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Expert system for diagnosing measles in children based on android

Jupron*, Tri Prasetyo, Cendra Harmon, Gigih Amrillah Ibnurhus

* University of Pamulang, Jl. Raya Puspitek, South Tangerang 15310, Indonesia

* Corresponding Author: dosen02664@unpam.ac.id

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ABSTRACT

Measles is a contagious disease caused by the Morbillivirus, and it can be fatal, especially in children. In Indonesia, cases of measles have significantly increased due to low vaccination coverage and limited access to healthcare services in rural areas. The main problem faced is the lack of early detection of measles by communities that do not have direct access to medical professionals. To address this challenge, an Android-based expert system has been developed that allows users to perform early diagnosis of measles independently based on the symptoms experienced. This system uses the Forward Chaining inference method to determine the possible diagnosis from the combination of symptoms chosen by the user. The system development process is carried out using Agile and Rapid Application Development (RAD) approaches to ensure that development can be conducted quickly and flexibly according to user needs. System testing is conducted using the Blackbox Testing method to evaluate outputs based on specific inputs, and the Whitebox Testing method assesses the internal logic of the system. The test results show that this expert system has an accuracy rate of 92.5% in diagnosing measles symptoms, based on test data that has been validated by medical professionals. In addition to diagnosis functionality, the system is also equipped with features for storing diagnosis history, food recommendations, and education about measles. This application is expected to be an effective solution in raising awareness and knowledge of the public about measles, as well as encouraging them to take medical action promptly to prevent more serious complications, especially in areas with limited health facilities.

Keywords: Expert system; measles; forward chainin; android mobile

1. Introduction

The symptoms of measles, an infectious disease brought on by the Morbillivirus virus, include a high temperature, coughing, runny nose, red eyes, and the development of skin rashes. Particularly in children under five, the illness can lead to severe consequences and is extremely infectious. (Placeholder1) Measles can be lethal if not treated appropriately [1]. In Indonesia, measles infections have again become a big worry in the realm of health. The number of measles cases in 2023 was much higher than in other years, according to data from the Indonesian Ministry of Health. 18 provinces reported 2,161 suspected measles cases between January 1 and April 3, 2023, with West Java accounting for the most cases (796), Central Papua for 770, and Banten for 197. This rise in instances is affected by numerous causes, including a fall in vaccination coverage during the COVID-19 pandemic and an increase in the number of persons who refuse vaccinations (anti-vaccines) [2].

In addition to Indonesia, measles incidences have increased worldwide. According to WHO figures, there were over 14 million measles cases globally in 2022—a rise of over 70% over the year before. This circumstance demonstrates that measles is a critical global health concern that has to be addressed, particularly in attempts to boost vaccination rates [3]. Access to health care is a major barrier to measles prevention and control in Indonesia, particularly in rural regions. People in areas

like Papua, Maluku, East Nusa Tenggara, West Kalimantan, and West Sumatra face significant obstacles due to things like a shortage of medical professionals, inadequate transportation, and lengthy distances to health facilities [4]. Because of this, a lot of individuals in the area put themselves at risk for more serious consequences by delaying medical attention. One way to address this issue and provide people greater access to healthcare is through the use of technology. Sadly, a large number of expert system applications are still web-based, which necessitates reliable internet connectivity, which is challenging to obtain in rural locations [5]. Thus, the creation of an Android mobile expert system application may be a more efficient way to diagnose measles. It is anticipated that this application would improve the public's ability to independently identify measles symptoms [6]. Additionally, this tool can help doctors in remote locations make faster and more precise diagnoses. As a result, patients may receive the right medical care right away, reducing the risk of complications and improving recovery [7]. It is anticipated that the creation of an Android-based expert system application would be a novel step in raising the standard of healthcare, particularly for those living in Indonesia's more rural locations [8].

