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THE QUEUING SYSTEM ANALYSIS FOR PATIENT REGISTRATION COUNTERS AT A HOSPITAL

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Abstract
Hospitals are vital for healthcare and must continually enhance service quality to boost patient satisfaction. Lengthy outpatient service times, particularly during peak demand, can detrimentally affect service quality. This study investigates the application of queuing theory to the registration service facilities at PKK Hospital. The goal is to identify an appropriate queuing model to describe the outpatient registration counters' conditions and assess the model's performance. The research employs a quantitative approach, using data from observations and literature review, with purposive sampling. The study concludes that the Multiple Channel – Single Phase queuing model is most suitable for describing the outpatient registration counters at PKK Hospital. According to the findings, this queuing model offers optimal performance, with an average service time of 4.076 minutes per patient and a corresponding waiting time of approximately 3-8 minutes.

Keywords:
Queuing system; services; hospitals; multiple channels-single phase

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1. Introduction

The increasingly rapid development of the era must be balanced with the need to be able to keep up with the flow of current developments in the field of goods or services which are currently occurring rapidly. Like providing fast service in the hospital service industry. Hospitals are important institutions of the system service health that provides complex medical services, emergency services, knowledge and technology transfer centers and acts as a referral center. Hospital need always improving quality service to use increase satisfaction user services where this is appropriate Decree of the Minister of Health of the Republic of Indonesia No.983/SK/MENKES/XI/92 which states that the hospital's mission is to provide quality and affordable health services to the community to improve the level of public health.

The minimum time standard for outpatient service based on the Ministry of Health Number 129/Menkes/SK/II/2008 is less or equal to 60 minutes. Queues that occur in hospitals can have an impact on this function if the waiting time is too long, that matter can reduce the quality of service perceived by the community. Very long queues and taking too long to get a turn for service are very annoying, which is detrimental to those who need service because time is wasted just waiting [1], [2]. The provider also experiences indirect losses because it will lower work efficiency, profit, even giving rise to an image that bad for the patient [3].

Queuing theory is the science of queue formation [4]. Queuing is the activity of waiting for your turn to be served due to the arrival of customers and unbalanced service times. The difference between the number of requests for service facilities and the facility's ability to serve gives rise to two logical consequences [5], [6]. Therefore, queuing theory is the right method to solve the problem of long queues in a facility.

According to previous research, queuing theory used to compare manual counters (with serving staff) and the use of self-service counters (THB). The results show that the use of self-service counters reduces queues for ticket purchases [7]. Several other studies show an increase in customer satisfaction after improving the queuing system [8]–[11]. This research examines patient registration queues at hospitals, which has not been studied much by previous research.

To see the application of this queuing theory to registration service facilities, the author chose the PKK hospital as the research object. PKK Hospital is one of the hospital centers located in Bekasi which provides various community needs with complete and adequate facilities so as to attract people's interest in coming for treatment. Currently there are 2 registration counters which are used to serve patients seeking treatment. At certain times, many visitors come to the PKK hospital, resulting in busy service and queue problems. When providing services to patients, events occur in the system queue no can avoided and becomes a problem that must be addressed immediately find a solution. Facilities and services, including queue management, are factors that influence customer satisfaction [12]–[15]. Good service, including queue management, will increase customer satisfaction, including hospital patients [3], [16]. Long queues make patients feel disturbed,because it considers their waiting time spend it wasted free for queue forserved. Queue waiting time will be a determining factor in choosing hospital services. So this research was carried out with the aim of determining an appropriate queuing model to describe the conditions at the outpatient registration counter at PKK Hospital and to determine the performance of the queuing model at the outpatient service registration counter at PKK Hospital.

2. Method

In this research the author uses a quantitative approach with descriptive research type [17] states that "the quantitative approach is the measurement of quantitative data and objective statistics through scientific calculations derived from samples of people or residents who are asked to answer a number of questions about a survey to determine the frequency and percentage of their responses.

Queuing theory is considered appropriate in solving queuing problems [5], [6], [18]. The descriptive research in this study explains how the queuing theory is applied to the queuing system in outpatient registration based on the results of the queuing formula calculation for model B (M/M/S). The research was carried out in December 2021 with data collection carried out over 14 random days. Based on initial discussions with management, this research was carried out at the outpatient registration facility in the poly department from 9 am to 4 pm.

This research involves a dependent variable and an independent variable. Identification of variables in this research is used to assist in determining the data collection tools and data analysis techniques used. The variable grid can be seen in the table below.

