

Comparative Analysis of Outpatient Queuing Systems to Improve Hospital Services at ENT Polyclinics and Internal Medicine Polyclinics

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Abstract

Long outpatient queues reduce the effectiveness of hospital services and keep vulnerable patients waiting in crowded rooms, yet the queue conditions of polyclinics with very different patient volumes are rarely compared across hospitals. This study analyzes and compares the outpatient queue systems of the ENT Polyclinic and the Internal Medicine Polyclinic at Kardinah Regional Hospital, Tegal City, and Dr. Soeselo Regional Hospital, Tegal Regency. A mixed method was used. The chi-square goodness-of-fit test was applied to verify that arrivals follow a Poisson distribution and service times an exponential distribution, which is the condition for choosing the M/M/s queue model; the queue model was then determined with Kendall's notation; system performance was measured by the utilization factor ρ and, where a steady state exists, by the probability of an empty system, the queue length, and the waiting times; and a satisfaction questionnaire was given to 200 respondents. Observations covered the registration stage (07.00–10.00) and the doctor's examination stage (10.00–13.00). Both hospitals apply First In First Out and the M/M/1/ ∞/∞ model at the polyclinics. The utilization factor exceeded one ($\rho > 1$) in 32 of the 33 observed periods, so the queue systems were not in a steady state, and the registration stage was the bottleneck. Although 90% and 95% of respondents at Dr. Soeselo and Kardinah Hospitals were satisfied, adding servers and check-in machines at the registration stage is proposed to reduce congestion; the proposals should be validated before adoption.

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1. Introduction

Hospitals are institutions that provide various types of health services as well as areas for research and development of health sciences (Ahmad et al., 2022), (Kartikasari, 2019), (Septiani et al., 2017). The more optimal a hospital is in providing health services, the more satisfaction it will create, which leads to loyalty. However, as the population of sick people increases, the queues at hospitals become longer (Eko & Sinaga, 2018), (Nabyla & Sigitta, 2019).

A queue is a series of waiting lines formed by one or more customers to get service. Queues have many varieties that can be analyzed based on their characteristics, including queue actors, arrival characteristics, and service characteristics. The characteristics of queue actors include First In First Out (FIFO), Last In First Out (LIFO), Service in Random Order (SRO), and General Service Discipline (GSD). Arrival characteristics are divided into three categories: including arrival population, arrival patterns, and arrival behavior. Service characteristics are the relationship between the design of the queue system and the distribution of service time. The design of the queue system is Single Channel and Multiple Channel (Aseha et al., 2023). The distribution or distribution of service time can be estimated using the exponential probability distribution (Harpeni, 2020), (Juwana et al., 2024), (Nurhidayati et al., 2022) (Pratiwi et al., 2020), (Suzanti et al., 2024).

The characteristics of a queue in a place are based on the applicable operational system policy. Queue theory and characteristics can be found in various industries, especially those engaged in the service and service sector. In the service sector, for example, customer queues at the cashier, customer queues at the bank teller, vehicle queues at gas stations, and patient queues at hospitals (Heryana & Mahadewi, 2020), (Pratiwi et al., 2020).

However, the application of queuing theory does not always require customers or units to come to the place directly to carry out the queuing process. In the digital era, like today, the queuing process can be done with the help of technology, either through a website or a mobile application (Rinaldi & Ardiatma, 2024). This can certainly make it easier for humans as queuing service providers to be able to reduce waiting times, so that they are not too long (Nurrohman, 2021).

The queue characteristics that apply at Dr. Soeselo Regional Hospital Tegal Regency, and Kardinah Regional Hospital Tegal City, in the Outpatient Installation are First In First Out (FIFO), or patients who register earlier will be served first. In this case, patients can register online through the JKN Mobile Application provided. However, in January 2025, Kardinah Hospital, Tegal City, just conducted socialization regarding online registration using the JKN Mobile Application. Patients can also come directly to the registration counter by bringing the required documents. Then the patient will be served according to the registration order at their respective polyclinics after the practicing doctor on duty has arrived. In addition, both hospitals also implement multi-channel services, so that the queue of patients at the registration counter is not too crowded.

Although Dr. Soeselo Regional Hospital Tegal Regency, and Kardinah Regional Hospital Tegal City have used technology to help manage the patient queue system, it is possible that the existing system has not been considered to meet the standard rules for outpatient queues that have been in effect. The waiting time for patients in each queue cannot be equated. The speed or length of the service process for each patient is adjusted according to the complaints experienced by the patient. As a result, patients do not know the picture of the waiting time that can be allocated to rest in a place other than the waiting room while waiting for the queue to run. The length of the waiting process in the queue can also have a negative impact, allowing for the transmission of disease between patients who have more vulnerable physical conditions through the air in the waiting room.

