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Simulating and Analysing Patients' Waiting Time in Outpatient Department at Public Clinic in Johor Using Arena Software

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ABSTRACT

The simulation is a time-based representation of a real-world given system's performance. This study aims to simulate and analyse patient waiting time in the outpatient department at a public clinic in Johor. A quantitative approach was used in this study. The data collection method was observation. The patients' waiting time at the health clinic will be observed. The data collection will be held for ten days. There have 400 respondents who participated in the study. Arena Software analysed the collected data on waiting time from observation. There were two categories of outpatients in that queue modelling: express and regular. Patients that receive express care are pregnant, old, and disabled. Whereas healthy and young patients were classified as regular patients. The data obtained from the simulation and the observation will be compared to determine whether it satisfies the verification and validation requirements.

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1. Introduction

A government clinic is divided into several departments based on their specialisations: outpatient, emergency, dental, and mother and child. Compared to the other departments, Aziati & Hamdan (2018) claimed that the outpatient department of the public health clinic had the most queues. There has been much research conducted around the world to improve the quality of services provided by outpatient departments and prove that it is not a new issue (Ahmad & Hasan, 2016; Azraii et al., 2017; Glowacka et al., 2017; Johannessen & Alexandersen, 2018). This is because the outpatient department is an essential health centre section.

A patient is someone who receives healthcare treatment from healthcare providers. The book 'Diagnosis and Treatment Manual' describes a patient as any person who has a complaint of illness or injury, apparent signs of illness or injury, or has been diagnosed with a disease or disability by another person (Manual, 2016, p. 4). An outpatient is a patient who visits an outpatient facility to stay at most of the appointment time. A study by Jamjoom et al. (2014) has several types of patients in the outpatient department: new, follow-up, walk-in, and return. The new patient is a patient who is making their first treatment at the outpatient clinic. The follow-up patient who attended the outpatient facility with the same medical complaint will be followed up. The walk-in patient is a patient who appears at an outpatient facility without making an appointment. Hence, return patients, whether they are new or follow-up patients, the doctor sends them to take laboratory tests at the laboratory station. They need to return to the doctor's queue.

Simulation is a technique for examining the existing or proposed system's quality management effectiveness in various situations and extended periods (Maria, 1997). In the late 1950s, simulation was developed. Simulation has become the most used of the classic Operational Research approaches across various industries and users (Hollocks, 2017). According to (Banks et al., 2020), a simulation replaces a real-world mechanism or device over time. It establishes mathematical, logical, and symbolic relationships between the device entities of interest. It also estimates device efficiency measurements with simulation-generated data.

Stojkovikj et al. (2016) state that the simulation model expresses various system operations assumptions. These assumptions are represented in the mathematical, logical, and symbolic relationships between the system's entities or objects of interest. The model can be applied to real-world systems to answer, "what if?" questions. Simulation involves developing an artificial history of a system and observing artificial history to derive assumptions about its existing system's operating characteristics. Simulation minimises the chances of failing to fulfil requirements, reduces unexpected inefficiencies, avoids under or over-utilization of resources, and improves system performance when making changes to an existing system or constructing a new one.

According to the previous literature, the study showed that the researchers utilised a simulation model to demonstrate the waiting time in the system (Ali & Kassam, 2017; Aziati & Hamdan, 2018; Luo et al., 2016). According to Alhaag et al. (2015), the primary goal of the simulation model is to minimise patient waiting times while simultaneously improving service quality.

A queuing system can optimise resource utilisation, such as doctors and nurses, reducing patients' waiting time. Many approaches can be taken to boost the efficiency of the queuing method in outpatient clinics, thus increasing patient satisfaction. It is helpful in healthcare facilities experiencing patient overcrowding and long waiting times (Ting & Sufahani, 2021).

2. Experiment

2.1 Population and Sample

This study's population was patients seeking treatment in the outpatient department at a public clinic in Johor. There have 400 respondents who participated in the study.

2.2 Study Design

To understand the objectives of the study, a quantitative approach was used in this study. The data collection method was observation. The patients' waiting time at the health clinic will be observed. The data collection will be held for ten days and include 400 respondents.

2.3 Approach and Method of the Research

Arena Software analysed the collected data on waiting time from observation. Arena software is used in constructing a queuing model based on the data collected from observation.