2. Method

The Agile method is implemented in this research to ensure that the system development process takes place in an iterative, adaptive, and collaborative manner [9]. The first stage begins with the compilation of the product backlog, which is a list of features and system components designed to enhance diagnostic accuracy [10]. In the context of this research, the product backlog includes activities such as collecting symptom data from medical literature and clinical cases, consulting with professional medical staff, data cleaning and validation processes to ensure quality, descriptive statistical analysis of symptoms, data visualization using tables and graphs, and the development of a pattern-based recommendation system [11]. After the backlog is prepared, sprint planning is conducted to plan the tasks to be completed in one sprint cycle, with a duration of one to two weeks. Each sprint has specific goals, such as processing primary data, creating visualization models, or validating analysis results by medical experts [12]. During the sprint execution, the development team holds daily stand-up meetings to evaluate daily progress, identify technical obstacles, and align work among team members. After one sprint is completed, a sprint review is conducted to demonstrate the work results to stakeholders, including researchers and healthcare professionals, to obtain direct feedback on the features and findings produced. This evaluation is important to ensure that the results obtained are clinically relevant and meet the needs of end users [13]. Following that, a sprint retrospective is held as a forum for the team to reflect on evaluating the effectiveness of the workflow process and identifying aspects that need improvement in the next sprint [14]. Each sprint is expected to produce an increment, which is a gradual improvement to the system being developed, such as a data analysis module, a symptom trend visualization feature, or an early diagnosis recommendation component. By applying an Agile approach, the development process of this expert system can be more structured, allowing for continuous integration of inputs from various parties, and gradually contributing to the improvement of diagnostic accuracy based on data analysis and validated clinical guidelines [15]

Figure 1. Agile Stage

Figure *1*. illustrates the software development cycle that follows the Agile methodology. This model depicts the iterative and incremental workflow typical of Agile.

Activity Diagram

Figure *2* Activity Diagram is a diagram that illustrates the sequence of activities or actions in a process. This diagram is one type of Unified Modeling Language (UML) used to model business processes, represent the sequence of activities in an information system, explain the sequence of activities in a process [16], identify the activities of the actor/user, and capture the dynamic behavior of the system [17].

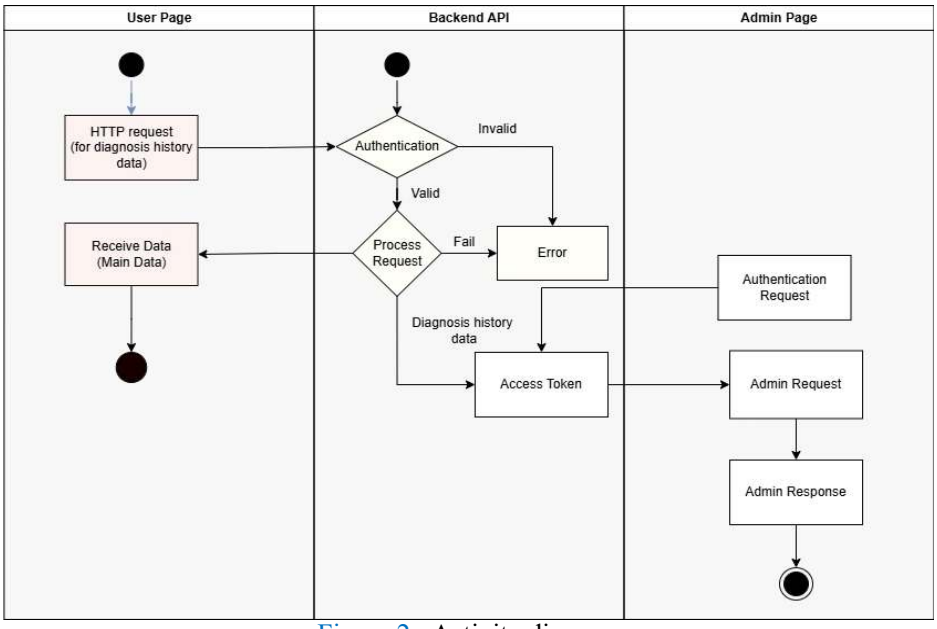

Figure 2. Activity diagram

Use Case Diagram

Figure *3* A Use Case diagram is a description of the functions of a system from the user's perspective. Use Case works by describing typical interactions between a user of a system and the system itself through a story of how a system is used [18]. The sequence of steps that explains the interaction between the user and the system is called a scenario [19].

