime Text for coding, and Chrome for testing and accessing the system through a web browser. These technical specifications ensure that the system is efficient, responsive, and capable of delivering the desired user experience.

Modeling Quick Design

This stage emphasizes the rapid development of an abstract representation to define the system's structure and functionalities. It acts as a bridge between understanding user requirements and detailed system implementation. The quick design process prioritizes efficiency, clearly depicting how the system will work and addressing users' needs, thereby seeking to create an intuitive and effective acne identification tool.

The interface layout, workflow, and data interactions are outlined during this stage. For example, the user interface design would focus on ease of use, with screens for symptom input, diagnosis results, and treatment recommendations. The workflow of the forward chaining approach would also be defined, detailing how user inputs, such as skin symptoms (e.g., redness, oiliness, or inflammation), are processed through predefined rules to identify the type of acne and suggest appropriate actions. Furthermore, the data flow between the user interface, knowledge base, and inference engine is structured to ensure seamless interactions. Quick design tools like flowcharts, mockups, and diagrams help visualize the system's core components. Flowcharts might illustrate the logical sequence of the forward chaining process, while mockups showcase how users interact with the platform. Entity-relationship diagrams (ERD) could define how user profiles, symptom data, and diagnostic rules are stored and accessed. This stage also outlines the rule-based system architecture, focusing on how rules are created and applied based on dermatological knowledge to derive accurate results.

The output of the quick design stage is a prototype that allows early validation of the system concept with stakeholders, such as dermatologists and potential users. This feedback ensures the system meets user expectations, provides a clear, logical flow, and aligns with usability standards. Focusing on iterative refinement, this stage sets a solid foundation for developing a comprehensive and reliable online acne consultation system.

Prototype Construction

This stage focuses on building a functional version of the system based on the quick design framework. This involves developing the knowledge base, which houses dermatological rules to identify acne types from symptoms, and implementing the forward chaining inference engine to derive diagnoses and recommendations. The system's backend integrates this logic with a user-friendly interface that allows users to input symptoms and view results.

During this stage, the user interface is designed to ensure accessibility and ease of use, accommodating a broad audience with varying technical skills. The interface includes features for entering symptoms, viewing diagnoses, and receiving tailored recommendations. Simultaneously, backend components, such as databases and system logic, are developed using appropriate technologies (Python, PHP, or relevant frameworks). This integration ensures seamless data flow between the user interface and the inference engine. The prototype undergoes internal testing to validate functionality, including the accuracy of the forward chaining mechanism, responsiveness, and error handling. Stakeholder feedback is incorporated iteratively to address shortcomings and improve the system. By the end of this stage, a refined prototype is ready for extensive testing and eventual deployment, ensuring it aligns with user needs and delivers reliable acne identification.

Deployment, Delivery, and Feedback

This stage involves launching the system for real-world use and ensuring it is accessible to end users. Deployment includes hosting the system on a suitable platform, such as a cloud-based server or a web hosting service, to provide seamless access via desktop and mobile devices. Necessary configurations, including domain registration, security measures, and performance optimization, are implemented to ensure a seamless user experience and protect sensitive user data.

Once deployed, the system is delivered to its intended audience, such as dermatologists, patients, or general users seeking online acne consultations. To ensure successful adoption, this stage includes creating user guides, tutorials, or help documentation to familiarize users with the system's features and functionalities. Support mechanisms, such as a dedicated help desk or frequently asked questions (FAQs), are established to address potential user inquiries and technical issues. This ensures users can fully leverage the system's capabilities for accurate acne identification and personalized recommendations. The feedback loop is critical in this stage, enabling continuous system improvement. Users are encouraged to provide feedback on their experiences, including usability, accuracy of diagnoses, and overall satisfaction. This feedback is collected through surveys, user reviews, and analytics tools that monitor system performance and user interactions. Insights gained from this feedback guide future updates and refinements, ensuring the system remains relevant, effective, and aligned with user needs over time.

