Improving Performance of Outpatient Queuing System: A Simulation Based Case Study

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Abstract. Nowadays, hospitals are facing overcrowding of patients in outpatient treatment. It caused many problems because the patient takes a long time to wait. The long waiting times would lead to patient dissatisfaction. This study aims to improve the performance of the outpatient queuing system. The simulation technique is applied to analyze the existing system. First, the system description is constructed to determine the outpatient process flow. Next, the required data is collected, and the probability distribution is then fitted. The simulation model is developed using ARENA software. The model is then verified using a run check model and validated using paired T-Test. The simulation reports are analyzed, and it obtained the problems of long waiting times of internal medicine patients and the high utilization of internal medicine Doctors. Scenarios are then suggested to improve system performance. Scenario-3 of addition one internal medicine Doctor and develop a booking system is selected as the best scenario. The scenario can reduce the average waiting time of internal medicine patients from 97.4 minutes to 8.5 minutes and internal medicine doctor utilization from 87% to 75%. This research hopes can help hospital managers continuously improve their service quality and patient satisfaction.

1. Introduction

Queuing theory is used extensively in engineering and industry for analysis and modeling of processes. In the actual system, it allows manager to determine the optimal supply of fixed resources to meet the variable demand. Nowadays, health policy researcher has also attempted to apply this technique more widely throughout the health care system \cite{1}. Unfortunately, most of the proposed queuing model has no actual-world validation and perhaps for this reason, has not been embraced by hospital directors. Therefore, to explore the utility and the implications of queuing theory as it relates to the supply and demand for critical care services, it is needed to develop and analyze a queuing model in a busy hospital \cite{2}.

Health care providers face increasing pressure to deliver high quality and efficient services while fighting rising costs. One of the primary measures for the quality of service is the waiting time of patients. The long waiting times would lead to patient dissatisfaction, resulting choose another health care provider who can provide better service quality. Therefore, time is a valuable asset to patients seeking service at any health center, either public or private providers, and even more useful for patients in critical condition \cite{3}. Hospital services, either private or government-owned, have a mission of providing excellent and quality health services and sustainable and affordable to improve
the health of society. The most practical approach is the use of queuing theory. A significant element in the queue theory includes people looking for services, login, form a queue, queue discipline, and service processes [4].

Regarding satisfying the needs of patients, it cannot be separated from the number of counters that serve the patient's needs. Therefore, the number of counters and room doctors has an essential role in a hospital's excellent service. Good quality service is serving the patient quickly, so the patients do not need to wait for a long time. All hospitals must always pay attention to the quality of their service to achieve patient satisfaction. Outpatient services become one of the significant concerns hospitals worldwide because of the number of outpatients much more extensive than inpatient. The effect of outpatients becomes a source of huge financial income. The income of inpatient in the future can improve hospital finance [5]. The main problems of outpatient services usually caused by a doctor often come late, the double job of doctors, human resources are not friendly, waiting time of the patient is too long, the high workload of nurses, uncomfortable waiting rooms, incomplete facilities, medicines are not available at the pharmacy, the layout of hospital is not good, the distance of supporting room is very far, and patient files are often come late [6]. The main areas that significantly impact patient waiting times are appointment scheduling, resource availability, patient routes, and flow schemes [7].

One problem that often arises in a hospital's outpatient department is waiting too long to get the service. Long waiting time is determined by the patient starts to register to obtain service by a Doctor. According to the Regulation of Minister of Health of Republic Indonesia No. 129/Menkes/SK/II/2008 about the minimum service standard of a hospital, it is noted that the standard waiting time for outpatient service is maximum 60 minutes [8]. The queue is an inevitable problem in all systems where patients are seizing a process or services. Many patients have complained and feel uncomfortable because their time is wasted when they wait to be served. Therefore, it is needed to reduce the waiting time of patients to get service in the hospital to achieve excellent service quality.

Previous research has applied simulation in the health care system. [9] developed a simulation model for an Obstetrics/Gynecology clinic to reduce patient total waiting time. [10] applied simulation to minimize the total time spent in the exam room and total time spent in the clinic. [11] used simulation to evaluate the response variables of waiting time, the number waiting, and utilization of each server and test the three scenarios to improve them. [12] developed a simulation model to improve public health clinic services and plan their resources wisely.

