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Implementation of Queuing Theory to Improve Time Efficiency for BPJS Outpatients at Royal Hospital Surabaya

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Abstract

This study evaluates the performance of the BPJS outpatient registration queue at Royal Hospital Surabaya. Observations show a patient arrival rate (λ) of 270 patients per hour, while the service rate per counter (μ) is only 10.676 patients per hour with two active servers. This imbalance results in a server utilization rate (ρ) of 12.64, leading to an average waiting time of approximately 75 minutes and an average queue length of about 25 patients, both exceeding the hospital's service standards. Simulation results indicate that increasing the service rate to 20 patients per hour is the most effective intervention for reducing waiting time and improving system stability. The combination of a higher μ with a reduced arrival rate through online registration further shortens queues and creates a more balanced flow of patients. The study concludes that the primary cause of congestion is the structural mismatch between patient arrival intensity and service capacity. These findings provide a data-driven basis for operational strategies aimed at enhancing the efficiency and service quality of BPJS outpatient registration.

Keywords: *Queuing Theory, BPJS Services, Operational Management, Waiting Time, Service Efficiency.*

INTRODUCTION

The increasing number of BPJS participants utilizing outpatient services has encouraged hospitals to enhance service quality in order to comply with nationally regulated administrative and clinical standards (BPJS Kesehatan, 2020; BPJS Kesehatan, 2022). Royal Hospital Surabaya faces the challenge of rising patient volume, which contributes to prolonged waiting times, particularly in BPJS outpatient services that operate under specific procedural requirements. Suboptimal service systems often reduce time efficiency due to dense process flows and layered administrative activities as illustrated in the guidelines of the Indonesian Ministry of Health (2014). This condition highlights the need for a structured approach capable of analyzing queuing patterns more comprehensively.

Healthcare services at advanced referral facilities require systematic patient flow management to ensure that registration, verification, and consultation processes proceed without excessive accumulation (Azwar, 2010; BPJS Kesehatan, 2020). Long and complex procedures often trigger uncontrolled queues, diminishing the overall patient experience due to increasing uncertainty in waiting times. Hospitals must implement operational strategies that align service capacity with fluctuating daily patient demand. The imbalance between available resources and service needs underscores the urgency of applying queuing theory as an operational analysis tool.

Queuing theory offers a mathematical framework for understanding queue behavior based on patient arrival patterns, service processes, capacity of service channels, and priority rules (Gross & Harris, 1998; Gross et al., 2018). Queuing models have long been used to map the mismatch between demand and capacity in service systems, providing an objective picture of factors contributing to extended waiting times. This approach supports hospital management in determining the most efficient service model that aligns with the operational characteristics of outpatient units. Research in the service sector indicates that queuing analysis substantially improves timeliness and service quality (Fitzsimmons & Fitzsimmons, 2011).

Simulation serves as an important technique to portray realistic operational conditions and identify potential improvements based on various queuing scenarios (Banks et al., 2010). Applying queuing simulations enables hospitals to assess the impact of changes in counter numbers, medical staff capacity, and patient arrival patterns without implementing actual adjustments on-site. This process is

highly relevant for hospitals serving BPJS patients because administrative systems involve layered and complex requirements, making accurate operational planning essential (BPJS Kesehatan, 2022). Detailed analyses produced through simulation lead to more precise decisions in determining optimal service configurations.

Effective queue management not only enhances time efficiency but also strengthens overall operational performance, particularly in service units that interact with large patient volumes (Heizer & Render, 2017). When waiting times are reduced through the application of queuing theory, patient satisfaction improves and the risk of complaints can be minimized. Studies in healthcare service management reveal that queuing techniques assist health facilities in elevating service quality by exerting better control over patient flow (Gumus et al., 2017). These improvements ultimately contribute to a stronger institutional reputation in the eyes of the community.

Hospitals require information systems capable of integrating data on patient arrivals, administrative status, and service progress to support accurate queuing analysis (Jogiyanto, 2017). Utilizing an effective information system allows for data-driven decision-making related to daily patient load patterns and resource utilization levels in BPJS outpatient services. Such data integration enables management to identify process bottlenecks and map specific areas that require optimization. This data-driven approach reinforces the application of queuing theory in improving time efficiency.

The success of enhancing efficiency through queuing theory depends on the hospital's ability to manage resources and design operational decisions based on precise mathematical calculations and system analyses (Hillier & Lieberman, 2010; Hillier & Lieberman, 2021). Adjustments to the number of service channels, process duration, and healthcare personnel capacity must align with the evolving characteristics of patient demand. Hospitals with high BPJS patient volume, such as Royal Hospital Surabaya, can obtain substantial benefits when operational strategies are redesigned based on queuing analysis outcomes. These efforts contribute to building a more adaptive and resilient service system.