Ethical and privacy considerations are critical in the development of health-related digital systems. To protect user information, the system employs basic security measures, including HTTPS encryption, user authentication, and restricted access to sensitive data. Personally identifiable information is stored separately from symptom records to reduce the risk of re-identification. While the current system is primarily intended for local use, its design is guided by international data protection principles outlined in regulations such as HIPAA (USA) and GDPR (EU), particularly in anticipating future deployment in broader contexts. Moreover, the system aligns with Indonesia's Personal Data Protection Law (UU No. 27/2022), ensuring that user data is handled responsibly and ethically throughout the consultation process.

Results

After completing the symptom selection on the consultation page, the user is directed to the consultation results page, as shown in Figure 3. This page displays the name of the diagnosed acne type, a detailed description of the condition, and personalized solutions or treatment recommendations. The results are based on the symptom inputs provided by the user and processed through the forward chaining inference engine. The system's use of predefined rules ensures that the diagnosis is accurate and aligned with the symptoms selected.

Including the description allows users to understand their condition better, offering valuable insights into what they might be experiencing. The personalized solution section also provides practical recommendations, such as skin care routines or lifestyle changes, that can help address the identified acne type. This feature enhances the system's utility by diagnosing the acne type and offering guidance on managing or treating the condition. Users wishing to conduct another consultation can easily reset the process by clicking the "Repeat Consultation" button. This functionality ensures flexibility, allowing users to recheck their symptoms or explore other potential conditions based on different inputs. It enhances the user experience by enabling them to refine their queries and obtain new insights based on updated symptom data. This seamless transition from consultation to results and back again contributes to the overall ease of use and effectiveness of the system.

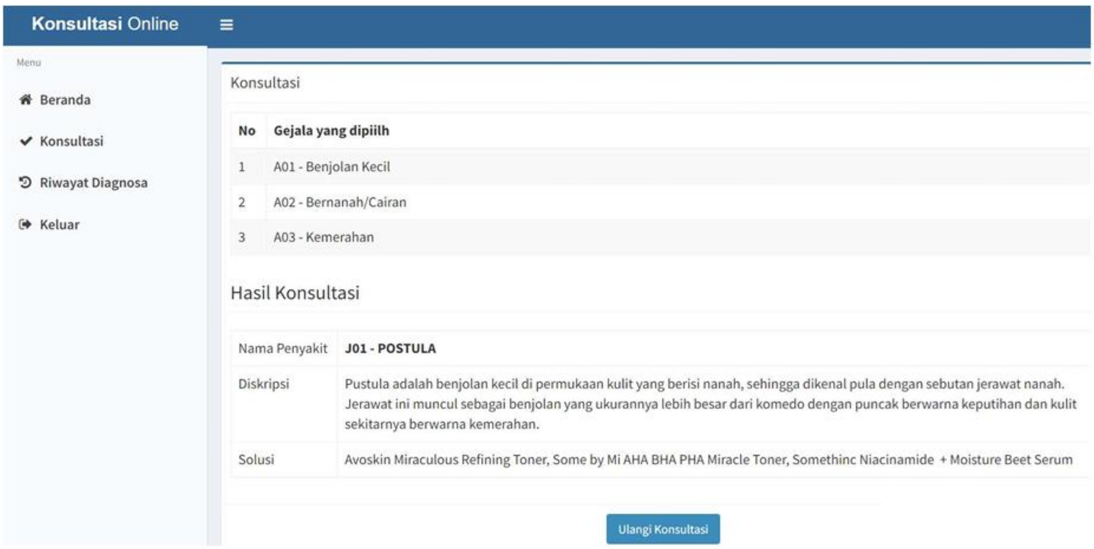

Figure 3. Consultation Results and Treatment Recommendations (Indonesian User)

The testing phase was crucial to ensure all system features functioned as expected. Black-box testing was employed to evaluate the system's performance [32]. This method focuses on assessing the system's functionality from an end-user perspective without considering the internal code structure. The goal was to verify that the system processes user inputs and produces the intended outputs correctly.