Table 1. Variable Grille

Variables	Variable dimensions	Indicator	No. Items
Outpatient registration counter queuing system (Haizer & Render, 2005)	Operational	1. The outpatient registration counter is open from 7 am to 9 pm 2. The hospital opens poly clinic services from 8 am to 8 pm	1 2
	Queue	3. Using a queuing theory system to register 4. Reduces the occurrence of complications during registration	3 4
	Registration process	5. Provide information and education to patients 6. Entering and checking patient personal data and asking for collateral used	5 6
	Number of counters registration	7. Counters are opened according to the number of queues 8. If there is a buildup at one counter, the counter will be opened again	7 8
	Average arrivals	9. View the number of arrivals on the previous day 10. Analyzing the number of arrivals to meet the number of counters that will be opened,	9 10
	Performance	11. Have accuracy, speed, responsiveness and provide clear information in serving patients 12. Hospital employees provide performance in accordance with company SOPs	11 12
	Optimal service	13. Able to provide effective communication to patients 14. Service officers provide accurate information regarding the doctor's arrival schedule	13 14

To obtain data in this study, the author used primary and secondary data obtained from direct observation in the field. In this study, the researcher observed directly at the registration counter, what had to be observed was service time, patients waiting and patients who were undergoing the registration process. And the results of studying various libraries and other literature that are relevant to research objectives such as online media and textbooks. The sampling technique used in this research is purposive sampling. Purposive sampling is a data collection technique with certain considerations. Sampling technique with certain criteria. In this study, the sample used is data from the queue at the registration counter for outpatient registration at the PKK hospital for the period January 2022.

The steps that must be taken in implementing and analyzing data are as follows:

1. Input research data, namely data on the number of arrivals and number of services divided into 60 minutes, and calculate the average number,
2. The average number of arrivals and the number of services must meet steady state conditions ($\rho = < 1\frac{\lambda}{c\mu}$) Where λ is the average number of arrivals. μ is the average number of services and c is the number of officers. If it has not met the steady state then the number of service facilities must be increased.
3. Test the suitability of the Poisson distribution on the number of arrivals and exponential data on service levels using the chi square test.

$$x^2 = \Sigma_{i=1}^{b}\Sigma_{j=1}^{k}\frac{\left(O_{lj} - E_{lj}\right)^2}{E_{lj}} \quad (1)$$

   If the hypothesis is accepted then the distribution follows Poisson and exponential, if the hypothesis is rejected then the distribution is general.

4. Determine the queue model

   Determining the performance measure of the service system, namely (Ls) the number of customers estimated in the system (Lq) the number of customers estimated in the queue (Ws) the estimated waiting time in the system (Wq) the estimated waiting time in the queue.

5. Make conclusions and make decisions based on the value of the analysis obtained to optimize services.

3. Result and Discussion

A. Research Result

In this study, arrivals at the outpatient registration counter at PKK Hospital had a Poisson distribution and service time was assumed to have an exponential distribution. To test the truth, a chi square test was carried out.

Table 2. Data on The Average Number of Service Times at The Outpatient Service Patient Registration Counter at PKK Hospital

Day	Observation time				Number of patients	Amount of time
	09.00-10.00		13.00-14.00			
	Number of patients	Amount of time	Number of patients	Amount of time		
Monday	26	3.92	20	4.15	46	8,073
Tuesday	21	3.95	18	4.22	39	8,175
Wednesday	18	4.17	24	3.88	42	8,042
Thursday	22	4.23	18	3.89	40	8,116
Friday	20	4.25	23	3.91	43	8,163
Monday	20	4.20	19	4.37	39	8,568
Tuesday	20	4.15	25	3.84	45	7,990
Wednesday	19	4.16	20	3.85	39	8,008

Day	Observation time				Number of patients	Amount of time
	09.00-10.00		13.00-14.00			
	Number of patients	Amount of time	Number of patients	Amount of time		
Thursday	21	4.29	19	4.00	40	8,286
Friday	24	4.04	21	4.24	45	8,280
Total	**211**	**41.35**	**207**	**40.35**	**418**	**81,700**

Matrix form for the number of patients from 09.00 - 10.00

1. Matrix A is a matrix that contains the number of patients every day from 09.00-10.00
2. Matrix B is a matrix that contains the total number of patients every day

$$A = \begin{bmatrix} 13 \\ : \\ 11 \end{bmatrix} \qquad B = \begin{bmatrix} 12 \\ : \\ 8 \end{bmatrix}$$

The properties of matrix multiplication are:

If the column and row have the same number then they can be added:

So, $C = A + B = \begin{bmatrix} 25 \\ : \\ 19 \end{bmatrix}$

Calculation Results Based on Analysis Using Queuing Theory

Based on the results of the queuing system regarding arrival rates and service time levels, the outpatient service queuing system model at PKK Hospital is a queuing system model with a Poisson arrival pattern and exponential service time.

a. Average patient arrival

$\lambda = \frac{patient\ count}{duration\ of\ observation}$

$\lambda = \frac{418}{20\ jam}$

λ = 20.90 patients every hour

λ = 0.348 patient every minute

It can be seen that in 1 minute there are 0.348 patients who come or 1 patient comes every 2.874 minutes.