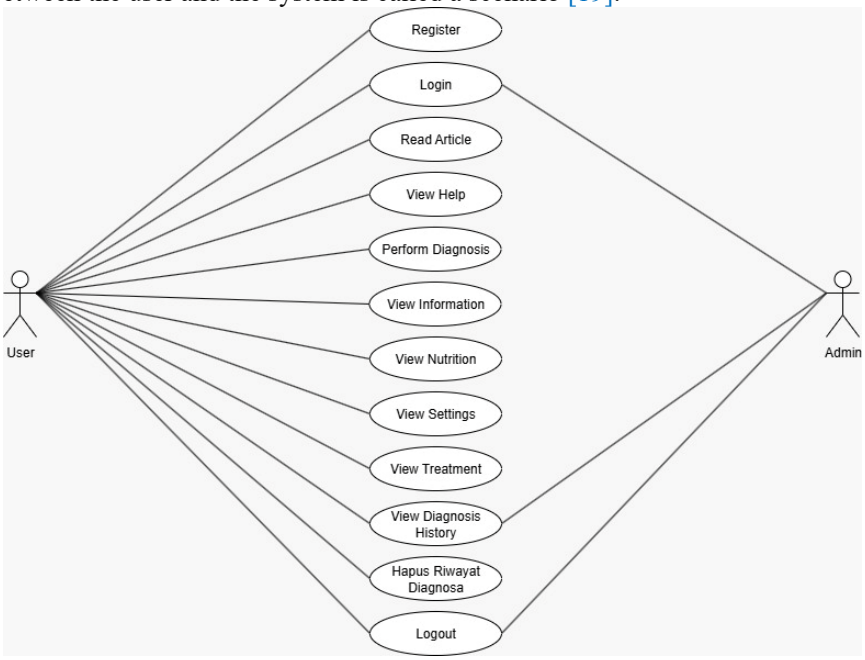

Figure 3. Use Case Diagram

3. Results and Discussion

Implementasi Tools

a. Hardware Specifications

Table *1* Hardware used in this research is appropriate and sufficient to support the development and testing process of the expert system application based on Android. The capacity and performance of the devices used allow the application to run smoothly, especially in development using the Flutter framework. In addition, the specifications of the devices used also support the installation of supporting software such as Visual Studio Code and Android Studio, and are capable of running computation processes stably and efficiently during the research implementation.

Table 1. Hardware Specifications

Device Specifications	
Device Name	DESKTOP-FM1BVA7
Processor	AMD A9-9425 RADEON R5, 5 COMPUTE CORES 2 C +3G 3.10 GHz
Installed RAM	4,00 GB (3,89 GB usable)
Device ID	5954127E-E704-4394-9944-8A22955F5C994
Product ID	00327-35862-34744-AAOEM
System Type	64-bit operating system, x64-based processor

b. Spesifikasi Windows

Table *2* device used in this research employed a Windows operating system that is suitable for supporting the development and testing processes of the application. This operating system is stable and compatible with various development tools, making the implementation of the research and the design of the system easier.

Table 2. Spesifikasi Windows

Windows Specifications	
Edition	Windows 10 Home Single Language
Version	22H2
Installed on	31/08/2023
OS Build	19045.5247
Experience	Windows Feature Experience Pack 1000.19060.1000.0

c. Software specifications

Table *3* software used in this research has been selected to optimally support the application development process. The use of common code editors such as Visual Studio Code and Android Studio facilitates the writing and management of program code, while the Android physical simulator allows for real-time application testing in an environment resembling actual devices. In addition, modeling tools like UML are also used to design and visualize the system more structurally, thus supporting the smoothness of all stages of application development.