Based on the observation, the waiting time of patients to get service is relatively long. The patients stated the waiting time starting from the registration service until the patients see the doctor is more than an hour, where the standard of hospital service is a maximum of 60 minutes. The average waiting time in outpatient services was 128.7 minutes. Crowded patients occur during the morning operation from 7:00 to 11:00 am. The density of patients inside and outside the waiting room builds up the long queue. Although in the waiting room, patients are provided various facilities such as seating, television, and others to make the patients feel comfortable while waiting, it still cannot eliminate the boredom of patients waiting for services. The long waiting time has made the patient feel bored and depressed [12]. Therefore, it is needed to improve the performance of the outpatient queuing system. This research hopes can enhance service quality as well as patient satisfaction.

2. Methodology
This study is conducted in a public hospital in West Sumatra, Indonesia. The simulation technique is used to analyze and improve the outpatient queuing system's performance in the hospital. This study only focused on two hospital clinics because of those clinics recorded as the highest outpatient, which affects the long queue. The methodology is divided into seven stages as shown in Figure 1.
2.1. System description
This stage is used to understand the observed system. A series of observations and interviews were conducted to develop the process flow of outpatient in the hospital. The schedule of doctors in the clinic is six days from Monday to Saturday. The registration is started at 07.30 – 12.00 am on Monday until Thursday, 07.30 – 10.30 am on Friday, and 07.30 – 11.00 am on Saturday.

2.2. Data collection
The required data were collected and recorded according to the outpatient process flow. The data collection is conducted without interrupting the operating system. The stopwatch method was used in the data collection. The data was collected for seven operation days which representing the hospital services in one week. The probability distribution of gathered data is then fitted using an input analyzer of ARENA software.

2.3. Model development
The simulation model is developed using ARENA software. The model development consists of a simulation model of arrival counter, close entrance, admission process, clinic decision, internal medicine clinic process, and pulmonology clinic process. The simulation model is constructed using the modules required in each process.

2.4. Model verification
Verification is carried out to ensure that the simulation model is built in the right way. The verification process of the queuing simulation model using ARENA software is conducted in two ways. First, using the "run check model" tool. The verification is carried out continuously according to the stages of the model development. If the model is correct, it will show a notification that there is no error. If the model is made incorrect, then a notification will appear that an error has occurred. Second, the model verification is conducted using ARENA software animations, such as statistical reports and object animations to show the suitability of the running model to the processing time of each patient's arrival.

2.5. Model validation
Validity testing is needed to determine whether the developed model can represent the actual system. The model validation is conducted using face validation to check the model as a whole process, regardless of what happens in the model. The model validation is performed using the Paired T-Test. It compares the number of outpatient between the simulated data and the actual data using five replications.

2.6. Simulation Results
The simulation results are analyzed based on the simulation reports in terms of entity, queue, and resource.
2.7. Development of scenarios
The scenarios are then developed based on the simulation results.

3. Results and discussions

3.1. System description
The system description of outpatient in this hospital is presented in Figure 2. It started with the patient arrives in the hospital and go to the queue ticket machine. The patient will be taking the queue ticket and waiting for admission. When the number is calling, the patient will go to the admission counter. The patient will be provided with a medical record and get the new queue ticket to meet the doctor. Then the patient will go to the waiting clinic area. Finally, the patient will meet the doctor and exit the hospital. All the processes are using first in first out (FIFO) system.

![Figure 2. Outpatient process flow in the hospital](image)

3.2. Data collection
The required data were collected and recorded according to the outpatient process flow. The data collection is conducted without interrupting the operating system. The stopwatch method was used in the data collection. The data was collected for seven operation days which representing the hospital services in one week. A total of 920 data are obtained for each process. The probability distribution of gathered data is then fitted using the input analyzer of ARENA software. The results are shown in Table 1.