b. Average patient service time

To find the eaverage service time obtained from:

$$x = \frac{cumulative\ service\ time}{patient\ count}$$

$$x = \frac{1704}{418}$$

$x =$ 4.076 minutes per patient

It can be seen that, 1 patient is served for 4,076 minutes, so:

$$\mu = \frac{1}{average\ service\ time}$$

$$\mu = \frac{1}{4.076}$$

$\mu = 0.245$ patients per minute

By obtaining the values of λ and μ where λ > μ, to calculate the performance of the queuing system, it is necessary to know whether the steady state condition is met or not. Steady state is a condition where the level of utility or service facility is less than 1 or the average patient arrival time is smaller. of the average patient service time required. Can be searched as follows:

1. Probability of busy times

$$\rho = \frac{\lambda}{c\mu}$$

$$\rho = \frac{0.348}{2\ (0.245)} = 0.710 = 71\%$$

The value of the service facility usability level obtained is less than 1, meaning that the average patient arrival time does not exceed the average patient service time provided so that it meets steady state conditions.

2. The probability that all officers are unemployed

$$P_0 = \frac{1}{\left[\sum_{n=0}^{C-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right) n\right] + \frac{1}{c!}\left(\frac{\lambda}{\mu}\right) C \frac{c\mu}{c\mu - \lambda}}$$

$$P_0 = \frac{1}{\frac{1}{0!}\left(\frac{0..348}{0.245}\right)^0 + \frac{1}{1!}\left(\frac{0.348}{0.245}\right)^1 + \left[\frac{1}{2!}\left(\frac{0.348}{0.245}\right)^2 \frac{2(0.245)}{2(0.245) - 0.348}\right]}$$

$$P_0 = 0.169 = 16.9\%$$

It can be seen that the probability that there are no patients or staff who are unemployed is 16.9%.

3. Average number of patients in the system

$$L_s = \frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^c}{(C-1)!\ (C\mu - \lambda)^2} P_0 + \frac{\lambda}{\mu}$$

$$L_s = \frac{(0.348\ \times 0.245)\left(\frac{0.348}{0.245}\right)^2}{(2-1)!\ \times ((1 \times 0.245) - 0.348)^2} \times 0.169 + \frac{0.348}{0.245}$$

$L_s = 2.862$ patient every minute

4. Average number of patients in queu

$$L_q = L_s - \frac{\lambda}{\mu}$$

$$L_q = 2.862 - \frac{0.348}{0.245}$$

$$L_q = 1.411$$

It can be seen that, in 1 minute on average there are 1,441 patients in the queue or there is 1 patient in the queue every 0.693 minutes.

5. Average waiting time in the system

$$W_s = \frac{L_s}{\lambda}$$

$W_s = \frac{2.862}{0.348} = 7.706$ minutes per patient

This means that an average of 1 patient waits in the system for 7,706 minutes.

6. Average wait in queue

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$$W_q = \frac{L_q}{\lambda}$$

$$W_q = \frac{1.411}{0.348} = 4.14$$

It can be seen that, on average, 1 patient waits in the queue for 4.14 minutes.

At PKK Hospital the number of outpatient visits that come every day varies as can be seen in the graph below.

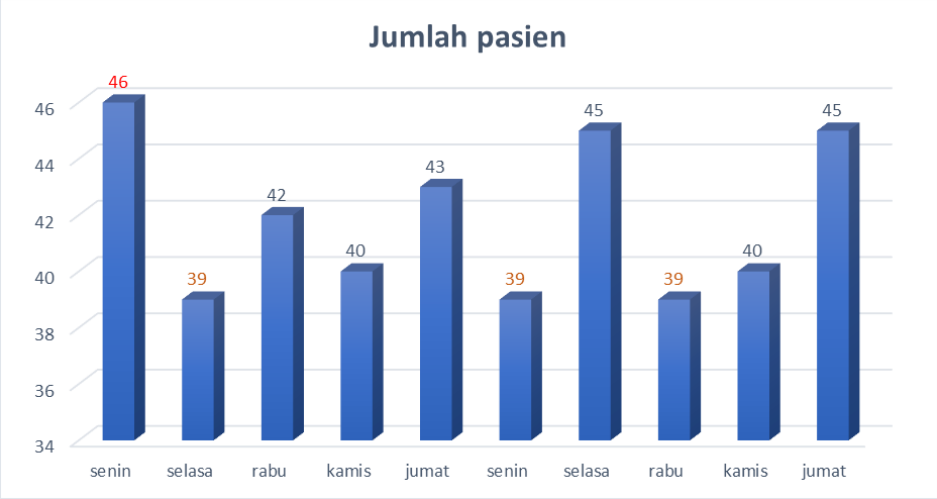

Figure 1. Data on The Number of Outpatients at PKK Hospitals

Based on Fig. 1. the research carried out for 14 days at the PKK hospital had the highest number of outpatients, namely on Monday in the first week, there were 46 patients, while the lowest number of outpatients at the PKK hospital was 39 patients. on Tuesday in week I, Monday in week II and Wednesday in week II.

