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DESIGN OF QUEUING SYSTEM USING PRIORITY QUEUE ALGORITHM AND MULTI CHANNEL MULTI PHASE METHOD AT WEBSITE-BASED PATIENT REGISTRATION SECTION (CASE STUDY OF DONGGALA HEALTH CENTER)

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ABSTRACT
This research was conducted to regulate the queuing process which is often longer than the service standards set in the Decree of the Minister of Health Number 129 / Menkes / SK / II / 2008 stipulates that the waiting time for outpatients is equal to 60 minutes or less than 60 minutes, This study aims to design and build a website-based electronic queuing system at Puskesmas Donggala using the Priority Queue algorithm and the Multi Channel Multi Phase method. This system is designed to improve the efficiency of patient registration by reducing waiting time and providing priority for patients with emergency conditions. The research method includes data collection through observation and interviews, as well as system testing through simulation. The results show that the proposed system can reduce waiting time and increase patient satisfaction. The implementation of this system is expected to provide an effective solution to queuing problems in health facilities.

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I. INTRODUCTION

Queuing is an activity that is often done or encountered daily [1], [2]. Queuing is a process that causes a waiting line, or it can also be interpreted as waiting lines to get service. [3]. The queuing process at the health center is a process related to the arrival of patients at a service facility, then waiting in the queue line if they cannot be served, and leaving the service facility when they have finished being served [4] .

The Ministry of Health determines waiting times through minimum service standards set out in Minister of Health Regulation No. 129/Menkes/SK/II/2008 on Minimum Hospital Service Standards and must be adhered to by each health center in providing outpatient services. The waiting time must be less than or equal to 60 minutes. Providing timely services means paying attention to the length of time patients wait at the health facility, starting from the time the patient registers at the counter, queues, and waits for a call to the general clinic to be interviewed and examined by a doctor, nurse, or midwife. The waiting time can be categorized into more than 60 minutes (long category), 30-60 minutes (medium category), and less than 30 minutes (fast category) [5], [6]. But in reality, there are many patients who can wait longer than the waiting time as set by the government. Given the people who queue, that is, people who are sick. Waiting in a queue for a long time has more adverse effects on patients whose physical condition is not optimal. This is exacerbated by the possibility of disease transmission by fellow patients in the waiting room, especially diseases that can be transmitted through the air, such as influenza and tuberculosis [7]. This can aggravate the patient's condition which must be treated immediately, and the patient also feels less satisfied with health services.

In previous research conducted by Aryandi and Jorgha Akram Nugraha in 2023. this study aims to overcome the problem when patients make visits and register until finally getting a visit queue number which is still done manually and causes a lot of patient time to be wasted waiting. To overcome this problem by building a web-based

Patient Visit Online Queuing System based on priority queue where this system makes it easier for patients to register, so that the process of taking patient queues does not take long and becomes more efficient for patients. The achievement of this research is that this online queuing system can make it easier for patients to take the patient registration queue and this queuing system can also provide valid information about queues in real time and provide information about the queue that is running [8].

In other research conducted by Antonius Purba and Insan Taufik in 2018. The research focuses on the problem of patient accumulation when taking queue numbers, too many queues in the queuing system and the long waiting time in the queuing system so that the queuing process is considered to slow down the service process. The proposed solution is a queuing system equipped with several service entry points and several service stages called the Multi Channel Multi Phase queuing system, the achievement of this research is by using the Multi Channel Multi Phase method which initially served 18 people / hour to 12 people / hour and then the use of the Multi Channel Multi Phase queuing system can be fulfilled [9].

This research will combine the Priority Queue Algorithm with the Multi Channel Multi Phase method. There are several queuing algorithms including First Come First Served (FCFS), Last In First Out (LIFO), Service In Random Order (SIRO) and Priority Queue (PQ). In the First Come First Served (FCFS) algorithm, customers who arrive early will get service first. This is a commonly used queuing discipline. Last In First Out (LIFO) is the customer who arrives last will be served first. Service In Random Order (SIRO), namely service based on random opportunities or service performed randomly. And the algorithm used in this study is Priority Queue, namely service priority is given to those with higher priority than those with lower priority and this algorithm is used to solve queue management problems based on level of importance and needs, while the First Come First Served (FCFS), Last In First Out (LIFO), Service In Random Order (SIRO) algorithms cannot accommodate the problems in this study. And the Multi Channel Multi Phase method is Multi Channel (Many channels) and Multi Phase (Many stages), By applying this method, the development of a queuing system can produce more optimal services, reduce customer waiting time, and increase the efficiency of the queuing process. The diversity of channels and stages allows adjustment to various customer needs, while proper prioritization can speed up handling in emergency cases.