2.4 Research Framework

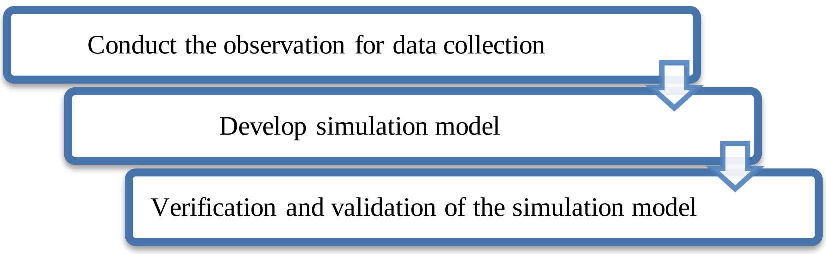

Figure 1. Research Framework

i. Conduct the Observation for Data Collection

Research assistants will be placed at several checkpoints, such as the registration counter, waiting room, doctor's room, laboratory, and pharmacy. They recorded the arrival and departure times at each checkpoint for each patient. Each patient who joined the observation would wear a mini sticker on the shoulder to avoid confusion. Before that, the researcher explained the procedures to the patients and got their permission in participated the study. The observation included 400 respondents and was held for ten days.

ii. Develop Simulation Model

This study used Discrete-Event Simulation (DES) to develop a simulation model. The accuracy of the information and data undertaken by the researcher relies on the records during observations. The start and finish timings of each respondent at each checkpoint are precisely recorded, and this data is processed to create a simulation representative of the actual situation. To develop the simulation model, there have two tools that can be used, which are Arena Simulation Software and Input Analyzer.

iii. Verification and Validation of the Simulation Model

The simulation model should be verified and validated to produce an accurate model and ensure it is free from logical errors. The verification test ensures that the simulation model is free from logical errors. In contrast, the validation test refers to the process of ensuring the simulation model and its implementation is valid and accurate by using the correct data and being able to represent the real-world situation (Sargent, 2010). In this study, the researcher used the percentage of verification, little's Law, animation, face validity, and the Turing test to ensure the validation and verification.

3. System Description

There were two categories of outpatients in that queue modelling: express and regular. Patients that receive express care are pregnant, old, and disabled. Whereas healthy and young patients were classified as regular patients. Typically, the queue for express patients was special, faster than regular patients. Twenty officers operate from the first checkpoint to the last checkpoint for this operating system. Some checkpoints have more than two officers, such as the doctor's room and the pharmacy.

Table 1. Officers and Checkpoints

No.	Officers	Checkpoints
1.	Registration Take Number Officer	Patient's triage
2.	Registration Counter Officer 1	Registration section
3.	Registration Counter Officer 2	
4.	Take Blood Pressure Officer	Take blood pressure
5.	Doctor Take Number Officer	Doctor's room
6.	Express Doctor Officer 1	
7.	Express Doctor Officer 2	
8.	Express Doctor Officer 3	
9.	Regular Doctor Officer 1	
10.	Regular Doctor Officer 2	
11.	Lab Officer	Laboratory
12.	Radio Officer	Radiology
13.	Dressing Officer	Dressing room
14.	Pharmacy Take Number Officer	Pharmacy
15.	Express Search Drug Officer 1	
16.	Express Search Drug Officer 2	
17.	Express Search Drug Officer 3	
18.	Regular Search Drug Officer 1	
19.	Regular Search Drug Officer 1	
20.	Pharmacist 1	

4. Data Observation

To achieve the objective, observational time studies were performed. There have 200 express patients and 200 regular patients that were observed. There were four actual time outcomes for each patient at every checkpoint: the actual arrival time, the actual service time, the actual waiting time, and the actual departure time. The actual visit duration was taken from the difference between departure and arrival times. It is to make sure the data is accurate and valid.

Table 2. Average Number of Patients Enter into The System

Patient's type	Number of Patients (Person)
Express Patients	200
Regular Patients	200

The table below shows the average service time for each entity at each checkpoint. Service time is the time allotted by the physician to provide treatment or consultation to the patient.

Table 3. Average Service Time Per Entity

Patient Flow	Service Time (min)
Registration Take Number	0
Registration Counter	1.805
Take Blood Pressure	2.74
Doctor Take Number	0
Express Doctor Room	7.3
Regular Doctor Room	18.18
Laboratory Process	19.28
Radiology Process	15.935
Dressing Process	10.2
Pharmacy Take Number	0
Express Search Drug	7.38
Regular Search Drug	7.38
Express Pharmacy Counter	1.487
Regular Pharmacy Counter	1.4865

The table below shows the average waiting time per entity at each checkpoint. Waiting time is when patients wait before meeting with a physician or receiving the necessary health care.

