# Simulation Model of Patient Service Queue at Pasar Minggu Cirebon Hospital using ProModel

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**Abstract**
*This research aims to minimize patient waiting time in queues by simulating the patient service system, identifying the queues within the system, and proposing recommendations for improving the service system at Pasar Minggu Cirebon Hospital. The simulation model in this study uses Promodel 2016 tools with design of experiments (ANOVA). In the developed simulation model, there are two queues: the clinic queue caused by specialist doctor shifts and the pharmacy drug queue that does not differentiate between drug queues from the ER (general) and the clinic. The queue lengths in the existing condition are 5 patients for the clinic queue, 13 people for the clinic drug queue, and 47 people for the general drug queue. After the model is verified and validated, the focus of this research shifts to the pharmacy drug queue because it contributes the longest queue in the system. Proposed improvements in the service system related to the pharmacy at Pasar Minggu Hospital include increasing three factors: pharmacy capacity, BPJS pharmacy service time, and non-BPJS pharmacy service time. The selected alternative after analyzing the improvements related to these three factors consists of increasing the pharmacy capacity to three units, shortening the BPJS pharmacy service time to an average of 12 minutes, and the non-BPJS pharmacy service time to an average of 15.9 minutes. These three changes related to the three factors will impact the average queue length for medication retrieval, reducing it to 6.94 people.*

**Keywords**: Queue system simulation, Promodel 2016, ANOVA

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## 1. Introduction

Health is an ideal state desired by every individual where their body, mind, and social aspects function optimally. Healthcare services are created with the primary goal of providing the necessary care and treatment for individuals who are sick or experiencing health problems. Healthcare providers, such as hospitals, must deliver high-quality services. Quality, in this context, refers to services that are fast and accurate to improve public health. Pasar Minggu Cirebon Hospital is one of the private hospitals serving as a referral center for medical treatment in Cirebon Regency. From facility completeness to drug availability, this hospital is one of the reasons why people seek medical treatment there. However, the queues at the hospital have become an issue that can impact both patient health and loyalty. Present-day customers seek service quality commensurate with the price they pay (Wang & Fung, 2015). For example, long waiting times for patients seeking consultations are a recurring source of complaints (Amar, Pomey, SanMartin, De Coster, & Noseworthy, 2015). Long queues at hospitals can significantly affect patient health. Some possible impacts include delayed patient recovery due to examination delays, worsening patient conditions due to the development of the patient's illness, and increased stress and anxiety for patients waiting at the hospital. On the other hand, increasing competition in healthcare services has made it important to assess and improve healthcare service performance. However, due to a lack of scientific management, the healthcare industry is still struggling to become fully "patient-centered" and "committed to serving patients" (Lin, Liu, Wang, & Li, 2015). Currently, improving productivity in hospitals has become a primary concern (Arafeh, Bargash, Sallam, & AlSamhouri, 2014). Research on improving the efficiency of healthcare systems has attracted a lot of attention, with the Discrete Event Simulation (DES)-based approach appearing to be the dominant tool (Barghash & Saleet, 2018). DES can provide detailed analysis results for existing healthcare systems, forecast potential changes' impact, and provide guidance for management (Zhou, Wang, & Li, 2014). With the development of computer science and rapidly increasing computing power, simulation using appropriate software to project object changes in the model before making any changes to the real system has become more popular (Mubiena, 2021). Many studies related to DES in healthcare systems have been conducted, one of which is Paul and Lin Lin's (2012) research on developing a model to streamline patient flow and minimize waiting times in the emergency department of a hospital. Zhou et al. (2014) also used DES to analyze process mining in clinical workflow, a case study in the outpatient clinic of Chicago. Lin et al. (2015) used Promodel for process optimization in the operating room in China. Astanti et al. (2020) also conducted a simulation of outpatient care flow (Polyclinic) in a hospital using Promodel software. This research is conducted to minimize patient waiting times at Pasar Minggu Cirebon Hospital. Improvement methods can be viewed from the resources or locations within the hospital using Promodel 2016.

## 2. Research Methodology

The purpose of this research is to model, simulate, and analyze the services of Pasar Minggu Cirebon Hospital. The simulation software used is Promodel 2016. There are several stages in the modeling and simulation process in this research. The first stage is the identification of issues in the patient service system. In this research, the main focus is on the long waiting times for patients. The second stage involves gathering information or data related to variables of interest, such as data on administrative service times, the time it takes to service neurology patients, drug retrieval times, and emergency room service times. In the second stage, a conceptual model is also formed based on the identified issues. Inductive studies related to previous research are conducted in the formation of this conceptual model. Next, data input collected is tested and its distribution is determined. This data is used as input for modeling in the Promodel 2016 software, with the expectation that the model can represent the real system. Verification and validation are performed on the constructed model. Subsequently, design of experiments is carried out to analyze factors and their impacts, followed by an analysis of the simulation results and proposing improvements based on the assessment. The final stage involves drawing conclusions and making recommendations for improvement.