Table 3. Software Specifications

Software Specifications	
Code Editor	IDE umum Visual Studio Code dan Android Studio
Simulator	Android Emulator Fisik
UML Tool	Draw.io

Implementasi User Interface

a. Display of the Login Page

When the program initially opens, this is the first screen that appears. If you already have an account, you must fill in this column; if not, you must first register by clicking the registration button here. After that, you will be sent to the registration page.

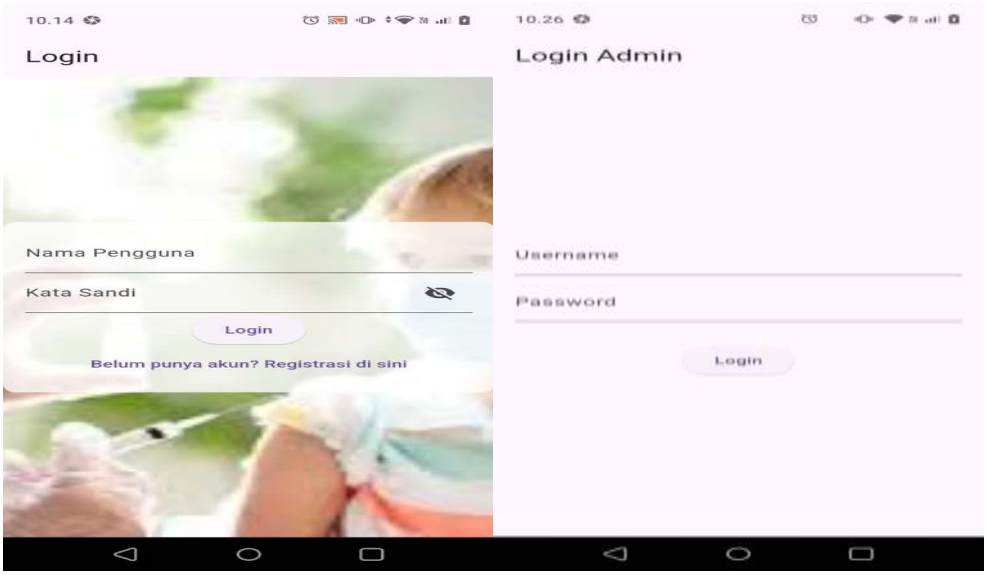

Figure 4. User and admin login

Figure 4 shows the user interface (UI) for the login page specifically designed for general users and admins in the application system. In this view, users are prompted to enter their login information consisting of a username and password to access the system. The UI design is kept simple and intuitive to make it easy to use for various groups, including users without a technical background. Additionally, this page also provides an option to switch between logging in as a user or as an admin, each of which will be directed to the appropriate page based on their role after successfully logging into the system. This view serves as the main gateway that ensures secure access to the application's data and functions.

b. Display of the Registration Page

Users are required to fill out and complete all of their personal information accurately and thoroughly in this section before they can proceed with the login process into the system, as this data is crucial for identity verification purposes, maintaining account security, and ensuring that only legitimate users have access to the available services.

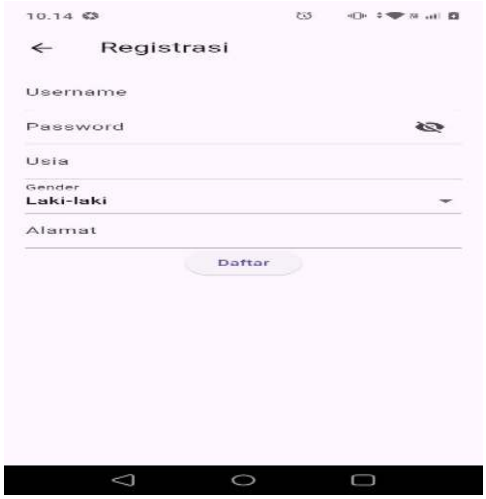

Figure 5. Registrasi User

In Figure 5, the information entered will be used to match the user's identity with the data that has been stored in the system, thereby preventing unauthorized access or account misuse. This process also helps to provide a safer and more personalized user experience. Additionally, the completeness of personal data will facilitate the customer support team in assisting users in case of technical