Table 4. Average Service Time Per Entity

Patient Flow	Waiting Time (min)
Registration Take Number	0
Registration Counter	35
Take Blood Pressure	13
Doctor Take Number	0
Express Doctor Room	47
Regular Doctor Room	100
Laboratory Process	40
Radiology Process	46
Dressing Process	60
Pharmacy Take Number	0
Express Search Drug	1.56
Regular Search Drug	30
Express Pharmacy Counter	1.566
Regular Pharmacy Counter	1.1

5. Simulation Model

The data already collected from the observation was codded into Arena Simulation Software. The figure below shows the simulation model of the patients at the outpatient department that was codded from the observation data.

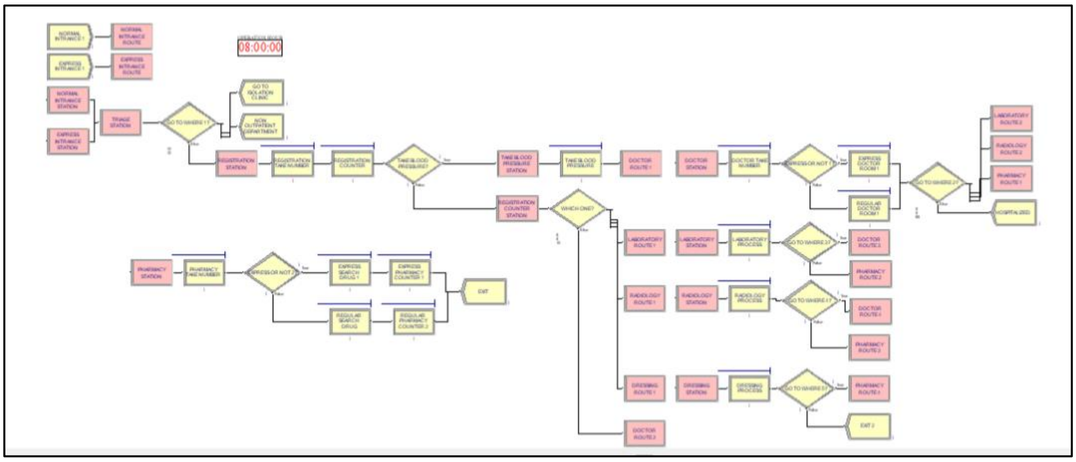

Figure 2. Simulation Model

Table 5. The Patient Flow, Type, Value, and Action

No.	Patient Flow	Type	Value (min)	Action
1.	Registration Take Number	Constant	5	
2.	Registration Counter	Expression	0.5 + EXPO (1.3)	Sieze delay release
3.	Take Blood Pressure	Expression	0.5 + WEIB (2.53, 2.01)	Sieze delay release
4.	Doctor Take Number	Constant	5	
5.	Express Doctor Room	Expression	1.5 + ERLA (2.9, 3)	Sieze delay release
6.	Regular Doctor Room	Expression	1.5 + ERLA (2.9, 3)	Sieze delay release
7.	Laboratory Process	Expression	NORM (18.2, 6.04)	Sieze delay release
8.	Radiology Process	Expression	6.5 + 25 * BETA (1.2, 1.15)	Sieze delay release
9.	Dressing Process	Expression	4.5 + LOGN (11.7, 7.75)	Sieze delay release
10.	Pharmacy Take Number	Constant	5	
11.	Express Search Drug	Expression	TRIA (2.5, 5, 15.5)	Sieze delay release
12.	Regular Search Drug	Expression	TRIA (2.5, 5, 15.5)	Sieze delay release
13.	Express Pharmacy Counter	Expression	TRIA (0.25, 0.938, 3)	Sieze delay release
14.	Regular Pharmacy Counter	Expression	0.25 + LOGN (1.24, 0.697)	Sieze delay release

As shown above, the table patient flow, type, value, and action in simulation modelling. This information would be entered into the Arena Simulation Software to generate the result of the average total time, the average waiting time, and the utilisation of resources.