## 3. Result and Discussion

### 3.1. Conceptual Model

The conceptual model in this research is represented in the entity flow diagram below.

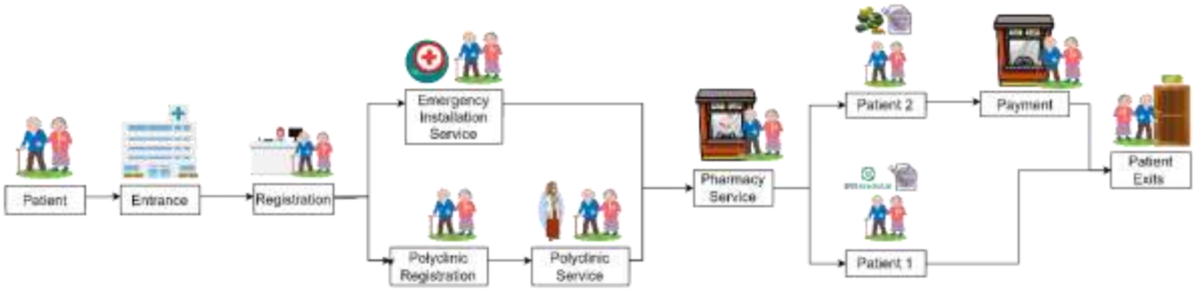


Figure 1. Entity Flow Diagram

The purpose of the simulation is to determine the number of specialist neurologists, the number of employees in the pharmacy department, and to speed up the patient's waiting time in the neurology specialist and pharmacy departments to reduce patient queues and minimize the risk of disease spread. In contrast to the research conducted by Dewanto (2019), this study does not focus on the entire clinic in hospital but only on the neurology clinic, which is consistently busy. From the entity flow diagram that has been depicted, there is information that needs to be collected related to entity information, workstation information, processing sequence, arrivals, movetimes, and other information needed to create a simulation model using Promodel 2016.

### 3.2. Simulation Model

The results of the simulation model design for Pasar Minggu Hospital consist of layout, location, entities, arrival, variables, resources, and processing, which can be seen in Figure 2.

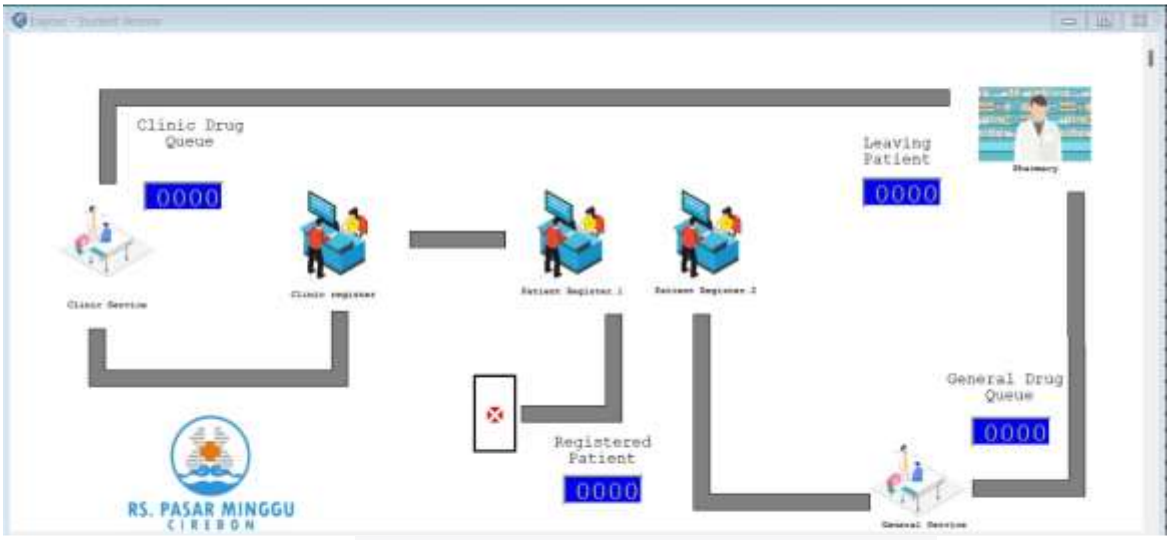


Figure 2. Simulation Model of Pasar Minggu Hospital.

In this simulation model, there are 12 locations designated for processing entities and waiting areas for entities to be processed. These locations consist of two patient registration units, one outpatient clinic registration unit, one pharmacy unit, one outpatient clinic service unit, one general service unit, and six queues for each location. These queues serve as waiting areas as patients move from one location to another, and each location has a different capacity.