difficulties or security issues. Therefore, users are urged to ensure that all the data filled in is accurate, up-to-date, and does not contain false information

c. Display of the Home Page

Users will be taken to the application's main page after logging in, which includes a number of features. Simply pressing the feature icon will enable users to view or utilize the function.

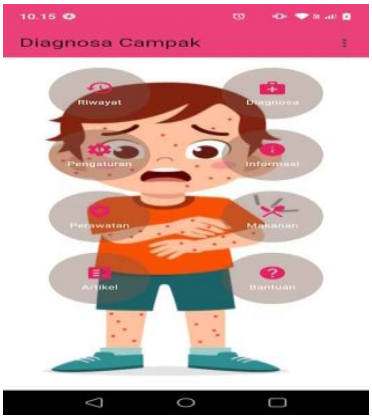

Figure 6. UI Beranda

Figure *6* Home, displays the user interface on the main page of the application, where users can access various important features such as History, Diagnosis, Settings, Information, Care, Food, Articles, and Help. Each menu is designed to provide ease of navigation and an intuitive user experience. The History menu contains records of previous activities or results that the user has performed, while Diagnosis allows users to conduct digital health condition analysis. Settings are used to adjust account and system preferences, and Information provides a general explanation related to the application. The Care feature presents guidelines or suggestions for medical actions, while Food contains nutritional information and healthy eating patterns. Articles provide educational content about health, and Help is designed to provide technical support or guidance if users encounter difficulties while using the application.

d. Display of Diagnosis Pages

When the Diagnose feature is selected, the user will be directed to a page containing a list of measles symptoms and only needs to select the symptoms experienced by checking the checkbox then press the start diagnose button and the system will start working with the diagnosis process.

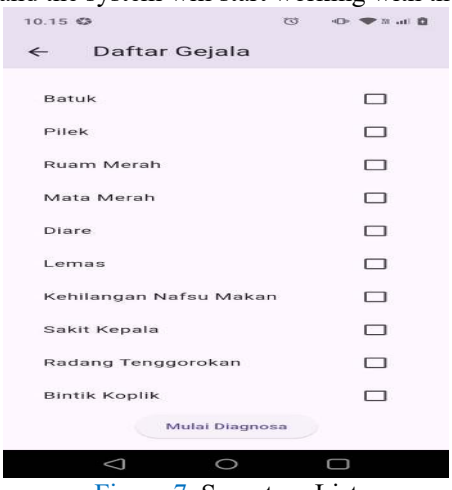

Figure 7. Symptom List

Figure *7* Symptom List, shows a list of symptoms that can be selected or identified by users in the process of checking their health conditions through the application. This display is designed to facilitate users in noting or selecting the symptoms they are experiencing. Some of the symptoms listed include cough, cold, red rash, red eyes, diarrhea, weakness, loss of appetite, headache, sore throat, and Koplik spots. Each symptom in this list represents an early indication of a specific health

condition and will be used as the basis for further diagnostic processes in the system. This interface provides ease and clarity for users to quickly and accurately identify symptoms.

e. Presentation of Diagnostic Findings

The system will show the diagnosis findings based on the specified symptoms after the diagnosis procedure is finished. the results can be seen in the image below, there it can be seen that there are several possibilities for the disease to be detected and the percentage of the highest results is the main result. There is also a home icon in the corner so that users can return to the homepage.