6. Results and Discussion

Table 6. Number In, Number Out, and Patients Remain in System of Simulation Report

	Express Patient (Person)	Regular patient (Person)	Total (Person)
Number in	196	202	398
Number out	194	183	377
In system	2	19	21

The total time in the system has been set for 9 hours, based on the operation hour of the clinic, which is from 8.00 am to 5.00 pm. The replication was already established as 30 replications. According to the table above, 196 patients were express patients entering the system, while 194 patients were express patients leaving the system. There were still 3 individuals in the system. 202 patients entered the system as regular patients, while 183 patients were express patients leaving the system. There were still 19 individuals in the system. So, the total number of patients who entered the system was 398. The total patient's exit the system was 377. 21 patients remained in the system.

Table 7. Service Time, Waiting Time, Total Time and WIP

	Express Patient (Person)	Regular Patient (Person)
Service time	19.2695	16.9886
Waiting time	71.6728	133.19
Total time	91.4298	150.91

For express patients, the service time was 19.2695 minutes. The waiting time was 71.6728 minutes. The total time was 91.4298 minutes. For regular patients, the service time was 16.9886 minutes. The waiting time was 133.19 minutes. The total time was 150.91 minutes.

Table 8. Waiting Time for Each Patient's Queue

Patient Queue	Waiting Time (min)	Target Time (min)
Registration Take Number	0	< 15 minutes
Registration Counter	32.9574	
Take Blood Pressure	11.2710	
Doctor Take Number	0	< 30 minutes
Express Doctor Room	47.2500	
Regular Doctor Room	106.27	
Laboratory Process	33.3897	
Radiology Process	48.1436	
Dressing Process	38.9175	
Pharmacy Take Number	0	< 30 minutes
Express Search Drug	1.5320	
Regular Search Drug	30.8990	
Express Pharmacy Counter	1.5320	
Regular Pharmacy Counter	1.2985	

As shown above, the average waiting time for the regular doctor room queue was the highest value which was 106.27 minutes. The second highest was the radiology queue with 48.1436 minutes, followed by the Express Doctor Room queue at 47.2500 minutes, the Dressing Process queue at 38.9175, the laboratory queue at 33.3897 minutes, the registration counter queue at 32.9574 minutes, the regular search drug queue with 30.8990 minutes, take blood pressure queue with 11.2710 minutes, express search drug queue with 1.5320 minutes, express pharmacy counter queue with 1.5320 minutes, regular pharmacy counter queue with 1.2985 minutes, and registration take number, doctor take number, and pharmacy take the number with 0 minutes.

Azraii et al. (2017), state that each phase has a target waiting time. For registration, the waiting time must be at least 15 minutes. Waiting time at the doctor's room must be less than 30 minutes. Waiting time at the pharmacy must be less than 30 minutes. Hence, the total waiting time from registration to the consultation must be less than 90 minutes. The service time for consultation must be between 10 and 20 minutes. However, the KPI for the average waiting time in the outpatient department is 60 minutes (Aziati & Hamdan, 2018). Based on the table of waiting time and the target of waiting time, there have been some improvements and adjustments in this study.

Table 9. Percentage of Utilization for Each Officer

Officer	% Of Utilization
Registration Take Number Officer	4.92
Registration Counter Officer 1	53.87
Registration Counter Officer 2	53.45
Take Blood Pressure Officer	55.78
Doctor Take Number Officer	4.41
Express Doctor Officer 1	86.88
Express Doctor Officer 2	86.22
Express Doctor Officer 3	86.08

Regular Doctor Officer 1	94.25
Regular Doctor Officer 2	93.89
Lab Officer	76.40
Radio Officer	82.98
Dressing Officer	62.50
Pharmacy Take Number Officer	4.45
Express Search Drug Officer 1	69.06
Express Search Drug Officer 2	68.69
Express Search Drug Officer 3	68.70
Regular Search Drug Officer 1	95.57
Regular Search Drug Officer 2	93.89
Pharmacist 1	73.57

As shown above, the highest utilization of resources was regular search drug officer 1 with 96.00%. The second highest was the regular search drug officer 2 with 95.12%, followed by the regular doctor officer 1 with 93.65%, regular doctor officer 2 with 93.42%, express doctor officer 1 with 85.31%, express doctor officer 2 with 84.09%, express doctor officer 3 with 83.61%, radio officer with 83.00%, lab officer with 81.15%, pharmacist 1 with 73.05%, express search drug officer 2 with 68.71%, express search drug officer 1 with 68.67%, dressing officer with 68.39%, express search drug officer 3 with 67.78%, take blood pressure officer with 57.69%, registration counter officer 1 with 54.73%, registration counter officer 2 with 53.90%, registration take number officer with 49.84%, pharmacy take number officer with 4.47%, and doctor take number officer with 4.43%.