The current service flow at the donggala puskesmas is still local, where patients come directly to the puskesmas, takes the queue number so that with a large number of patients the registration waiting room is getting full of patients, the queuing system has also not been able to distinguish patients who must be served first for priority and emergency reasons, so the Priority queue algorithm is used to determine patients who must be prioritized. Using Priority Queue algorithm, this system can give priority to patients with emergency conditions, so that their waiting time can be minimized. Priority Queue is a form of data structure based on queue structure. Basically, priority queues have three types of priorities: high, medium, and low. Priority queues are generally followed by several sets of instructions, such as insert and delete, as well as searching for maximum or minimum values [10]. Priority Queue is based on the rule Elements with higher priority are processed first compared to elements with lower priority and two elements with the same priority are processed in the order they were put into the priority queue [8], [11], [12]. By implementing a multi-channel - multi-phase queuing system, where there will be more than one entry point for registration, so that the patient arrival pattern is divided into several times and paths that are adjusted to the time requirements of the patient and there is more than one stage of service [9], [13].

II. METHODS

A. Types of Research

The research used in this study is an applied research method. Applied research is conducted with regard to practical realities, application, and development of science produced by basic research in real life. Applied research serves to find solutions to specific problems. The main objective of applied research is problem solving so that the results of the research can be utilized for the benefit of humans either individually or in groups. This applied research is to solve problems by improving service quality through optimizing patient queues. This is expected to increase patient satisfaction and the effectiveness of medical services [14]. The applied research method was chosen because of its focus on the practical application of research results to solve real problems, such as the development of a queuing system at Puskesmas Donggala with the Priority Queue algorithm and a multi-channel multi-phase system. This method is more appropriate than basic research because it allows the implementation of immediate solutions that can improve the efficiency of patient registration services, reduce waiting time, and improve patient experience. In the context of this research, the applied approach also facilitates collaboration with healthcare practitioners to capture field needs and design practically relevant solutions.

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B. System Development

The waterfall method is often called the classic life cycle, the name of this model is actually the "Linear Sequential Model" where it describes a systematic and sequential approach to software development, starting with the specification of user requirements and then continuing through the stages of planning, modeling, construction, and delivery of the system to users (deployment), ending with support for the complete software produced [15]. Can be seen in Figure 1.

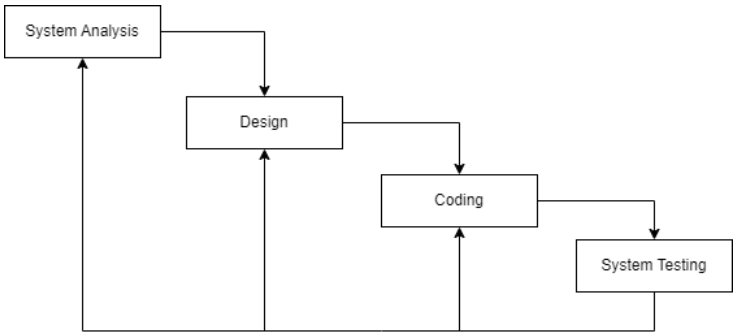

Figure 1 Metode Waterfall

1. System Analysis
   This stage requires communication aimed at understanding the software expected by users and the limitations of the software. Information can be obtained through interviews, discussions or direct surveys at Donggala Health Center. The information is analyzed to get the data needed by the user and incorporated into the system being built.
2. Design
   The next design process requires creating a program design that allows users to use this information system software more easily. users to use this information system software more easily. To make it easier to adapt the program design into the form of a website, the author sketches the appearance design before making the program design.
3. Coding
   In this coding stage, the author translates the design into the PHP programming language that can be understood by the computer operating system into a website display. PHP programming language that can be understood by the computer operating system into a website display. And the author uses a database as a database for the program to be created.
4. System Testing
   System testing uses Blackbox testing to ensure that there are no errors in the program to be run, so testing of the developed program is carried out. Checking every implementation of the program code that has been made is a testing process. In addition, using the System Usabity Scale (SUS), this test is carried out from the user's point of view with a questionnaire to evaluate the system whether the system is easy to use. Questionnaires are data collection used for information from respondents or users.