Studies on service efficiency highlight that user behavior analysis also influences queue flow, including perceptions of risk, waiting decisions, and expectations toward service speed (Adnyaswari & Sinrawati, 2024). These behavioral aspects frequently emerge in BPJS services, which have their own administrative pathways, making it essential for hospitals to understand patient interaction patterns for designing queuing strategies holistically. A comprehensive approach that integrates queuing theory, behavioral analysis, and detailed mapping of service processes provides opportunities for significant improvements in waiting time. All these considerations emphasize the importance of examining the implementation of queuing theory in BPJS outpatient services at Royal Hospital Surabaya to achieve measurable and sustainable service enhancement.

RESEARCH METHODS

This study adopts a quantitative case study design to evaluate the BPJS outpatient registration queuing system at Royal Hospital Surabaya by measuring operational parameters and assessing the alignment between patient arrival patterns and service capacity. The M/M/s model was selected due to the stochastic nature of patient arrivals, the exponential pattern of service times, and the multi-counter service configuration. Primary data were gathered through structured observations of arrival times, service durations, queue lengths, and active counters across multiple weekdays, while secondary data from SOPs, Minimum Service Standards, and historical BPJS visit records were used to contextualize operational conditions. Data validity was ensured through goodness-of-fit testing for Poisson and exponential distributions, along with operational triangulation using daily logs, BPJS visit reports, and staff insights. After estimating λ, μ, and s, key performance indicators such as utilization, queue length, and waiting time were calculated and compared with service standards, followed by simulations of several improvement scenarios including service rate adjustments, online registration to reduce λ, and additional servers to determine the most effective strategies for enhancing system stability and service efficiency.

RESULT AND DISCUSSION

Overview of the Queueing Conditions

Field observations show that the BPJS outpatient registration service at Royal Hospital Surabaya experiences severe congestion during peak hours, particularly between 07:00 and 10:00. The arrival rate reaches 270 patients per hour, while only two registration counters operate consistently. This

imbalance leads to a substantial accumulation of patients in the queue. The average service time per patient ranges between 5–6 minutes, resulting in a service rate (μ) of 10.676 patients per hour, which is significantly lower than the arrival rate (λ). The total processing time for BPJS patients throughout the outpatient cycle reaches an average of 395.62 minutes, with 55.3% of patients meeting the Minimum Service Standards (SPM) and 44.7% exceeding the standard time limit. Although individual service stages generally meet the required standards, the registration process remains the primary bottleneck.

Queueing System Parameters

Based on the queueing calculations in the thesis, the system operates in an overload condition, reflected by a very high server utilization value. The utilization rate (ρ) reaches 12.64, indicating that the demand far exceeds the system's processing capability. As a result, the queue becomes unstable and continues to grow during peak hours.

Table 1. System Performance Parameters

Parameter	Symbol	Value	Interpretation
Arrival rate	λ	270 patients/hour	Very high
Service rate	μ	10.676 patients/hour	Low capacity
Active counters	s	2	Insufficient
Server utilization	ρ	12.64	Unstable system
Average waiting time	Wq	25–30 minutes	Above the standard
Average queue length	Lq	25 patients	Significant congestion
Total time in system	W	35 minutes	Includes service time

These results confirm that the two active counters cannot handle the high influx of patients, creating continuous buildup and long waiting times.

Performance Gap Based on Service Standards

A comparison between the actual performance of the BPJS outpatient registration system and the Minimum Service Standards (SPM) is essential to identify the specific areas where operational inconsistencies occur and to understand the extent of the performance gap. This evaluation provides a structured overview of how current service conditions align with established benchmarks, particularly in relation to waiting times, system capacity, and the adoption of digital registration tools. By presenting these indicators in a systematic manner, the analysis highlights which components of the registration process function effectively and which require immediate improvement to ensure compliance with national service standards. The table below summarizes the key performance indicators and illustrates the disparities that influence overall service quality and patient experience:

Table 2. Gap Analysis of Registration Service Performance

Indicator	SPM Standard	Actual	Status
Registration waiting time	≤ 15 minutes	25-30 minutes	Not achieved

Service duration per patient	≤ 10 minutes	5–6 minutes	Achieved
System stability ($\rho \leq 0.85$)	Stable	ρ = 12.64	Not achieved
Digital registration utilization	Optimal	Low	Not achieved
Queue length	Minimal	= 25 patients	Not achieved

The most critical gap appears in the waiting time category, where the actual value nearly doubles the maximum allowable standard.