### 3.3. Verification and Validation

Model verification is a part of comparing the simulation model designed with the conceptual model that has been previously designed. Verification in this research is conducted using 3 methods, namely checking against the output, manual visualization of the model's animation, and using the trace and debug features in the Promodel software. Validation, on the other hand, is a process that can determine whether the designed model represents the real system or not. The model can be considered valid if the results of the model and the real system do not have significant differences. There are several techniques that can be used to validate a model, such as comparing the model with the real system, comparing the model with another model, testing face validity, and so on. In the validation of the simulation model of Pasar Minggu Hospital, the technique used is to compare the results of the simulation model with the real system.

### 3.4. Analysis and Design of Experiments

Once the model has been verified and validated, the next step is the analysis and design of experiments, which involves detailing the factors and responses, design of experiments, results of the design of experiments, and ANOVA testing. Here is a description of the factors and levels used.

**Tabel 1**. Description of the factors and levels used.

| Faktor | Low Level (-) | High Level (+) | Hypothesis |
|---|---|---|---|
| Pharmacy capacity total | 1 | 3 | An increase in pharmacy capacity will expedite the medication retrieval process and reduce waiting times. |
| Pharmacy service time for BPJS | N(19,8.61) | N(12,8.61) | Improving pharmacy service time can expedite the medication retrieval process and reduce waiting times. |
| Pharmacy service time for non-BPJS | N(20.9,8.14) | N(15,8.14) | Improving pharmacy service time can expedite the medication retrieval process and reduce waiting times |

The selection of these factors is influenced by the existing conditions obtained through ProModel simulation. In the existing condition, the longest queue occurs during drug retrieval at the pharmacy. Three unit of pharmacy capacity were chosen as the high level with the consideration of the space availability and the hospital's plan to add more doctors in the future. Moreover, the selection of high-level and low-level of service time is based on consideration with hospital's target time, the longest time, and the shortest time for patient services. Here is a table of the queue conditions in the existing condition.

**Tabel 2**. Current Queue State.

| No. | Queue Name | Maximum Value | Average Value |
|---|---|---|---|
| *1* | Outpatient Medication Queue | 30,25 | 13,06 |
| *2* | General Medication Queue | 102,15 | 47,38 |

Once the factors and their respective levels are determined, the design of experiments process continues by combining all possible levels for each factor. Based on the previous section, there are 2 factors in total, resulting in 8 combinations for these factors. Here are the combinations for each design.

**Tabel 3**. Details of Required Design Points.

| Design Point | Factor 1 | Factor 2 | Factor 3 |
|---|---|---|---|
| 1 | - | - | - |
| 2 | + | - | - |
| 3 | - | + | - |
| 4 | + | + | - |
| 5 | - | - | + |
| 6 | + | - | + |
| 7 | - | + | + |
| 8 | + | + | + |

The first design point indicates no changes for each factor compared to the existing condition, while the 8th design point signifies that each factor used is altered with the aim of reducing the queue. Through ANOVA calculations, the results for each response for every design point are obtained as follows.

**Tabel 4**. Design Point Response.

| Design Point | Factor 1 | Factor 2 | Factor 3 | Response |
|---|---|---|---|---|
| 1 | - | - | - | 47,38 |
| 2 | + | - | - | 13,59 |
| 3 | - | + | - | 37,91 |
| 4 | + | + | - | 7,63 |
| 5 | - | - | + | 44,54 |
| 6 | + | - | + | 12,39 |
| 7 | - | + | + | 34,63 |
| 8 | + | + | + | 6,94 |

From the table above, it can be concluded that the response that shows the most significant difference is 4 and 8. Alternative 4 occurs when the pharmacy's capacity is increased to 3, and the BPJS pharmacy service time is accelerated, while alternative 8 occurs when all the specified factors are changed to the high level. The process continues using the t-test: paired for two sample means in Microsoft Excel's data analytics.

After conducting the experiment design with three factors and two levels, two best alternatives were obtained, which provided the response of the average waiting time in the outpatient pharmacy. The best alternatives are alternative four and alternative eight. The combination of the three factors with two levels can be seen based on the following table.