III. REASULT AND DISCUSSION

A. *Planning*

In the early stages of the research, Puskesmas Donggala faced challenges in the efficiency of patient registration services, with irregular queues and uncontrolled waiting times. This research aims to design and implement a web-based Queuing System with Priority Queue Algorithm and Multi Channel Multi Phase Method. Priority Queue Algorithm sorts patients based on priority, ensuring patients with urgent needs are served faster. The Multi Channel Multi Phase Method divides the service process into multiple channels and phases, allowing for more structured and efficient handling. In this way, patients can be directed to channels and phases that suit their priorities and needs, improving overall efficiency and quality of care.

The effect of the priority system on waiting times is seen in two main aspects. First, with different priority categories, higher priority patients will experience shorter waiting times as they are served faster, while lower priority patients may have to wait longer. This ensures that more critical cases get immediate treatment. Secondly, overall, waiting times may become more efficient as the prioritization system helps to better manage and allocate

resources.

The impact of a prioritization system on patient satisfaction and service quality includes several important points. High-priority patients will usually feel more satisfied as they receive prompt service according to their immediate needs. Conversely, lower priority patients may experience decreased satisfaction due to longer waiting times. In terms of service quality, an effective prioritization system can improve the overall quality of service by ensuring that patients who require immediate attention receive prompt and appropriate treatment. In addition, the multi-channel multi-phase method contributes to improved service quality by reducing waiting times and enabling more structured case handling.

B. *Analysis*

At this stage the analysis was carried out by observing the outpatient service process at the Donggala Health Center, which included patient registration, waiting time for medical services, and the service process itself. Observation includes measuring medical service time for the first 10 patients in each outpatient clinic as a sample. The results showed that registration started at 7am and closed at 11am on the same day, when the counter was closed patients could not register and had to return the next day. Many patients try to arrive early to obtain a queue number as soon as possible, which results in a buildup before the registration process begins. Registration service time is fixed each day, the number of service channels is single or single channel, After registration, patients queue in the order of arrival at the poles that have one service room. The queue uses the First Come First Serve (FCFS) principle, but patients have to wait an average of 2 hours after registration to receive medical services from the doctor. The main problem lies in the long waiting time before receiving medical services, which is not conducive for patients who are not in good health. To solve this problem, it is necessary to develop a new efficient system for registration and queue monitoring, so that patients can be more comfortable before receiving services at the outpatient clinic.

The new queuing model built on a web-based system can accept customers who are still limited according to the operating hours of the puskesmas. The number of channels or service channels becomes more, which was previously Single Channel turned into Multi Channel. The system capacity and patient population that was previously limited can change to unlimited because it is entirely handled by the system, while the service discipline uses a priority queue which previously used the First Come First Serve (FCFS) rule. Using a priority queue over FCFS lies in its ability to set priorities between entities based on relative importance, allowing faster handling of urgent cases such as emergency patients or critical conditions, rather than simply following the order of arrival. The results of the analysis carried out previously by observation showed that the time spent by patients from the registration process to getting medical services was 2 hours, while after being implemented on the website, registration simulations were carried out by several users to calculate the time spent by patients. The time calculation results obtained are only 5 minutes from the user registering to getting a queue number. This proves that the new system built reduces patient waiting time very efficiently.

C. *System design*

The system flowchart is used as a simulation of the running system in accordance with the real conditions of the system and makes it easier to model the system, even the efficiency of the system can already be seen based on the flowchart made even though it has not been expressed in numbers [16]. Can be seen in Figure 2.

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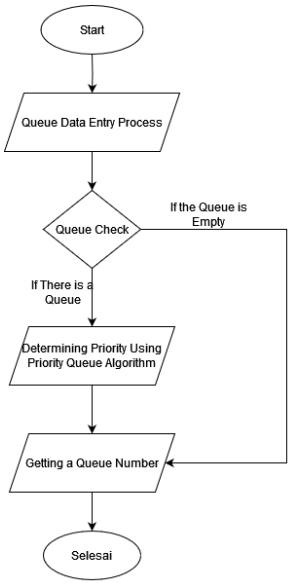

Figure 2 Flowchart Queueing

System rules serve a variety of important purposes, including managing processes in an efficient and organized manner, and providing guidance for consistent and fair decision-making. In addition, system rules maintain security and compliance with laws and policies, and ensure that products or services meet established quality standards. Rules also assist in risk management by identifying and mitigating potential problems, facilitating the development of clear training materials, and organizing user interactions with the system for a consistent experience. Can be seen in table 1.