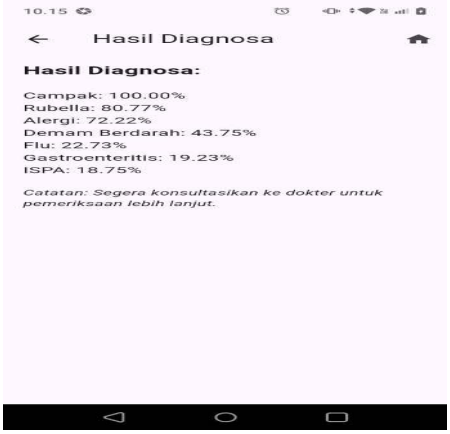

Figure 8. Diagnosis Results

Figure *8*: Diagnosis Results displays the diagnostic analysis results based on the symptoms previously selected by the user. In this view, the system presents the percentage likelihood of several diseases related to the experienced symptoms. The diagnostic results indicate that the highest possibility is Measles with a percentage of 100%, followed by Rubella at 80.77%, Allergy at 72.22%, Dengue Fever at 43.75%, Flu at 22.73%, Gastroenteritis at 19.23%, and ARI (Acute Respiratory Infection) at 18.75%. This display aims to provide an initial overview of the user's potential health conditions, serving as a consideration for the next steps, such as further medical consultation or initial care measures.

f. Display of Diagnostic History

The diagnostic history will be saved in the a diagnosis history feature after the diagnosis findings are finished. Because there is already a garbage symbol in the top corner, the history won't be erased unless the user deletes it.

Figure 9. Diagnosis history

Figure *9*: Diagnosis History displays a list of diagnostic results recorded by the user previously. In this view, users can see detailed information about the time of diagnosis, symptoms experienced,

and the results or possible diseases detected from each examination. This history feature is useful for monitoring the development of health conditions over time, helping users to track changes in symptoms, and providing references for medical personnel if further consultation is needed. With the existence of diagnosis history, users can manage personal health data in a more organized and controlled manner.

g. Display of Help Pages

There are various queries and answers in this assistance feature. To view the answers and questions, simply hit the down arrow button. These are measles-related questions; if the user wants to learn more specific information, they may utilize this option.

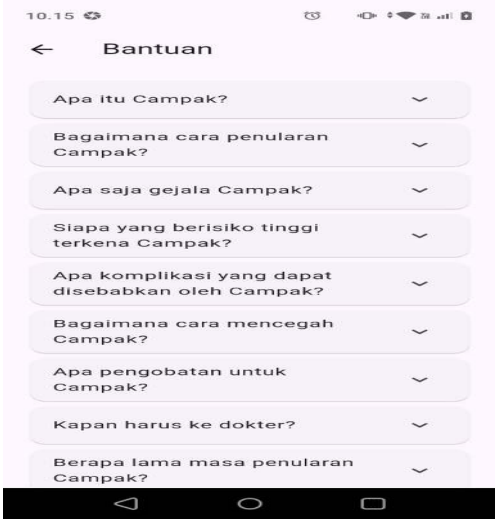

Figure 10. help

Figure *10*: Questions About Measles displays a list of common questions along with answers related to measles that are frequently asked by users. This display serves as an educational information center to help users understand more about measles. Some of the questions presented include explanations about what measles is, how to deal with measles, when is the appropriate time to see a doctor, and how long the contagious period of this disease lasts. The answers provided are written in easy-to-understand language, aimed at giving users initial guidance so they can take the right steps when facing measles symptoms, as well as raising awareness of the importance of quick and proper handling of this disease.

h. Views of Pages

Food Suggestions This food feature lists foods that people with measles should limit or avoid because some meals might exacerbate the illness, while others can help people feel better by keeping them hydrated and less dehydrated.