The speed and slowness of the queue process that occurs is also influenced by the number of patients in each polyclinic in the hospital. According to the results of observations conducted by the author at Dr. Soeselo Hospital Tegal Regency, and Kardinah Hospital Tegal City, it was found that the Internal Medicine Polyclinic tends to have a busy queue of patients. While the ENT (Ear, Nose, Throat) Polyclinic tends to have a quiet queue of patients. This is based on patient data at Dr. Soeselo Hospital Tegal Regency in December 2024 which shows that the number of outpatients at the ENT Polyclinic was 399 patients and at the Internal Medicine Polyclinic was 2,881 patients. Meanwhile, patient data at Kardinah Hospital Tegal City in December 2024 shows that the ENT Polyclinic had 547 patients and the Internal Medicine Polyclinic had 1,177 patients. Due to these differences in characteristics, the author is interested in conducting research on the two polyclinics to be used as samples.

The urgency of this research lies in the visible gap between patient demand and the capacity of the registration and examination services. The numbers of outpatients in December 2024 differ strongly between the two polyclinics and the two hospitals, so the load on each service is not the same. Patients cannot tell how long they will wait and therefore cannot use the waiting time elsewhere, and a long wait in a shared waiting room increases the risk of airborne disease transmission to vulnerable patients. Online registration through the JKN Mobile application is available, but it was only socialized at Kardinah Hospital in January 2025, and patients can still register directly at the counters. Evidence on where the queue system breaks down, at registration or at examination, is therefore needed before capacity is added.

Queuing theory was chosen because it describes the relation between the arrival rate, the service rate, and the waiting time mathematically and gives measurable criteria for system performance (Gross et al., 2008). Before a queue model can be applied, its assumptions must be verified. The chi-square goodness-of-fit test compares the observed frequencies of arrivals per interval and of service times with the frequencies expected under the Poisson and the exponential distributions, so that the model is chosen from the data and is not merely assumed. The queue model is then determined with Kendall's notation, and system performance is measured by the utilization factor ρ , which shows whether a steady state exists ($\rho < 1$), together with the queue length and the waiting times. A questionnaire is added because performance measures alone do not show how patients perceive the service, and a mixed-methods design combines the two kinds of evidence (Creamer, 2022).

Previous studies have analyzed hospital queues from several angles. Mustafa and Nisa (2015) compared single-server (M/M/1) and two-server (M/M/2) models in the registration, outpatient, and pharmacy departments of hospitals, and Khaskheli et al. (2020) compared the queuing systems of the outpatient departments of two public hospitals. In Indonesia, queue analyses have been reported for the outpatient registration counters of hospitals in Pontianak (Pratiwi et al., 2020), Jakarta (Septiani et al., 2017), and Pekanbaru (Aseha et al., 2023), and for outpatient administration in Yogyakarta (Harpeni, 2020) and at Prasetya Bunda Hospital (Juwana et al., 2024), while Nabyala and Sigitta (2019), Nurrohman (2021), and Rinaldi and Ardiatma (2024) designed online registration or web-based queue systems. Hasibuan (2025) compared two hospitals in Medan and found significant differences in waiting time but not in satisfaction. These studies mostly concentrate on one stage of service, on a single hospital, or on the design of an application.

To the authors' knowledge, this study differs from them in four ways. It compares two hospitals in neighboring regions (Tegal City and Tegal Regency) and two polyclinics with contrasting patient volumes. It analyzes both the registration stage and the examination stage, so that the bottleneck can be located. It verifies the queue model with the chi-square test and measures performance by ρ in every observed period. And it combines the queue analysis with a satisfaction survey of 200 respondents and uses both to propose a queue model for each hospital.

This study aims to analyze and compare the outpatient queue systems at Dr. Soeselo Regional Hospital, Tegal Regency, and Kardinah Regional Hospital, Tegal City. The research questions are: (1) which queue model applies at the ENT and Internal Medicine polyclinics of the two hospitals, according to the chi-square test and the queue characteristics; (2) what are the steady-state condition and the performance of the queue system at the registration and examination stages; (3) how satisfied are patients with the queue service; and (4) which queue model can be proposed to improve the service?