TABLE 1
SYSTEM RULES

No.	Conditions	Priority	Description	Implementation
1.	Emergency Patient	Highest	This includes urgent medical circumstances such as heart attacks, accidents, or other critical conditions.	Prioritized for immediate acceptance without waiting.
2.	Pregnant Mother	Height	Need special care and regular monitoring during pregnancy.	Special queuing facilities are provided for pregnant women with minimal waiting time.
3.	Age 60 Years and Above	Height	Prone to more serious health complications.	Prioritized for faster care and treatment.
4.	Patients with Disabilities	Height	Requires extra assistance in navigation and medical care.	Accessibility and special handling facilities are provided as needed.
5.	Allergic Reaction	Medium	Presents a potential risk to certain medical treatments.	Closely monitored to prevent allergic reactions during treatment.
6.	TBC	Medium	Requires intensive medical care to reduce the spread of infection.	Special attention is given to isolation management and prevention of TB transmission.
7.	Flu	Low	Usually mild but requires treatment to reduce the spread of infection.	Flu treatment facilities are provided with regular monitoring of the patient's condition.
8.	Age 5 Years and Below	Low	Have special needs but tend to be more medically stable.	Special facilities are provided for children including child-friendly care.

Use case diagram is a diagram used to model system behavior, Use case describes the interaction between system users and the system. [17]. Can be seen in Figure 3

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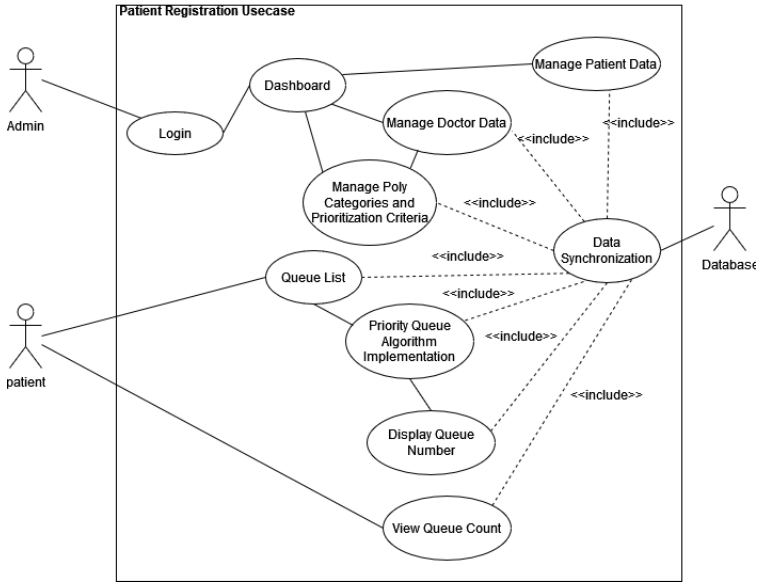

Figure 3 Usecase Diagram

The design of the activity diagram will explain the description or flow of users in a system [18]. Can be seen in Figure 4.