Figure 11. Food Recommendations

Figure *11*: Food Recommendations for Measles shows a list of foods that are recommended for consumption by measles patients to support the healing process and maintain body resilience. This figure explains that recommended foods include vitamin-rich foods such as green vegetables and fruits, high-protein foods such as eggs, chicken, or fish to accelerate cell regeneration, as well as foods containing vitamin C such as oranges, kiwis, and papayas that are beneficial in boosting the immune system. Additionally, it is recommended to consume soft and easily digestible foods such as porridge or soup to avoid irritating the throat which may feel sore. Adequate fluid intake is also important to prevent dehydration and assist in the body's detoxification process. Lastly, probiotic-rich foods like yogurt are recommended to maintain digestive health during recovery. This display aims to provide the right nutritional guidelines so that measles patients can recover faster and avoid complications.

i. Views of Pages

Settings for a Dark Theme Because some individuals prefer brighter light and others are sensitive to too much light, this feature allows users to choose a dark or light theme depending on how comfortable they are using the program.

Figure 12. Dark theme

Figure *12* the dark theme settings page displays the application's settings interface in dark theme mode. On this page, users can access several important options such as emergency contacts to save numbers that can be reached in emergencies, privacy settings to manage personal data and application access permissions, as well as the delete diagnosis history feature that allows users to delete previous diagnostic records. This dark theme appearance is designed to provide visual comfort, especially when used in low light conditions.

j. Views of Pages

First Aid This article includes advice on how to take care of yourself, including keeping yourself clean, and how to start treatment if you think you have measles but haven't had time to see a doctor.

Figure 13. Initial care

Figure *13*: Home Self-Care Tips presents a guide to self-care that can be done when experiencing symptoms of illnesses such as measles. The recommended tips include getting enough rest to speed up recovery, drinking plenty of fluids to keep the body hydrated, and maintaining personal and environmental hygiene to prevent the spread of infection. Additionally, it also shows signs of when to seek medical help immediately, such as difficulty breathing, seizures, and signs of severe dehydration like dry mouth and very little or no urine. This display aims to provide practical education to users so that they can take care of themselves properly and know when a condition requires immediate medical attention.

k. View of the Article Page

Users may read more thorough information on measles by clicking on the links to articles from the Ministry of Health and WHO that are included in this feature.

Figure 14. Article page

Figure *14*: Articles and Educational Videos about Measles feature informative content in the form of articles and videos aimed at providing education to users about the measles disease. The material presented includes information about the causes, symptoms, transmission methods, prevention, and treatment of measles. The articles are written in easy-to-understand language, while the videos are presented visually to facilitate comprehension. This presentation aims to increase users' awareness and knowledge so they are better prepared to face or prevent measles prevent measles.

l. Display of Information Pages

A brief description and facts on measles are provided on this page.

Figure 15. Information Pages

Figure 15: Measles Information presents a comprehensive summary of measles that includes several important aspects, namely definition, symptoms, methods of transmission, and potential complications. The definition section explains that measles is a contagious disease caused by a virus and generally affects children. The displayed symptoms include fever, red rash, cough, runny nose, and red eyes. The information about transmission explains that the measles virus spreads through airborne droplets from the cough or sneeze of an infected person. Meanwhile, the complications section alerts users to the serious risks of measles such as lung infection, encephalitis, and even death if not properly managed. This display aims to provide users with a fundamental and comprehensive understanding of the importance of recognizing and being aware of measles.

m. *WhiteBox Testing*

Table 4 WhiteBox Testing is a testing technique that focuses on the internal system, especially the source code of a program. The main goal of WhiteBox Testing is to use it as a tool for assembling programs or code. For developers and programmers, performing white box testing is an important step in determining the complexity level of certain parts of the code [18].