Queue Theory

Queuing theory is a science that is related to the queue line for waiting in mathematical science. Generally, queuing theory is related to customer service, both in the category of goods or services. Queuing theory was first developed by AK Erlang, a Danish mathematician and engineer in 1900 (Yusnita & Marsa, 2024). Queues will occur when service facility providers cannot handle the number of customers coming, so customers have to wait a while to receive service (Andini & Astuti, 2021), (Dahoklory & Ismail, 2017). The concept of queue includes a situation where customers or goods wait to be served at a particular facility (Khaskheli et al., 2020), (Mustafa & Nisa, 2015), (Serlina, 2018), (Yusnita & Marsa, 2024).

Based on the description above, queues can be categorized into two parts as follows.

1. A queue consisting of customers or units that require service, such as patients, students, shoppers, passengers, and others.
2. Service facilities that include services and service channels, such as cinema counters, bank tellers, and others.

The queuing system has several basic components in the queuing process, including the following: (Farkhan, 2018).

1. Arrival

Every queuing problem involves arrivals, such as people, cars, or phone calls requiring service, which are often referred to as input processes. Input processes include the source of arrivals or calling population and the pattern of arrivals, which is usually a random variable. The characteristics of the population being served can be described by its size, the arrival population, and its behavior. Based on size, the population can be finite or infinite. The pattern of arrivals can be regular or random. A random variable is a variable whose values can vary as a result of a random experiment. A random variable can be discrete, if it has only a few specific values, or continuous, if its values can vary within a certain range.

2. Service

A service or service mechanism can consist of one or more service units. For example, a toll road has several toll gates. A service mechanism can also be a single service unit in one facility, such as a cinema ticket counter. In this service mechanism, there are three important aspects that need to be considered, namely:

- a. The occurrence of service

Service mechanisms are not always available all the time. For example, in a cinema, the ticket counter is only open at certain times between one show and the next. When the counter is closed, the service mechanism stops, and the staff can take a break.

- b. Service capacity

The capacity of the service mechanism is measured based on the number of customers that cannot be served simultaneously. This capacity is not always constant; some are stable, and some are variable. Therefore, service facilities can have one or more channels. Facilities that have one channel are called single channels, while facilities that have more than one channel are called multiple channels or multiple services.

- c. Length of service

Service time is the duration required to serve one customer or one unit, which must be stated clearly. The duration can be the same for all customers or can also be a random variable. Usually, for analysis purposes, service time is considered as a random variable that is freely and identically distributed and independent of arrival time.

3. Queue

The emergence of queues is influenced by the characteristics of arrival and service processes. If the queue is not formed, it indicates excess capacity or service facilities that are not used optimally (Farkhan in Mulyono, 1991).

2. Method

This study compares the outpatient queue systems of the ENT Polyclinic and the Internal Medicine Polyclinic at Dr. Soeselo Regional Hospital, Tegal Regency, and Kardinah Regional Hospital, Tegal City. It is a mixed-methods study that combines quantitative queue calculations with a descriptive questionnaire on patient satisfaction (Creamer, 2022). Descriptive methods examine the current status of a group of people, an object, a system of thought, or a class of events (Antoro, 2024; Bahrin & Putra, 2021; Nugraha et al., 2017; Sutarto, 2020).

Queues were observed in January 2025 at two service stages: registration (07.00–10.00 WIB) and the doctor's examination (10.00–13.00 WIB). At each stage the number of arriving patients and the service time of each patient were recorded, and the arrival rate λ and the service rate μ were calculated for each observation day. The satisfaction questionnaire was given to 200 respondents, 100 at each hospital, and the answers were grouped into five levels from very dissatisfied to very satisfied.

The chi-square goodness-of-fit test was used to verify the queue assumptions. The null hypothesis states that the number of arrivals per interval follows a Poisson distribution and, separately, that the service time follows an exponential distribution. The test statistic is

$$\chi^2 = \sum (O_i - E_i)^2 / E_i$$

where O_i and E_i are the observed and expected frequencies in class i . The null hypothesis is rejected if χ^2 exceeds the critical value $\chi^2_{(\alpha; k - m - 1)}$, where k is the number of classes and m the number of parameters estimated from the data. If the null hypothesis is not rejected for both distributions, the queue is classified as $(M/M/s/\infty/\infty)$ in Kendall's notation, with First In First Out discipline, where s is the number of servers at the stage.