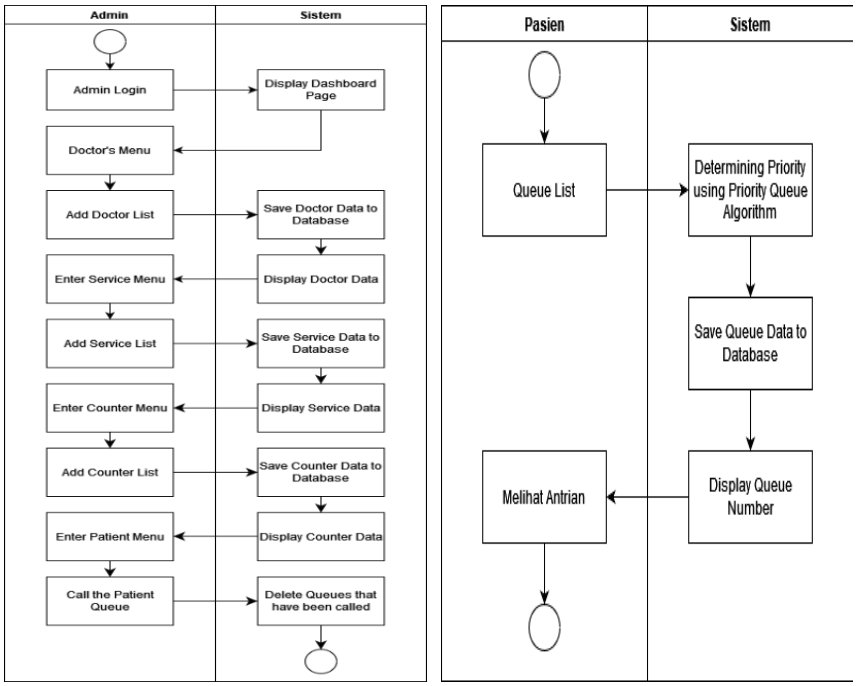

Figure 4 Activity Diagram

D. *Application*

This display is the dashboard page of the website-based queuing system at Donggala Health Center. Divided into two main sections, namely "Login" and "Add Patient Queue". Displays information about the ongoing queue, including the total number of queues, queues that have been served, and details of patients who are being served. This page makes it easy for patients to monitor queue status in real-time and assists health center staff in managing queues more effectively. The right section displays the admin dashboard page, this page displays total doctors, total services, total patients and total counters. Can be seen in Figure 5.

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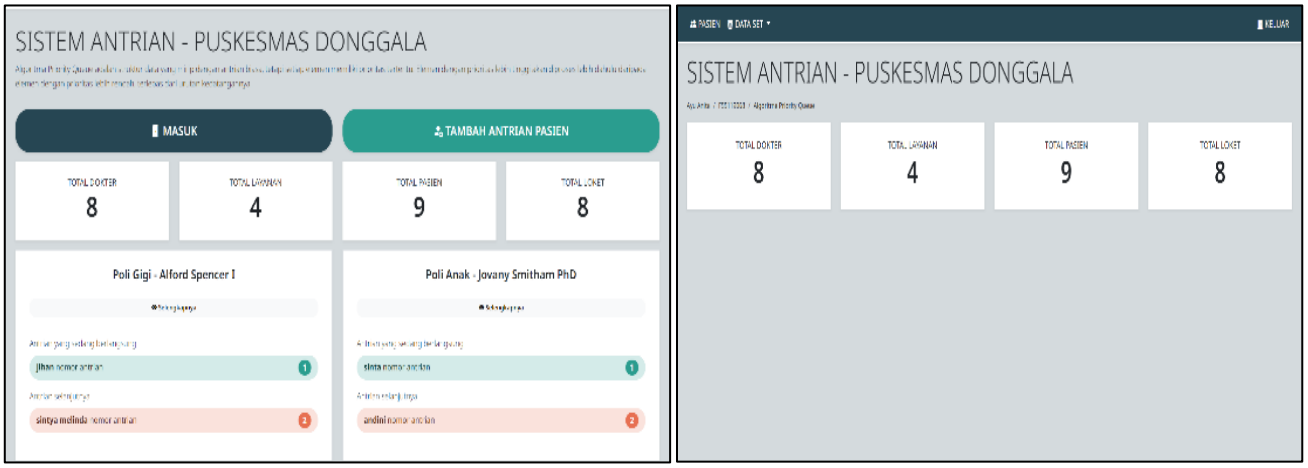


Figure 5.Dasboard View

The login page is a page that allows Admin to access the system by entering a username and password. This page allows the admin to monitor and make calls as well as remove patients from the queue list. can be seen in Figure 6