All significant features, such as symptom input, diagnosis result display, and the ability to restart the consultation, were tested to ensure proper operation. Test cases were designed to cover different scenarios, including selecting various symptom combinations, to ensure that the forward chaining approach produced accurate results. The system's user interface and navigation were also assessed for usability and responsiveness.

Table 5. Black-box Testing Results: Test Cases, Expected Outcomes, and Actual Results

No	Test	Scenario	Expectation	Result
1	Login	1. Enter the correct username and password 2. Enter the incorrect username and password 3. Enter the correct username and incorrect password 4. Enter the incorrect username and correct password	1. Successful redirects to the main page 2. Failed, remains on the login page 3. Failed, remains on the login page 4. Failed, remains on the login page	Valid
2	Consultation Menu	1. Click the "consultation" menu 2. Select the symptoms experienced 3. Click "process."	1. Displays consultation page 2. Check the symptoms experienced 3. Displays consultation results	Valid
3	Symptoms, Disease, Rules Menu	1. Click "symptoms," "disease," "rules." 2. Add, edit, and delete symptoms, disease, and rules data.	1. Displays symptoms, disease, rules page. 2. Data on symptoms, disease, and rules can be edited and deleted.	Valid
4	Diagnosis History Menu	1. Click "Diagnosis History." 2. Displays, prints, and deletes user data who has performed consultations.	1. Displays diagnosis history page. 2. Able to display, print, and delete user data from consultations.	Valid
5	Logout	Click "Logout."	Logs out and returns to the login page.	Valid

The results of the black-box testing can be seen in Table 5, which includes a summary of the test cases, expected outcomes, and actual results. The table demonstrates that the system passed all critical test cases, confirming that it meets the developers' expectations for functionality and performance. Any discrepancies or minor issues identified during testing were promptly addressed, ensuring the system's overall reliability and readiness for deployment. This thorough testing ensured that the system would perform well under real-world conditions and provide users with an effective tool for acne diagnosis.

The SUS testing evaluated the overall user-friendliness and satisfaction with the Online Consultation System for Acne Type Identification [33]. SUS involves engaging end-users directly in testing and assessing the system's usability based on real-world interactions, as shown in Table 6. This method does not follow a specific theoretical framework for selecting respondents, as the focus is on gathering feedback from the product's users.

Table 6. System Usability Scale (SUS) Testing Results and User Feedback

No	Question	Score
1	I will use this website again.	1. Strongly disagree
2	Some features of the website menu are complicated.	2. Disagree
3	This website is easy to use.	3. Neutral

No	Question	Score
4	I need technical support to use this website correctly.	4. Agree 5. Strongly agree
5	All functions on this website work well.	
6	I find many inconsistencies on this website.	
7	Many people will quickly learn how to use this website.	
8	This website is very confusing.	
9	There are no obstacles to using this website.	
10	I need to familiarize myself with many aspects before using this website.	

For this evaluation, 15 respondents, including nine females and six males who were acne sufferers, were randomly selected to complete a SUS questionnaire. The responses collected were used to calculate the system's usability score. The results of the SUS evaluation are summarized in Table 8. The average score obtained from the 15 respondents was 86.5, indicating that the system is highly user-friendly. A SUS score of 70 or higher is considered acceptable, and with a score of 86.5, the system exceeds this threshold, showing strong user acceptance.

This high SUS score suggests that the Online Consultation System with a Forward Chaining Method for Acne-type identification is well-received by users. The system's ease of use and practical value make it a valuable tool for individuals with acne who seek to understand and manage their condition. The positive feedback from the respondents confirms that the system meets user expectations, ensuring its potential for widespread adoption and successful implementation.