System performance was measured with the utilization factor $\rho = \lambda / (s\mu)$. A steady state exists only if $\rho < 1$ (Gross et al., 2008). If $\rho < 1$, the performance measures of the single-server model are

$$P_0 = 1 - \rho, \quad L_q = \rho^2 / (1 - \rho), \quad W_q = L_q / \lambda, \quad W_s = W_q + 1 / \mu$$

where P_0 is the probability of an empty system, L_q the mean number of patients in the queue, W_q the mean waiting time in the queue, and W_s the mean time in the system; for $s > 1$ the corresponding multi-server formulas were used. If $\rho \geq 1$, the queue grows without bound during the observation period, these measures are not defined, and only ρ is reported. The satisfaction answers were summarized as percentages, and the distributions of the two hospitals were compared with the chi-square test of homogeneity. Finally, queue models were proposed for the stage with the highest utilization, based on the queue calculation and the questionnaire together.

3. Results and Discussion

Queues were observed in January 2025 at the registration stage (07.00–10.00 WIB) and the examination stage (10.00–13.00 WIB) of the ENT and Internal Medicine polyclinics. Section 3.1 gives the queue model, Section 3.2 the steady-state condition and performance, Section 3.3 patient satisfaction, Section 3.4 the proposed queue models, and Section 3.5 discusses the findings.

3.1. Characteristics of the queue model

At both hospitals the queues of the ENT Polyclinic and the Internal Medicine Polyclinic follow the $(M/M/1/\infty/\infty)$ model: arrivals follow a Poisson distribution, service times follow an exponential distribution, the discipline is First In First Out, so that patients who arrive earlier are served first, and each queue line has one service facility (Yusnita & Marsa, 2024). At the registration stage, Kardinah Hospital has two lines, one for BPJS patients and one for general patients, each with one server; Dr. Soeselo Hospital has direct registration for BPJS patients with two servers and online registration with one server. The ENT Polyclinic of each hospital and the Internal Medicine Polyclinic of Kardinah Hospital have one examination server. The Internal Medicine Polyclinic of Dr. Soeselo Hospital has two examination rooms, and patients are assigned to a room when they register, so the two rooms were calculated as two separate queue lines.

Steady-state condition and performance of the queues

At the registration stage, Table 1 gives the number of servers s , the arrival rate λ , the service rate μ , and the utilization factor ρ .

Table 1. Utilization of the registration stage at Kardinah Hospital (Tegal City) and Dr. Soeselo Hospital (Tegal Regency)

Hospital	Line	Date	s	λ	μ	ρ	Condition
Kardinah	BPJS	6 Jan	1	190	102.667	1.851	Not stable
	BPJS	7 Jan	1	192.333	119	1.616	Not stable
	BPJS	8 Jan	1	101	57	1.771	Not stable
	General	6 Jan	1	190	17	11.176	Not stable
	General	7 Jan	1	192.333	19.667	9.780	Not stable
Dr. Soeselo	General	8 Jan	1	101	16	6.313	Not stable
	Direct	13 Jan	2	138	13	5.308	Not stable
	Direct	14 Jan	2	167.667	24.5	3.422	Not stable
	Direct	15 Jan	2	138.667	24	2.890	Not stable
	Direct	16 Jan	2	170.667	22.667	3.765	Not stable
	Direct	17 Jan	2	135	15.833	4.263	Not stable
	Direct	18 Jan	2	94.333	19.667	2.398	Not stable
	Online	13 Jan	1	138	14.333	9.628	Not stable
	Online	14 Jan	1	167.667	20	8.383	Not stable
	Online	15 Jan	1	138.667	15.667	8.851	Not stable
	Online	16 Jan	1	170.667	28.667	5.953	Not stable
	Online	17 Jan	1	135	20.667	6.532	Not stable
	Online	18 Jan	1	94.333	21.667	4.354	Not stable

Table 1 shows that ρ exceeded 1 on every observation day at the registration stage of both hospitals. At Kardinah Hospital, ρ ranged from 1.616 to 1.851 for the BPJS line and from 6.313 to 11.176 for the general line; at Dr. Soeselo Hospital it ranged from 2.398 to 5.308 for direct registration (two servers) and from 4.354 to 9.628 for online registration (one server). The queue therefore has no steady state: arrivals exceed the capacity of the servers, and the number of waiting patients grows during the observation period. In this condition the formulas for P_0 , L_q , W_q , and W_s are not valid, so they are not reported; negative values produced by applying them outside their range (Gross et al., 2008) have no meaning.