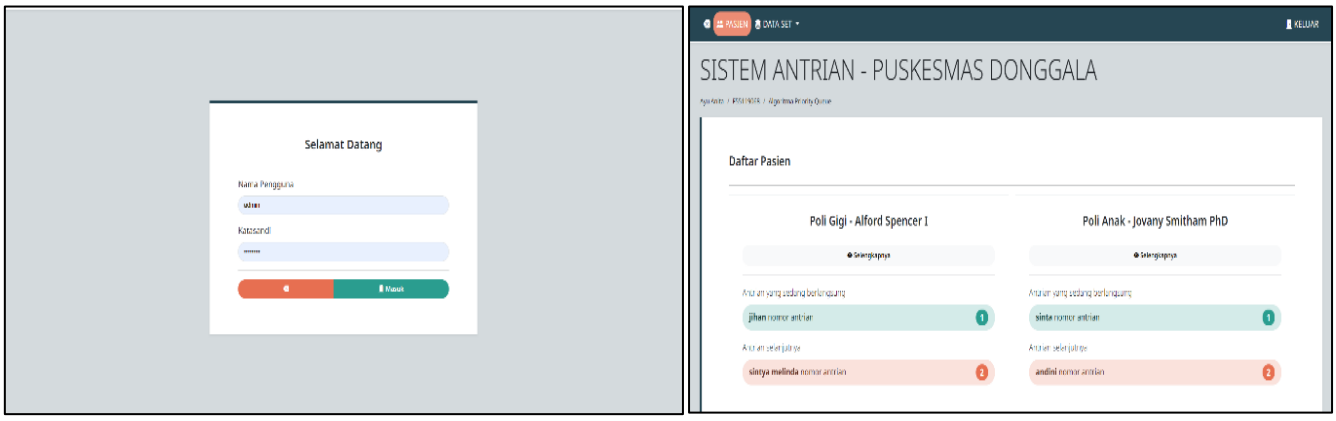
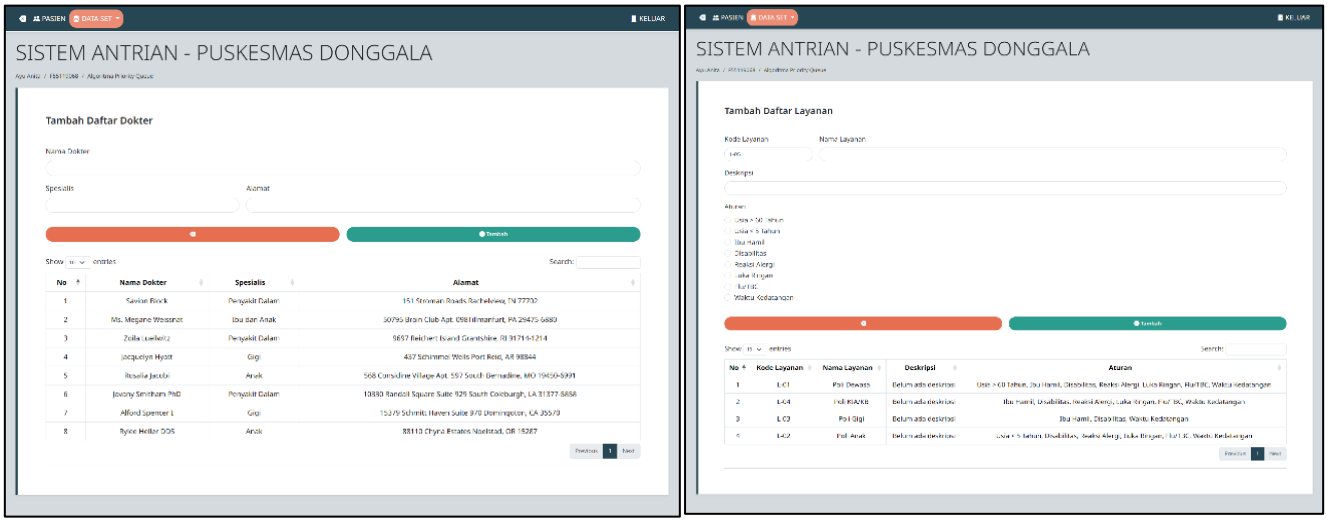


Figure 6 Login and Patient List View

If you press the data set button, it will display three options, namely service doctors and counters. In the doctor section, the admin inputs the name, address and specialist of the doctor. While in the service section, the admin inputs the code, name, description and priority rules. In the counter menu, the admin combines doctor data and service data into the counter menu. Can be seen in Figure 7.



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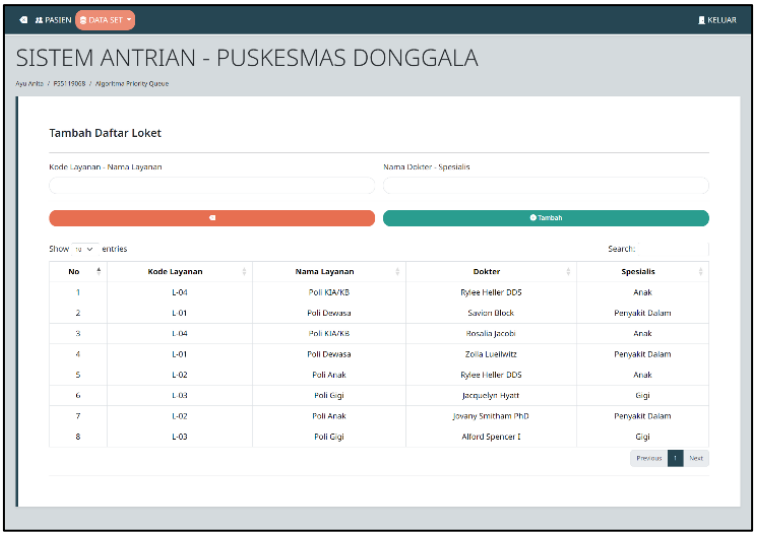