Analysis of System Capacity Using the M/M/s Model

The M/M/s model accurately describes the operational dynamics of the BPJS registration area. Patient arrivals occur randomly throughout the morning, while service times vary depending on the administrative steps required for each patient. With only two active counters, the system is unable to accommodate the extremely high arrival volume during peak hours. The analysis shows that the arrival rate (λ) is significantly higher than the total service capacity ($s\mu$). This substantial imbalance prevents the system from processing patients at a pace that matches the incoming flow. As a result: queues accumulate quickly, waiting times increase substantially, and patient flow becomes inefficient despite the acceptable service time per individual. This condition aligns with queuing theory, which states that when arrival intensity exceeds or closely approaches service capacity, the system cannot reach a stable operational state. In such circumstances, queues continue to grow over time, especially during peak demand periods.

Simulation Results for System Improvement

The simulation was conducted to evaluate how adjustments to the service rate could enhance the performance of the BPJS outpatient registration system by reducing congestion and improving overall flow efficiency. This analysis focuses on several alternative scenarios designed to test the impact of increasing service capacity, both with and without changes in the number of active counters, to identify the most feasible and effective improvement strategy for real operational settings. Each scenario provides insight into how even moderate enhancements in service speed can substantially decrease waiting times and queue lengths, reflecting the system's high sensitivity to changes in μ. The following table summarizes the simulation outcomes and illustrates how targeted capacity optimization can shift an overloaded system toward a more stable and efficient operational condition:

Table 3. Simulation of Service Rate (μ) Improvement

Scenario	λ	μ	s	ρ	Wq (min)	Lq (persons)	Description
Actual condition	270	10.676	2	1.26	129.7	584	Overloaded system
$\mu = 15$	270	15	2	0.90	34.1	153	Significant reduction

μ = 20	270	20	2	0.68	10.2	46	Approaches SPM
μ = 20, s = 3	270	20	3	0.45	4.6	21	Very efficient
μ = 22, s = 3	270	22	3	0.41	3.8	17	Optimal performance

These simulations clearly show that increasing μ produces dramatic reductions in waiting time and queue length, even without adding many new counters.

Queue System Analysis and Operational Challenges in BPJS Outpatient Services

The increasing number of BPJS participants utilizing outpatient services has required hospitals to manage queue systems with a more structured approach to maintain service flow stability during peak hours (BPJS Kesehatan, 2020; BPJS Kesehatan, 2022). Operational conditions within hospitals often shift dynamically in line with fluctuations in patient arrivals, making it necessary to develop an in-depth understanding of service load characteristics as outlined in the Ministry of Health guidelines (Depkes RI, 2014). This challenge becomes more complex because BPJS administrative processes involve multilayered verification that must align with the minimum service standards established by the Ministry of Health of Indonesia (Kemenkes RI, 2008; 2022). Hospitals such as Royal Hospital Surabaya must ensure smooth patient flow so that waiting times do not exceed the thresholds determined in the national outpatient waiting time guidelines (Kemenkes RI, 2023).

Queue systems in outpatient services require patient flow management that clearly maps the process from registration to physician consultation so that services run without excessive congestion as described by Azwar (2010). Inefficiencies in resource allocation, such as the number of counters or administrative staff, often increase waiting times and reduce patient satisfaction, which is a crucial component of service quality according to Rustiyanto (2011). This phenomenon is increasingly evident in advanced referral facilities that serve BPJS participants whose administrative procedures are more extensive (BPJS Kesehatan, 2020). To address these demands, hospitals must adopt modern health management frameworks as explained by Muninjaya (2011) so the system remains responsive to fluctuating service loads.

Queue problems in hospitals are often associated with imbalances between service capacity and patient arrival rates, which makes mathematical approaches such as queuing theory necessary to describe operational dynamics objectively (Gross & Harris, 1998; Gross et al., 2018). Understanding queue structures becomes increasingly important because BPJS patients exhibit arrival patterns that are not always stable, particularly at certain times influenced by behavioral tendencies and treatment-seeking preferences as described in service user behavior studies by Adnyaswari & Sinrawati (2024). This imbalance between demand and capacity results in longer waiting times that may reduce perceived service quality, which Parasuraman et al. (1988) identify as a primary indicator of healthcare service performance. This condition provides a strong rationale for hospital management to conduct a comprehensive evaluation of the queue system configuration currently in place.