Table 4. Whitebox testing

Code	**Test Case**	Selected Symptoms	Expected Results	Verification
Diagnosis Results	_Determine Diagnosis Result(): Normal Case	{Fever': true, 'Red Rash':true, 'Red Eyes': true}	{'Measles' : 90.0}	Check the output of the _determine Diagnosis() function and ensure the result is {'Measles': 90.0}
	Determine Diagnosis Result (): No Symptoms Case	{}	{}	Check the output of the function _determine Diagnosis Result() and ensure the result is {} . (Empty)
	Determine Diagnosis Result (): Case Not Compatible With Disease	('Fever': true, 'Cough': true)	{'Flu':66.67}	Check the output of the function determine Diagnosis Result () and ensure the result is {'Flu': 66.67}
	Save History()	['Fever': true, 'Red Rash': true, 'Red Eyes': true], [{'disease': 'Measles', 'probability': 90.0}] ['Fever': true, 'Red Rash': true, 'Red Eyes': true], [{'disease': 'Measles', 'probability': 90.0}]	History data is stored in SharedPreferences in the correct JSON format.	Check the data stored in SharedPreferences and ensure that the data is saved in the correct JSON format, including the date, symptoms, and diagnosis.
	_load History()	History data stored in SharedPreference	History data loaded correctly and displayed on the screen.	Check whether the history data is loaded correctly from SharedPreferences and displayed on the screen in the correct format.

Code	**Test Case**	Selected Symptoms	Expected Results	Verification
	_kirimData Riwayat()	History data stored in SharedPreferences	The history data was sent to the server correctly and the server received and processed the data.	Use a mock server to simulate HTTP requests to the server and check if the history data is sent correctly and the server receives and processes that data correctly.
_toggle Symptoms ()	_toggle Symptoms()		All symptoms in the symptoms Percentage are initialized as false.	Check if all symptoms in the selected symptoms are initialized as false.
	_toggle Symptoms()	'Fever', true	The symptom Selected [‘Fever’] becomes true	Check the symptom value Selected ['Fever'] and make sure the value is true.
	_toggle Symptoms()	'Fever', true	The selected symptom [‘Fever’] becomes false.	Check the symptom value Selected ['Fever'] and make sure the value is set to false.
	_reset Symptoms()		All symptoms in the selected symptoms are changed to false	Check if all the symptoms in the Selected symptoms have been changed to false.

4. Conclution

Based on the results of the research and discussion, it can be concluded that the development of an Android Mobile-based Expert System for Diagnosing Measles in Children has been successfully carried out effectively and structured. The development of this system uses Agile and Rapid Application Development (RAD) methods that allow the development process to take place iteratively, quickly, and flexibly. The use of this method plays an important role in producing an application that is adaptive to user needs, especially in the context of mobile-based health services. Meanwhile, the application of the Forward Chaining method in the expert system supports the logical reasoning process from the symptom data provided by the user towards the conclusion of the diagnosis, thus enabling the system to mimic the thinking process of an expert in diagnosing measles. The system is developed using the Dart programming language with the Flutter framework to ensure a user-friendly and responsive interface across various Android devices. Testing was conducted through two approaches, namely Blackbox Testing to test the system's functionality from the user's perspective, and Whitebox Testing to evaluate the logic flow and internal structure of the program. The test results show that the system operates well without logical errors and is capable of providing accurate and relevant diagnostic results based on the combination of symptoms selected by the user. In addition to technical accuracy, this system also demonstrates significant potential in social aspects, particularly in improving access to healthcare services in remote areas with limited medical personnel and healthcare facilities. With an Android mobile base, this application can be widely accessed and easily used by the community, even in conditions of minimal internet network. Besides diagnosis, the system also provides educational information about measles, including symptoms, modes of transmission, prevention, and treatment, which can enhance the knowledge and awareness of the

community in maintaining the health of their children. Therefore, the integration of an iterative software development approach, logical expert reasoning methods, and thorough system testing proves that this system is suitable to be used as a diagnostic aid as well as an effective health education medium.

Acknowledgement

Praise be to Allah SWT for His abundant grace and grace, so that this journal can be completed properly. I would like to express my gratitude to my parents, family, and friends who have given prayers, encouragement, and moral support during the process of compiling this journal. Hopefully this work can make a useful contribution to the development of science and become a useful reference for readers.

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