Figure 7 Display of Doctor, Service and Counter Menus

On the add patient queue page, where the patient enters his data and chooses the name of the service and the type of general patient or bpjs, if using bpjs must fill in the bpjs number. Then the patient chooses a rule to determine which patients should be prioritized. Can be seen in Figure 8.

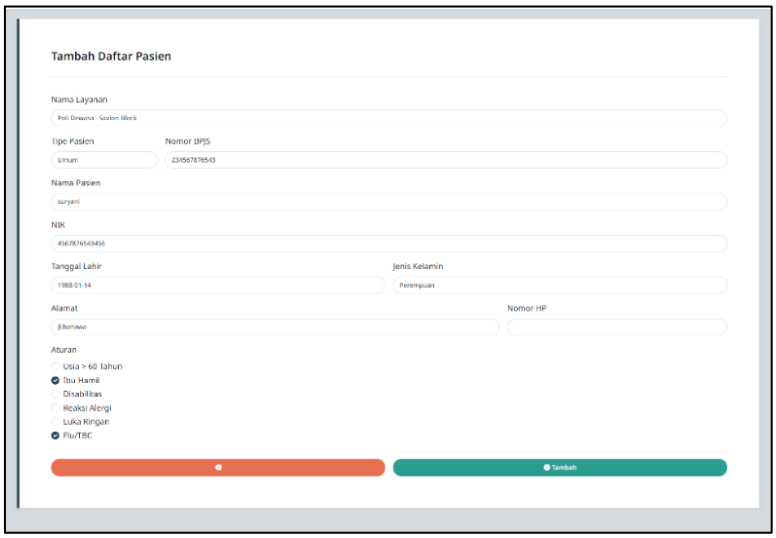

Figure 8 Display of Add Patient List

This page displays the queue of patients who have filled in the rules during previous registration, The choice of queue priority rules depends on the situation and needs. on this page the priority queue algorithm runs, Elements with higher priority will take precedence in taking the queue, rather than elements with lower priority. Can be seen in Figure. Can be seen in Figure 9.

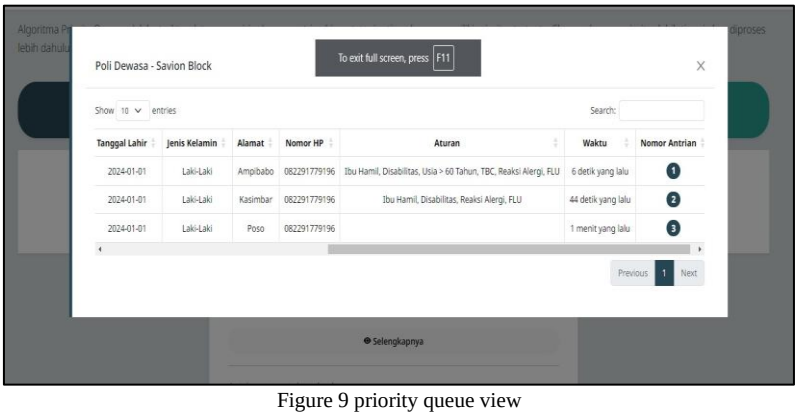

Figure 9 priority queue view

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E. *System Testing*

Blackbox is a testing method that focuses on the functional needs of the application, testing can define Test Cases and evaluate the functional needs of the application. Blackbox testing aims to check whether the system built can run properly. At this testing stage, the author will evaluate each feature contained in the system, if there are features that do not run or function properly, the researcher will make improvements to the system. Testing is said to be successful if all the features designed have functioned [19]. The following are the results of system testing with the Blackbox method on the queuing system at the Donggala Health Center. Can be seen in Table 2.