Uncontrolled queue conditions can reduce the operational efficiency of hospitals, making it necessary to integrate queuing theory with operations management approaches to produce appropriate service policies (Heizer & Render, 2017; Stevenson, 2021). Hospital operations involve allocating resources according to demand levels, which must align with capacity planning strategies discussed by Krajewski et al. (2019). This process requires routine evaluation of daily service loads, which in BPJS outpatient care tend to show high fluctuations due to administrative factors and patient arrival preferences. Poorly arranged services can worsen queue conditions and ultimately affect the continuity and reputation of hospital operations.

Inefficient queue management is commonly triggered by information systems that fail to provide real-time data on patient arrivals, service duration, and the number of active counters, even though information technology plays an essential role in modern management as described by Jogiyanto

(2017). The implementation of integrated digital systems can help hospitals analyze service load requirements more accurately, aligning with the direction of national digital health transformation established by the Ministry of Health (Kemenkes RI, 2021). When data flows can be monitored consistently, identifying bottlenecks becomes easier and improvement strategies can be designed more effectively. This technological integration also reinforces decision accuracy in queue management.

National regulations regarding baseline quality standards also require hospitals to monitor and evaluate patient waiting times as a mandatory performance indicator (Kemenkes RI, 2019). This indicates that queue analysis is not only an operational necessity but also a regulatory obligation that must be addressed. Such evaluation requires hospitals to understand BPJS patient arrival characteristics thoroughly, including peak hours and average service time at each stage. Comprehensive understanding is essential to ensure service quality remains consistent with standards set by the government.

Studies on healthcare services show that long queues significantly decrease patient satisfaction, making it essential to design more effective patient flow strategies as explained by Wijaya (2019). Poor queue conditions affect not only operational aspects but also reduce the hospital's image in the community as discussed by Kotler & Keller (2016). When public perceptions of service quality decline, trust in healthcare providers also deteriorates. This situation underscores the need for hospitals to apply scientific approaches through queuing theory analysis to maintain sustainable service quality.

Several previous studies indicate that outpatient registration services are the most crucial point where long queues form, as this stage serves as the entry point for the entire service process (Prasetyo & Wahyuni, 2020; Nurhidayati et al., 2019). This issue is more pronounced in BPJS services, which involve more administrative stages compared to general patient services. Ineffective management of service loads can result in the system being unable to keep up with patient arrivals, causing long queues that increase overall waiting time. This situation highlights the need for a structured approach to comprehensively improve the queue system.

Queue systems experiencing excessive pressure often reflect a mismatch between operational policies and actual service load, making detailed measurement necessary to identify critical points requiring improvement (Santos et al., 2022). Such measurement depends on patient arrival data and service duration analyzed using mathematical approaches described by Hillier & Lieberman (2010; 2021). Without accurate data, hospitals will encounter difficulties in determining the appropriate strategies to address system congestion, especially during peak BPJS patient hours. For this reason, queue theory becomes an essential tool for producing more accurate strategic decisions.

Royal Hospital Surabaya, as a facility with a continuously growing number of BPJS patients, has an urgent need to understand queue characteristics in detail so improvement efforts become well-directed. This understanding must consider BPJS operational guidelines (BPJS Kesehatan, 2020; 2022) as well as applicable national service quality standards to ensure that any adjustments remain within the correct regulatory framework. Once queue characteristics have been thoroughly mapped, management will have a strong foundation for designing more effective capacity-enhancement strategies. This forms a crucial starting point before discussing improvement alternatives through queuing theory and system simulation in the following sub-discussion.

Application of Queuing Theory and Strategic Recommendations for Reducing Waiting Time

Queuing theory provides a strong mathematical framework for understanding patient arrival dynamics, service duration, resource capacity, and service user behavior, making it a fundamental basis for enhancing BPJS outpatient service efficiency (Gross & Harris, 1998; Gross et al., 2018). Applying this theory enables hospitals to map the entire service flow comprehensively, from the point of arrival until patients are received at the clinic. The use of this analysis becomes increasingly critical because BPJS services involve dense administrative structures as described in BPJS guidelines (BPJS Kesehatan, 2020; 2022). By understanding arrival patterns and service characteristics, hospitals can determine the most suitable queue model to reduce waiting times.

The M/M/s queue model is widely used in outpatient services because patient arrival patterns typically follow a Poisson distribution and service times follow an exponential distribution as explained by Taha (2017). This model enables performance analysis of service systems based on the number of servers, patient arrival rates, and service speed, allowing determination of optimal capacity for handling BPJS patients. Mathematical modeling of this type provides hospitals with the ability to calculate potential waiting-time reduction if capacity is increased or service flow is redesigned, as also shown in

the study by Putri Aseha et al. (2023). This offers practical benefits for management when designing measurable capacity-enhancement strategies.