| Data analysis                                      | Distribution | Expression               |
|----------------------------------------------------|--------------|--------------------------|
| Inter arrival time                                 | Exponential  | 0.999 + EXPO (84.1)      |
| Transfer time 1 (to ticket machine)                | Triangular   | TRIA(4.5, 6, 8.5)        |
| Transfer time 2 (to admission waiting area)        | Triangular   | TRIA(19.5, 25, 35.5)     |
| Admission process time                             | Beta         | 15 + 404 * BETA (1.45 , 1.26) |
| Transfer time 3 (to internal medicine waiting area)| Triangular   | TRIA(27.5, 40, 56.5)     |
| Service time of internal medicine polyclinic       | Beta         | 606 + 768 * BETA (0.853, 0.914) |
| Transfer time 4 (to pulmonology waiting area)      | Triangular   | TRIA(69.5, 73.5, 150)    |
| Service time of pulmonology polyclinic             | Beta         | 244 + 414 * BETA (1.08, 1.5) |

Inter arrival time is the time between the arrival of one patient to the hospital and the next patient. Transfer time-1 is the time spent by the patient to walk from the hospital entrance to the queue ticket machine. Transfer time-2 is the time spent by the patient from the queue ticket machine to the admission waiting area. Transfer time-3 is the time spent by the internal medicine clinic patient from admission counter to the clinic waiting area. Transfer time-4 is the time spent by the patient of the pulmonology clinic from admission counter to the clinic waiting area. The admission process time is...
the time spent by the patient in the admission counter. Doctor service time-1 is the time spent by the patient to meet the internal medicine doctor. Doctor service time-2 is the time spent by the patient to see the pulmonology doctor.

3.3. Model development
The simulation model is developed according to the outpatient process flow in the hospital using ARENA software. The model is developed to taking ticket, admission counter, polyclinic decision, internal medicine polyclinic process, and pulmonology polyclinic process.

3.4. Model verification
The verification of the simulation model was conducted in two ways. First, using the "run check model" tools of ARENA software. The results show no errors or warnings in the model. Second, model verification is performed using animations provided by ARENA software. The animation variable is used to check whether the patient's output towards the internal medicine clinic, the pulmonology clinic, or other clinics. Based on the verification results, it can be concluded that the developed model is verified.

3.5. Model validation
The model validation was conducted using Paired T-Test with confidence interval = 0.95 and α = 0.05. The hypothesis is as follows:

\[ H_0: \mu_1 - \mu_2 = 0: \text{there is no significant difference between actual data and simulated data} \]
\[ H_1: \mu_1 - \mu_2 \neq 0: \text{there is a significant difference between actual data and simulated data} \]

The data tested is that the number of outpatients exits the hospital, which is compared to the actual data collected. It is obtained that p-value (0.393) higher than α value. Hence, the null hypothesis was not rejected. Therefore, it can be concluded that there was no significant difference between actual data and simulated data.

3.6. Simulation results
The simulation reports are presented in Table 2, Table 3 and Table 4. The results show that internal medicine patient is the highest entity with the total time spent in the system of 7,411.55 seconds (2.06 hr) and the average waiting time of 5,831.35 seconds (1.62 hr). The total time is obtained from the time of taking queue ticket, time of admission queue, time of blood pressure measurement queue, time of waiting of internal medicine Doctor, and time of internal medicine queue. The largest utilization resource is the internal medicine Doctor, with a value of 87%. The eight replications show the largest average of waiting time is 1.62 hr (5,841 seconds), and the maximum waiting time is 2.63 hours (9,477 seconds) by internal medicine patients. The waiting time is higher than the hospital's standard waiting time, i.e., \( \leq \) 60 minutes (1 hour). The waiting time of pulmonology patients is 0.97 hr (3,492 seconds), with the maximum time is 1.52 hr (5,472 seconds). The largest average of resources utilization is internal medicine Doctor (0.87). The utilization of pulmonology Doctor is 0.68. It can be concluded there is a problem in waiting time by the internal medicine patient and the utilization of internal medicine Doctors.
### Table 2. Simulation report of time