Table 2. Utilization of the examination stage at the ENT and Internal Medicine polyclinics

Hospital	Polyclinic / room	Date	s	λ	μ	ρ	Condition
Kardinah	ENT	6 Jan	1	12.5	12	1.042	Not stable
	ENT	7 Jan	1	12	7.5	1.600	Not stable
	ENT	8 Jan	1	8	7.5	1.067	Not stable
	Internal Medicine	9 Jan	1	19	12.667	1.500	Not stable
	Internal Medicine	10 Jan	1	18	21.5	0.837	Stable
Dr. Soeselo	Internal Medicine	11 Jan	1	23.667	20	1.183	Not stable
	ENT	13 Jan	1	22	7	3.143	Not stable
	ENT	14 Jan	1	17.5	10	1.750	Not stable
	ENT	15 Jan	1	17	15	1.133	Not stable
	Internal Medicine, room 1	16 Jan	1	19.333	12.333	1.568	Not stable
	Internal Medicine, room 1	17 Jan	1	22.5	18.667	1.205	Not stable
	Internal Medicine, room 1	18 Jan	1	22.667	12.333	1.838	Not stable
	Internal Medicine, room 2	16 Jan	1	19.333	8.5	2.274	Not stable
	Internal Medicine, room 2	17 Jan	1	22.5	12.5	1.800	Not stable
	Internal Medicine, room 2	18 Jan	1	22.667	14.5	1.563	Not stable

Table 2 shows the examination stage. ρ exceeded 1 in 14 of the 15 observed periods. The only stable period was the Internal Medicine Polyclinic of Kardinah Hospital on 10 January 2025, with $\rho = 0.837$, $P_0 = 0.163$, $L_q = 4.222$ patients, $W_q = 0.234$, and $W_s = 0.281$. On the other days of the same polyclinic and at all other polyclinics the queue systems were not stable. Based on the number of patients queuing, the ENT Polyclinic of Kardinah Hospital is estimated to serve 108 patients per week and 432 per month, and its Internal Medicine Polyclinic 282 per week and 1,128 per month; at Dr. Soeselo Hospital the estimates are 110 and 440 for the ENT Polyclinic and 576 and 2,304 for the Internal Medicine Polyclinic.

3.2. Patient satisfaction with the hospital service

Table 3. Satisfaction of respondents by hospital (n = 100 per hospital)

Level of satisfaction	Dr. Soeselo (%)	Kardinah (%)
Very satisfied	8	17
Satisfied	34	41
Quite satisfied	48	37
Dissatisfied	9	5
Very dissatisfied	1	0

The questionnaire was distributed to 200 respondents, 100 at each hospital (Table 3). At Dr. Soeselo Hospital, 90% of respondents were satisfied (8% very satisfied, 34% satisfied, and 48% quite satisfied), and 10% were dissatisfied or very dissatisfied. At Kardinah Hospital, 95% were satisfied (17%, 41%, and 37%), and 5% were dissatisfied. A chi-square test of homogeneity on the grouped categories (very satisfied, satisfied, quite satisfied, and dissatisfied or very dissatisfied)

gave $\chi^2 = 6.98$ with 3 degrees of freedom and $p = 0.072$, so the difference between the two hospitals is not significant at the 5% level, although Kardinah Hospital has a higher proportion of very satisfied respondents. Respondents also gave criticism and suggestions on queue control, speed of service, and supporting facilities such as waiting chairs, and they expect queue regulations that are easy to follow, especially for elderly patients who come without a companion.

3.3. Proposed queue models

Because the registration stage has the highest utilization, the queue models are proposed for this stage. At Dr. Soeselo Hospital two models are proposed. The first adds registration servers for general patients on the 2nd and 3rd floors, so that registration is not concentrated on the 1st floor, increases the direct registration servers for BPJS patients to three, and provides two check-in machines on each floor for BPJS patients who register online. The second model adds the general registration servers on the 2nd and 3rd floors and two check-in machines on each floor for online BPJS patients. At Kardinah Hospital, four machines for taking queue numbers are proposed, two for patients who register directly and two for check-in of online BPJS patients, and each direct BPJS server calls two queue numbers at once to shorten the queue at the counter and to make the queue more orderly. To check the effect of the extra capacity, the observed rates of direct registration at Dr. Soeselo Hospital were used: with three servers instead of two, ρ would be between 1.600 and 3.540 over the six days, which is lower than the present 2.398 to 5.308 but still above 1. The effect of the check-in machines on the service rate was not measured, so the proposals should be tested by a pilot or a simulation before adoption.