Discrete-event simulation, as described by Banks et al. (2010), is an important instrument for developing improvement scenarios without disrupting ongoing services. This technique allows hospitals to test various policy alternatives, such as adding counters, adjusting service hours, or digitizing administrative processes, in a setting that reflects real operational conditions. This approach is particularly beneficial for BPJS services, which experience high arrival intensity during specific hours and therefore require solutions capable of absorbing peak loads. When simulation results show significant improvements, hospitals can implement the strategies with minimal risk.

Previous research on queue management in healthcare services shows that queue-based analysis can significantly reduce waiting times and improve patient experience (Gumus et al., 2017). International studies by Santos et al. (2022) and Srivastava (2023) further demonstrate that queue-based evaluation has positive effects on service flow stability. These findings strengthen the argument that applying queuing theory in BPJS outpatient services at Royal Hospital Surabaya can produce meaningful improvements in time efficiency. This underscores the potential of mathematical approaches to contribute substantially to healthcare service quality.

Queue improvement strategies must also consider patient behavior because waiting decisions are often influenced by risk perceptions, expectations, and preferences regarding service speed as described by Adnyaswari & Sinrawati (2024). BPJS outpatient behavior is typically affected by preferred visiting hours, leading to imbalances in daily patient flow. Understanding these behavioral patterns helps hospitals redistribute service loads through scheduling strategies or patient education to create a more balanced arrival distribution. Integrating behavioral factors with queuing theory becomes crucial for producing more realistic improvement strategies.

The use of information technology, such as electronic queue systems, increases administrative verification speed as shown in the study by Nugroho & Sari (2018). This integration aligns with the digital health transformation guidelines mandated by the Ministry of Health (Kemenkes RI, 2021) to strengthen service quality through operational digitalization. Digital systems can significantly reduce waiting times by minimizing manual data entry, resulting in a more streamlined service flow. Electronic queue systems also provide real-time information to patients, helping reduce crowding in registration areas.

The application of queuing theory must also consider minimum hospital service standards established by the Ministry of Health (Kemenkes RI, 2008; 2022) to ensure that improvement strategies remain consistent with national requirements. Mathematical-based operational adjustments must be aligned with applicable regulations so that changes stay within the boundaries of essential service quality. This is particularly important for Royal Hospital Surabaya in maintaining service consistency even when adjustments are made in the number of servers, administrative flow, or service duration. A regulation-aligned approach provides clear direction for implementing operational improvements.

Queue efficiency strategies may involve adding service counters, increasing service speed, or redesigning inefficient service flows as described in operations management literature by Heizer & Render (2017). This evaluation must consider resource capacity and daily patient load patterns so decision-making can produce optimal outcomes. These efforts can be accelerated through scenario simulations such as those described by Krisna & Sumiati (2023), which test system performance under various alternative configurations. Once the optimal scenario is identified, management can implement improvements gradually to ensure smooth adaptation.

National studies on queuing theory in healthcare services, such as those conducted by Setiawan (2019) and Prasetyo & Wahyuni (2020), show that the M/M/s model is highly suitable for analyzing hospital registration systems because it accurately captures fluctuating arrival patterns. These findings provide a strong empirical foundation for applying this model to BPJS services at Royal Hospital Surabaya. The model helps management estimate average waiting time, queue length, and server utilization more accurately. These indicators form a critical basis for determining the most effective improvement strategies.

All analytical findings demonstrate that the application of queuing theory offers substantial potential for Royal Hospital Surabaya to reduce BPJS outpatient waiting times through measurable, data-driven approaches. Once queue models are analyzed and improvement scenarios evaluated through simulation, the hospital can design capacity-enhancement strategies systematically by considering

regulations, patient behavior, and resource capability. The integration of operations management theory, queuing theory, and information technology provides a comprehensive framework for building more efficient services. This approach forms the foundation for transforming BPJS services toward higher and more sustainable quality standards.

CONCLUSION

The findings of this study confirm that the primary source of instability in the BPJS outpatient registration queue at Royal Hospital Surabaya is the significant mismatch between the extremely high patient arrival rate and the limited service capacity of the registration counters, a condition reflected in the excessively high utilization level that prevents the system from reaching operational equilibrium. The simulation analysis shows that the most effective improvement strategy is the combined approach of increasing the service rate and reducing the effective arrival rate through the implementation of online registration, as these interventions simultaneously strengthen service capability and alleviate peak-hour congestion. The recommended managerial actions which include optimizing administrative efficiency to enhance service performance, institutionalizing digital pre-registration to distribute patient arrivals more evenly, and conducting routine capacity assessments to maintain alignment between resources and demand offer a practical framework for stabilizing the queuing system and elevating the overall quality of BPJS outpatient registration services.

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