Queuing System Model

Based on the results of the analysis of the average size of patient arrivals (0.348) and the suitability test is fulfilled, so when determining the performance size of the queuing system at inter-arrival times using a general model.

System Performance Measures

Based on the results of observations of the queuing system process at the outpatient service patient registration counter at PKK Hospital, the queuing performance will be calculated using the queue model (M/M/c): (GD /∞/∞).

The arrival rate and queue service level are known, namely:

$\lambda = 0.348$

$\mu = 0.245$

$C = 2$ officer

So, the queuing system utilization ratio is 71%, which means that the queuing system with 2 officers working is very good. If you test the performance of the queuing system by adding 3 and 4 officers, then the calculation results are presented in Table 3 as follows:

Table 3. Queuing System Utilization Ratio

	λ	μ	Utilization ratio
	Patients/min	**Patients/min**	**%**
1	0.348	0.245	71%
2	0.348	0.245	47.30%

	λ	μ	Utilization ratio
	Patients/min	**Patients/min**	**%**
3	0.348	0.245	35.50%

Based on the calculation results in Table 3, it shows that with the addition of counter officers to 3 and 4 officers, the queuing system utilization ratio decreases from 71% to 47.3% and 35.5%. This shows that the queuing system is working well if there are only 2 officers in the service and if there are additional officers, it will be even worse if there are 3 and 4 officers. Therefore it is recommended to maintain with 2 service officers which is quite efficient seen from the utilization ratio.

B. Discussion

Referring to the results of research conducted by the author, it shows that there is an analysis that influences the service at the registration counter. Looking at the results of this research and linking it with research that has been carried out previously by previous researchers regarding the application of queuing theory to BPJS patient services specifically for internal medicine at the Bunda Thamrin general hospital in Medan (Ade Kumalasari, 2018), it can be concluded that queuing theory uses the method according to (Heizer and Render, 2016) (M/M/2): (FCFS /∞/∞) has a role in knowing that service at the PKK hospital registration counter has been achieved with 2 counter staff and the result is 1 patient arrives every 2,874 minutes, and 1 patient waits for 4.1 minutes in the queue, 7,706 minutes of patient waiting in the system with a probability of busy periods of 71%,

This is in line with research (Ade Kumalasari, 2018) entitled "Application of queuing theory to BPJS patient services specifically for internal medicine at Bunda Thamrin Medan general hospital" which states (M/M/2): (FCFS /∞/∞). That patient arrival times have a Poisson distribution, and patient service times have an exponential distribution with the number of services of 2 officers with the result that 1 patient arrives every 2,899 minutes and 1 patient waits for 2.5 minutes in a queue of 12.3 minutes. With the stipulated time at Bunda Thamrin Medan General Hospital of 5-10 minutes.

Thus, the results above indicate that the faster the service provided by the registration officer, the more the patient's waiting time will be reduced. Queuing theory model using methodsaccording to Heizer and Render (2016) (M/M/2) : (FCFS /∞/∞). It is in accordance with previous research on the application of queuing theory in BPJS patient services specifically for internal medicine at the Bunda Thamrin general hospital in Medan (Ade Kumalasari, 2018) and can know that the waiting time for services is optimal according to the hospital's provisions for service times.

4. Conclusion

Referring to the research results and discussion of the previous chapter, the author concludes the application of queuing theory in PKK hospitals as follows:

1. The appropriate queue model to describe the conditions at the outpatient registration counter at PKK Hospital is the Multiple Chanel - Single Phase queue model because there is one queue line and has 2 outpatient registration counter service facilities at PKK Hospital. helps in anticipating queue build-up at outpatient registration counter services. The queuing discipline model used at PKK hospitals is First Come First Serve (FCFS), that is, the first patient to arrive will be served first and the arrival and service capacity is unlimited.
2. The performance of the queuing model for the outpatient registration service system at PKK Hospital is optimal because it has a level of use of registration facilities that is in accordance with the results obtained, namely an average of 1 patient served for 4,076 minutes per patient, this time is in accordance with the waiting time for services at the hospital. The optimal PKK is around 3-8 minutes.

5. Suggestion

Based on the research results and conclusions that have been presented, maintaining 2 service officers is quite efficient, seen from the utilization ratio of 71%. It is hoped that the results of this research can be used as guidance material for further research. The author suggests that future researchers who will research PKK hospitals conduct research using different variables and examine more sources and references.

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