|                  | Average | Half width | Minimum average | Maximum average | Minimum value | Maximum value |
|------------------|---------|-----------|-----------------|-----------------|---------------|---------------|
| **VA time**      |         |           |                 |                 |               |               |
| Interne patient  | 1505.72 | 43.52     | 1434.09         | 1581.93         | 804.12        | 2244.61       |
| Lung patient     | 671.95  | 20.80     | 624.75          | 697.99          | 311.88        | 1062.87       |
| Patient          | 226.33  | 8.18      | 206.38          | 237.27          | 0.00          | 423.40        |
| **NVA time**     |         |           |                 |                 |               |               |
| Interne patient  | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Lung patient     | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Patient          | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| **Wait time**    |         |           |                 |                 |               |               |
| Interne patient  | 5831.53 | 1558.57   | 3379.24         | 8961.44         | 859.39        | 15392.38      |
| Lung patient     | 3520.72 | 1027.21   | 1788.57         | 5328.81         | 0.00          | 8470.16       |
| Patient          | 215.94  | 73.56     | 101.71          | 393.29          | 0.00          | 1539.43       |
| **Transfer time**|         |           |                 |                 |               |               |
| Interne patient  | 74.30   | 0.49      | 73.41           | 75.13           | 59.17         | 92.14         |
| Lung patient     | 130.37  | 3.60      | 124.30          | 137.77          | 99.45         | 180.03        |
| Patient          | 32.65   | 0.17      | 32.43           | 33.04           | 0.00          | 41.65         |
| **Other time**   |         |           |                 |                 |               |               |
| Interne patient  | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Lung patient     | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Patient          | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| **Total time**   |         |           |                 |                 |               |               |
| Interne patient  | 7411.55 | 1569.34   | 4887.14         | 10541.20        | 2342.85       | 16682.71      |
| Lung patient     | 4323.04 | 1018.76   | 2597.29         | 6109.34         | 725.52        | 9194.43       |
| Patient          | 474.91  | 76.34     | 359.73          | 663.05          | 0.00          | 1775.45       |

### Table 3. Simulation report of queue

| Waiting time                      | Average | Half width | Minimum average | Maximum average | Minimum value | Maximum value |
|-----------------------------------|---------|-----------|-----------------|-----------------|---------------|---------------|
| Admission                         | 220.20  | 75.18     | 101.04          | 403.17          | 0.00          | 1550.25       |
| Blood pressure measurement        | 5.62    | 2.32      | 2.32            | 10.40           | 0.00          | 95.84         |
| Interne batch                     | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Interne process for single patient| 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Interne process                   | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Lung process                      | 0.00    | 0.00      | 0.00            | 0.00            | 0.00          | 0.00          |
| Taking queue number               | 0.11    | 0.03      | 0.06            | 0.17            | 0.00          | 5.68          |
| Waiting for interne doctor        | 5612.88 | 1535.79   | 3299.11         | 8746.99         | 817.69        | 14718.19      |
| Waiting for lung doctor           | 3285.41 | 1033.43   | 1518.80         | 5086.12         | 0.00          | 8470.16       |
Table 4. Simulation report of resource

| Scheduled utilization | Average | Half width | Minimum average | Maximum average |
|-----------------------|---------|-----------|----------------|----------------|
| Adm off 1             | 0.5973  | 0.04      | 0.5122         | 0.6394         |
| Adm off 1             | 0.5855  | 0.04      | 0.5091         | 0.6350         |
| Adm off 1             | 0.5830  | 0.04      | 0.5052         | 0.6242         |
| Intern doctor         | 0.8684  | 0.01      | 0.8464         | 0.8949         |
| Lung doctor           | 0.6831  | 0.08      | 0.5524         | 0.7994         |
| Nurse                 | 0.1358  | 0.01      | 0.1260         | 0.1477         |
| Ticket machine        | 0.0387  | 0.00      | 0.0331         | 0.0427         |

3.7. Development of scenarios

Based on the simulation results, three scenarios are developed to improve the outpatient queuing system's performance as follows:

- **Scenario-1: Adding one internal medicine doctor**
  There is only one internal medicine doctor in the existing model. This scenario is adding one internal medicine doctor. The results show the average waiting time of internal medicine patients reduce from 1.62 hr (5,841 seconds) to 0.23 hr (832.5 seconds) with the maximum waiting time from 2.63 hr (9,477 seconds) to 0.58 hr (2,070 seconds) and minimize the utilization of internal medicine Doctor from 87% to 84% for both Doctors.