**Tabel 5**. Comparison between Alternative 4 and Alternative 8.

| | Pharmacy Capacity Quantity | Pharmacy Service Time BPJS | Non-BPJS Pharmacy Service Time | Average Medication Retrieval Queue Length |
|---|---|---|---|---|
| Alternative 4 | 3 | N(12,8.61) min | N(20.9,8.14) min | 7.63 persons |
| Alternative 8 | 3 | N(12,8.61) min | N(15.9,8.14) min | 6.94 persons |

To test that there is a significant difference between alternative 4 and alternative 8, a t-test: paired for two sample means was conducted. The result shows that there is indeed a significant difference in the response, which is the average waiting time for medication pick-up, when comparing alternative 4 and alternative 8. This difference is indicated by the responses produced. In alternative 8, a faster response is achieved, which is 6.94 minutes, while alternative 4 takes 7.63 minutes. Therefore, it can be concluded that the better-implemented alternative is alternative 8. Alternative 8 involves increasing the pharmacy's capacity to 3, speeding up the BPJS pharmacy service time with a normal distribution of 12 minutes on average, and a non-BPJS pharmacy service time averaging 15.9 minutes.

Both alternative 4 and alternative 8 utilize the high-level capacity of the pharmacy factor. Pharmacy capacity is the most significant factor in reducing patient waiting times within the system. However, when designing the expansion of pharmacy capacity, it's essential to consider the number of workers involved in medication preparation. The increase in pharmacy capacity involves expanding the medication pick-up area and adding workers to the pharmacy department.

### 3.5. Analysis of Experimental Design Results and Proposed Improvements

Based on the experimental design results, alternative 8 has been selected as the best alternative for providing the response of average time in outpatient pharmacy. This requires increasing the pharmacy quantity to 3 people, pharmacy service time for BPJS to N(12, 8.61) minutes , and N(15.9, 8.14) minutes for Non-BPJS. Alternative 8 can decrease medication retrieval queue time by 6.94 minutes.

**Tabel 6**. Information regarding the Alternative chosen.

| Alternative | Increase pharmacy's capacity | Speeding up pharmacy service time for BPJS | Speeding up pharmacy service time for Non-BPJS |
|---|---|---|---|
| 8 | 3 persons | 12 minutes on average | 15.9 minutes on average |

In the implementation of alternative 8, the cooperation between stakeholder is required, specifically pharmacy staff and management. The things that need to be resolved are pharmachy capacity that consider the number of workers involved in medication preparation. In addition, management can implement the Six Sigma process improvement methodology as it can reduce waiting time by 50% (Arafeh, Bargash, Sallam, & AlSamhouri, 2014).

**1) Comparison Analysis of Simulation Results between Existing and Proposed Scenarios**

To check the differences between the existing condition and the proposed alternative 8, comparison of each aspect as follows.

**Tabel 7**. Comparison between Existing and Proposed Conditions.

| Comparison Aspect | Existing (a) | Proposed (b) | Difference (b-a) |
|---|---|---|---|
| Average length of clinic drug queue (persons) | 13,06 | 6,11 | -6,95 |
| Average length of general drug queue (persons) | 47,38 | 0,44 | -46,94 |

It can be seen that from the aspects average length of clinic drug queue and average length of general drug queue, the difference in the average length of the existing and proposed queues is very different. The proposed solution affects the length of the patient queue in order to increase customer satisfaction.

**2) Managerial Implications Analysis**

From an economic perspective, the implementation of these improvement can enhance the speed of patient services within the hospital, allowing for an increased number of patients to be served in one day. However, the increase in pharmacy capacity will lead in an increase in costs incurred by the hospital. These expenses can be covered by the increase in revenue generated by the hospital.

From a human resource perspective, management must ensure that medical and healthcare staff have adequate training to cope with the increased number of patients served. Furthermore, pharmacy services personnel must be constantly directed in terms of speed in order to reduce pharmacy service time for both BPJS and non-BPJS patients. Throughout the implementation, the pace of services must also be maintained. This may involve reviewing and adjusting protocols, inventory management of medicines, as well as integrating technology to enhance data tracking and reporting. With proper management of all these aspects, the increase in service time at the hospital can be carried out effectively and have a positive impact on service quality and operational sustainability.

## 4. Conclusion

In the developed simulation model, there are two queues: the outpatient clinic queue caused by the specialist doctors' working shifts and the pharmacy drug queue, which doesn't differentiate between drugs from the emergency room (ER) and the outpatient clinic. The queue lengths in the existing condition are 5 patients for the outpatient clinic queue, 13 people for the outpatient clinic drug queue, and 47 people for the general drug queue. After verifying and validating the model, the focus of this research shifted to the pharmacy drug queue since it contributed the longest queue in the system. Proposed improvements in the service system related to the pharmacy at Rumah Sakit Pasar Minggu involve enhancing three factors: pharmacy capacity, BPJS pharmacy service time, and non-BPJS pharmacy service time. The selected alternative after analyzing improvements related to these three factors includes increasing the pharmacy capacity to three units, shortening the BPJS pharmacy service time to an average of 12 minutes, and the non-BPJS pharmacy service time to an average of 15.9 minutes. These three changes related to the three factors will impact the average queue length for drug pick-up, reducing it to 6.94 people.

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