TABLE 2
SYSTEM TESTING RESULTS

Test Case	Test Scenario	Expected Results	Testing Results
Patient List	Pressing the Patient List button on the Home page and inputting Patient data and selecting priorities, then pressing the add button	Displays the new patient data form, and the new data is successfully saved into the database then displays the queue that the patient gets.	Valid
View the current Queue	Press the more button on the Home page	Displays the queue number	Valid
Opening the Admin Website	Opens the Admin website address	Displays the Login page	Valid
Perform Login	Enter the Admin username and password according to the database and press the Login button	Display the Admin Dashboard page	Valid
View Patient Data	Pressing the Patient button on the left sidebar menu	Display all patient data	Valid
Calling and Deleting Patient Data	Pressing complete then the patient queue will appear	Then a patient call will be made while deleting patient data in the queue.	Valid
Viewing Doctor Data	Pressing the doctor button on the left side-bar menu	Display doctor data	Valid
Adding Doctor Data	nput doctor data, then press the Save button	Display the new doctor data form, and the new data is successfully displayed	Valid
Changing Doctor Data	Change the contents of the selected doctor data and press the Save button	Display the selected doctor data form and the data has been successfully changed	Valid
Deleting Doctor Data	Pressing the Delete button on one of the doctor data, then pressing the OK button	Displays a delete confirmation dialog and the data is successfully deleted from the database	Valid
Viewing Service Data	Pressing the service button on the left side-bar menu	Display service data	Valid
Adding service data	Input service data, then press the Save button	Displays the new service data form, and the new data is successfully displayed.	Valid
Changing service data	Change the contents of the selected service data and press the Save button	Display the selected service data form and the selected data is successfully changed	Valid
Delete service data	Pressing the Delete button on one of the service data, then pressing the OK button	Displays a delete confirmation dialog and the data is successfully deleted from the database	Valid
View Counter Data	Pressing the counter button on the left sidebar menu	Displaying counter data	Valid
Adding counter data	Input counter data, then press the Save button	Display the new counter data form, and the new data is successfully displayed.	Valid
Changing counter data	Change the contents of the selected counter data and press the Save button	Display the selected counter data form and the selected data Selected data is successfully changed	Valid
Delete counter data	Pressing the Delete button on one of the counter data, then pressing the OK button	Displays a delete confirmation dialog and the data is successfully deleted from the database.	Valid

F. Questionnaire Testing

Questionnaires are data collection used for information from respondents or users. User satisfaction is a person's assessment of the performance received from a system in relation to the expectations of the system. In addition, using the System Usabity Scale (SUS), this test is carried out from the user's point of view with a questionnaire to evaluate the system whether the system is easy to use. The SUS questionnaire consists of 5 statements that are rated using a Likert scale containing five to seven scale levels. The Likert scale is used to measure the views, opinions, and perceptions of individuals or groups about social phenomena [1]. In this study, the use of a Likert scale involves five levels, namely 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree [20]. Can be seen in Table 3.

TABLE 3
QUESTIONNAIRE TESTING TABLE

No.	statement	SA	A	N	D	SD	Amount	Presentase
1.	I think I will use this system again	6	2	2	0	0	85	85%
2.	I think the system is easy to use	5	3	2	0	0	83	83%
3.	I think the features in this system work well.	5	3	2	0	0	83	83%
4.	I think others will understand how to use this system easily	4	4	2	0	0	80	80%
5.	I don't think there are any difficulties in using this system	5	4	1	0	0	85	85%
	Total						416	83%

The application of the System Usability Scale (SUS) method is carried out to analyze user satisfaction. The results of the calculation of the average SUS score related to user satisfaction have been interpreted based on the SUS Scores Rating Scale, resulting in a score of 83% with an Adjective Rating of Good so that the web-based queuing system is declared Acceptable. Thus, it can be concluded that the web-based queuing system is Acceptable and shows satisfaction with the application with Adjective Rating Good.

IV. CONCLUTION

The implementation of this system also reduces patient waiting time significantly by dividing the queue into several channels (multi-channel) and several phases of the process (multi-phase), so that the accumulation of queues at one point can be minimized. In addition, the web-based system provides easier access for patients to register and monitor their position in the queue and makes it easier for registration staff to manage and organize the queue more effectively. With a more structured and organized queuing system, the quality of service in the patient registration department improves, which in turn increases patient satisfaction and reduces complaints related to waiting time. Overall, this research shows that the application of the Priority Queue algorithm and the Multi Channel Multi Phase method in a website-based queuing system can provide an effective and efficient solution to overcome queuing problems in health facilities, especially in the patient registration section.

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