- **Scenario-2: Designing a booking system**
  Currently, the hospital is not applied to the booking system yet. The booking system will help to reduce the waiting time. The patient can directly go to the admission counter. It is assumed that 70% of patients will use the booking system, and the time spent by the patient in the admission counter is a constant of one minute. This scenario is used to implement the new modern internet technology to reduce the queuing problem for patient satisfaction. This scenario reduces the average waiting time of patient in admission counter from 0.05 hr (184.5 seconds) to 0.00 hr (9 seconds) and the maximum waiting time from 0.18 hr (657 seconds) to 0.06 hr (216 seconds) but slightly increase in the average of internal medicine patients from 1.62 hr (5,841 seconds) to 1.66 hr (5,967 seconds). There is no improvement in the maximum waiting time of internal medicine Doctors from 2.63 hr (9,477 seconds) to 2.70 hr (9,711 seconds). The utilization of internal medicine Doctors is still 87%.

- **Scenario-3: Combining scenario-1 and scenario-2**
  Scenario-3 developed by adding one internal medicine Doctor and implementing a booking system. The scenario can reduce the average waiting time of patients in the admission process and minimize internal medicine doctor utilization. The average waiting time of patient in admission counter is reduced from 0.05 hr (184.5 seconds) to 0.01 hr (49.5 seconds) and the maximum waiting time is reduced from 0.18 hr (657 seconds) to 0.14 hr (508.5 seconds) and the maximum waiting time is reduced from 2.63 hr (9,477 seconds) to 0.38 hr (1,359 seconds). The utilization of internal medicine Doctors is reduced from 87% to 76% for Doctor 1 and 75% for Doctor 2.

The comparisons of bottleneck identification from the scenarios can be seen in Table 5. It can be seen from Table 5 that scenario-3 can reduce the average waiting time of patients compared to the existing model and other scenarios. Besides, scenario-3 can also improve the utilization of resources by balancing the level of resource utilization. Therefore, it can be concluded that the best scenario is scenario-3 by adding one internal medicine doctor and applying a booking system. It is suggested for
the hospital to implement scenario-3 as a suggestion to improve the performance of the outpatient queuing system.

Table 5. The comparisons of scenarios

| Bottleneck Identification | Existing Model | Scenario-1 | Scenario-2 | Scenario-3 |
|---------------------------|----------------|------------|------------|------------|
| Average Waiting Time (hr) | Int. Patient   | 1.62       | 0.23       | 1.66       | 0.14       |
|                           | Max            | 2.63       | 0.58       | 2.70       | 0.38       |
|                           | Lung Patient   | 0.97       | 0.97       | 0.94       | 1.00       |
|                           | Max            | 1.52       | 1.42       | 1.51       | 1.49       |
|                           | Patient (adm)  | 0.05       | 0.09       | 0.00       | 0.01       |
|                           | Max            | 0.18       | 0.28       | 0.06       | 0.11       |
| Utilization of Resources  | Adm 1          | 60%        | 76%        | 25%        | 26%        |
|                           | Adm 2          | 59%        | 77%        | 26%        | 24%        |
|                           | Adm 3          | 58%        | 77%        | -          | -          |
|                           | Adm 3 (booking)| -          | -          | 33%        | 53%        |
|                           | Int. Doctor 1  | 87%        | 84%        | 87%        | 76%        |
|                           | Int. Doctor 2  | -          | 84%        | -          | 75%        |
|                           | Lung Doctor    | 68%        | 83%        | 68%        | 81%        |
|                           | Nurse          | 14%        | 15%        | 14%        | 13%        |
|                           | Ticket Machine | 4%         | 5%         | 1%         | 1%         |

4. Conclusions
This research has applied the simulation technique to improve the performance of the outpatient queuing system. The biggest problem occurs at the internal medicine clinic, with the average waiting time of patients is 1.62 hr (97.35 minutes), and the resource utilization of internal medicine Doctors is 87% that must be reduced because of below the minimum of standard waiting time. The hospital needs to pay great attention in order to improve hospital performance as well as patient satisfaction. Three scenarios are developed to enhance the performance of the outpatient queuing system. Scenario-3 is the best scenario that can reduce the waiting time of the internal medicine 1.48 hr (88.9 minutes) and the utilization of internal medicine Doctor 12% by implementing a booking system in hospital and adding one internal medicine Doctor. This study hope can help the hospital improve the performance of the outpatient queuing system and the whole hospital performance. Future research will be analyzing the implementation of scenario 3 in the hospital.

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