Compared to AI-based acne diagnostic tools that rely heavily on image recognition and deep learning models [12], [16], the proposed forward chaining expert system offers a rule-based, symptom-driven alternative. Image-based systems often require large annotated datasets and high-quality images, which may not be feasible in low-resource settings or for users without access to proper lighting and camera equipment. In contrast, our system relies on user input of symptoms, making it more accessible and lightweight, especially in mobile or web-based environments. While image-based systems may achieve high accuracy through training on large datasets, they often function as “black boxes” with limited explainability. Our rule-based approach offers greater transparency, as the diagnostic logic is clearly defined and auditable. However, it may have lower flexibility in detecting unexpected or rare cases, which could be addressed in future hybrid models. This highlights a trade-off between interpretability and adaptiveness, depending on the intended use context.

The system achieved a SUS score of 86.5, which, according to established usability benchmarks, falls within the "excellent" category. Ghorayeb et al. [34] reinforced the applicability of SUS in clinical decision support evaluation and proposed refinements to interpret usability results in healthcare-specific contexts. Although domain-specific SUS tools such as HSUS have been introduced, the standard SUS remains widely adopted for evaluating mobile and web-based health applications due to its simplicity and comparability.

While the system demonstrated high usability and functional accuracy through black-box testing and achieved a strong System Usability Scale (SUS) score, a formal clinical validation comparing its diagnostic outcomes with dermatologist assessments has not yet been conducted. Such comparative evaluation is essential to establish the system's diagnostic reliability in real-world clinical settings. A future study involving a small-scale clinical trial or inter-rater agreement analysis between the system and certified dermatologists is planned to quantitatively assess diagnostic concordance. This step will further validate the system’s effectiveness and strengthen its credibility as a clinical decision-support tool.

Conclusion and Suggestion

The Consultation System for Acne Type Identification, developed using a forward chaining expert system, demonstrates strong usability and diagnostic potential. By processing user-reported symptoms, the system successfully identifies acne types and provides tailored treatment recommendations. Black-box testing confirmed that all system functionalities performed as intended, and a System Usability Scale (SUS) evaluation yielded a high score of 86.5, indicating excellent user acceptance and interface intuitiveness. These results suggest that the system offers a practical and accessible platform for individuals seeking to understand and manage their acne. Features such as the ability to restart consultations and view historical diagnoses further enhance user engagement and flexibility. Overall, the system meets its objective of providing efficient and user-centered acne diagnosis support.

Despite these strengths, several limitations must be acknowledged. The rule-based nature of forward chaining systems depends heavily on the completeness and quality of predefined rules. As a result, the current system may struggle to handle rare or atypical acne presentations that fall outside the established rule set. This introduces a risk of diagnostic bias, as the system may favor common symptom patterns. Additionally, the static knowledge base limits adaptability to new clinical insights unless manually revised. To address these challenges, future iterations should explore hybrid approaches that integrate rule-based reasoning with machine learning (ML) techniques. ML models—such as decision trees, random forests, or neural networks—could enable the system to learn from new cases and recognize more complex symptom combinations, thereby increasing accuracy and adaptability. This hybrid strategy would combine the interpretability of expert systems with the adaptive learning capacity of ML.

Scalability is another important consideration. Currently, the knowledge base is informed by expert insights from a specific regional context. However, acne presentation varies significantly across populations due to differences in skin tone, climate, diet, and lifestyle. These factors can influence both symptom expression and treatment response. To ensure diagnostic accuracy across diverse settings, future versions of the system should incorporate geographically and demographically diverse data and support localization of recommendations.

Looking forward, the system could also benefit from integration with telemedicine platforms. This would enable seamless referrals to certified dermatologists in cases involving severe, ambiguous, or treatment-resistant symptoms—bridging the gap between AI-driven pre-diagnosis and expert consultation. Moreover, the system's rule base could be expanded to include additional dermatological conditions, such as eczema, psoriasis, or rosacea, broadening its utility for general skin health management. While the current system offers a promising tool for accessible acne diagnosis, its future development should emphasize adaptability, inclusivity, and clinical integration to maximize its impact and relevance in real-world healthcare environments.

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