3.4. Discussion

The utilization factors show where the queue system breaks down. The registration stage has the highest utilization (ρ from 1.616 to 11.176), clearly higher than the examination stage (ρ from 0.837 to 3.143), which supports directing the proposals to registration. The examination stage is closer to its limit: in 6 of 15 periods ρ is at most 1.25, so a modest gain in service speed or doctor time could bring it near stability, whereas registration needs a larger change. At Kardinah Hospital the general registration line (ρ from 6.313 to 11.176) is much more loaded than the BPJS line (1.616 to 1.851), and at Dr. Soeselo Hospital the one-server online line (4.354 to 9.628) is more loaded than the two-server direct line (2.398 to 5.308), which is in line with the expectation that more servers lower utilization. Patient volume alone does not explain the load: at Dr. Soeselo Hospital the ENT Polyclinic, with 399 patients in December 2024, had ρ from 1.133 to 3.143, higher than the Internal Medicine Polyclinic with 2,881 patients (1.205 to 2.274 per room), because the latter has two examination rooms. Capacity per doctor, and not monthly volume, therefore determines ρ .

The questionnaire and the queue calculation give different pictures: 90% and 95% of respondents were satisfied, yet ρ exceeded 1 in 32 of 33 periods. Several reasons are plausible. Satisfaction was measured for the service as a whole and not for waiting time alone, "quite satisfied" was counted as satisfied, and patients may accept a long wait at a public hospital; in addition, ρ describes the observation window and not every working hour. The satisfaction result should therefore not be read as evidence that the queue system is adequate.

Compared with previous studies, the finding that a registration counter is a bottleneck agrees with the studies of registration queues in hospitals (Pratiwi et al., 2020; Septiani et al., 2017; Aseha et al., 2023), and the lower utilization of the two-server line is consistent with the comparison of single-server and multi-server models by Mustafa and Nisa (2015). Hospital-to-hospital comparisons of outpatient queues, such as that of Khaskheli et al. (2020), show that queue conditions differ between hospitals; this study adds the separation of registration and examination, the check of the queue model with the chi-square test, and the use of ρ in every observed period. As in Hasibuan (2025), who found differences in queue time between two hospitals but not in satisfaction, the two hospitals here differ in utilization but not significantly in satisfaction ($p = 0.072$). Because the data sets, methods, and measures differ, the comparison is limited to the direction of the findings.

The novelty of the findings is that, for two hospitals and two polyclinics, the instability is located mainly at registration and not at examination, that load depends on the number of servers and the service rate rather than on monthly patient volume, and that high satisfaction can coexist with $\rho > 1$. For hospital managers, the results indicate that capacity should be added first at registration and checked against ρ , and that the examination stage needs a smaller adjustment. Several limitations should be noted. The assumptions of the M/M/1 model were applied to short observation windows, ρ was calculated from daily averages, and the arrival rate was identical for the two registration lines on each day (Table 1), which suggests that it was measured for the registration stage as a whole; if patients split between the lines, ρ per line would be lower. Future research should record arrivals and service times per line, use simulation to test the proposed models, and extend the observation to more days and polyclinics.

4. Conclusion

The four research questions are answered as follows. First, the ENT Polyclinic and the Internal Medicine Polyclinic at Dr. Soeselo Hospital, Tegal Regency, and Kardinah Hospital, Tegal City, apply the (M/M/1/ ∞/∞) queue model with First In First Out discipline; the registration stage uses one or two servers per line, as described in Section 3.1. Second, the utilization factor exceeded 1 in 32 of the 33 observed periods, so the queue systems were not in a steady state; the only exception was the Internal Medicine Polyclinic of Kardinah Hospital on 10 January 2025 ($\rho = 0.837$). The registration stage was the bottleneck (ρ from 1.616 to 11.176), and the examination stage was closer to its limit (ρ from 0.837 to 3.143).

Third, 90% of respondents at Dr. Soeselo Hospital and 95% at Kardinah Hospital were satisfied with the queue service, and the difference between the hospitals is not significant at the 5% level ($p = 0.072$); satisfaction therefore does not indicate that the queue system is stable. Fourth, adding servers at the registration stage is proposed: general registration servers, more direct BPJS servers, and check-in machines at Dr. Soeselo Hospital, and queue-number machines with two numbers called at once at Kardinah Hospital. With the observed rates, three direct-registration servers would still leave ρ above 1, so the proposals should be validated by a pilot or a simulation before adoption.

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