7. Verification and Validation Test

7.1 Verification Test

i. Percentage of Verification: The Arena Simulation Software simulation output and the real situation data should be compared in this study. If the difference between the simulation output and the actual data is less than or equal to 10%, then it is considered valid and accurate.

Percentage of verification =

$$\frac{|\text{simulation data} - \text{company's original data}|}{\text{company's original data}} \times 100\%$$

Table 10. Average Service Time per Entity for Real Data, Simulation Data and % of Verification

Patient Flow	Real Data (min)	Simulation Data (min)	% Of Verification
Registration Take Number	0	0	0
Registration Counter	1.805	1.8164	0.631578947
Take Blood Pressure	2.74	2.7288	0.408759124
Doctor Take Number	0	0	0
Express Doctor Room	10.2	10.0806	1.170588235
Regular Doctor Room	7.3	7.2352	0.887671233
Laboratory Process	18.18	17.9542	1.242024202
Radiology Process	19.28	19.5389	1.342842324
Dressing Process	15.935	16.0392	0.653906495
Pharmacy Take Number	0	0	0
Express Search Drug	7.38	7.7649	5.215447154
Regular Search Drug	7.38	7.5978	2.951219512
Express Pharmacy Counter	1.487	1.391	6.45595158
Regular Pharmacy Counter	1.4865	1.4736	0.867810293

Table 11. Average Total Entities Enter into The System for Real Data, Simulation Data and % of Verification

Patient's type	Real Data (person)	Simulation Data (person)	% Of Verification
Express Patients	200	197	1.52284264
Regular Patients	200	206	2.912621359

Based on the data above, the verification percentage for the average service time per entity and the average total entities entered the system was less than 10%. So, the validation was valid.

ii. Little's Formula: Little's formula is utilized to conduct the verification test to ensure the model is free from logical error (Little, 2011; Rani et al., 2014).

$L = \lambda\overline{W}$

Where;

L= the average number of patients in a stationary system/work in progress (WIP)

λ = the average effective arrival rate

$\overline{W}$ = the average time an entity spends in the system

$$\lambda = \frac{\text{Total entities arrival}}{\text{total (hour)}}$$

$$\lambda = \frac{196.10}{9x60} \qquad \lambda = \frac{202.30}{9x60}$$

$= 0.363$ $\qquad$ $= 0.375$

Express Patients	Regular Patients
$L = \lambda\overline{W}$	$L = \lambda\overline{W}$
33.6870 = λ x 91.4298	59.3715= λ x 150.91
λ= 0.368	λ= 0.393

There were two types of patients: express patients and regular patients. For express patients, based on the output data, the average number of patients in a stationary system/work in progress (WIP) was 33.6870 patients (L). The average rate of arrivals entering the system was 0.368 (λ). The average time of patients in the system was 91.4298 minutes ($\overline{W}$).

For regular patients, the average number of patients in a stationary system/work in progress (WIP) was 59.3715 patients (L). The average rate of arrivals entering the system was 0.393 (λ). The average time of patients in the system was 150.91 minutes ($\overline{W}$). Based on Little's law that was complied with, the simulation model was considered verified.

7.2 Validation Test

i. Animation: The queuing system of patients starts from the clinic entrance and continues to the triage, the counter registration, the doctor's waiting room, the laboratory unit, the radiology unit, and the pharmacy. This system will be depicted graphically to ensure that the model simulation represents the real situation in the clinic.

ii. Face Validity: After the simulation model was constructed, the researcher asked the management in the outpatient department and requested that they validate the accuracy of the model simulation.

Turing Test: The researcher consulted with a supervisor, someone with expertise and experience regarding the functioning of the model system, to ensure their ability to distinguish between the system output and the model.

8. Conclusion

Observations were made for 10 days to develop the simulation model. Two types of patients are designated in this study: express and regular. Express patients are old, vulnerable, disabled, and pregnant women. At the same time, regular patients are the opposite. Compared to other previous studies, it can be concluded that the researcher did not find a study that differentiates the queue between express and regular patients when this exists in the outpatient department. Express patients get more privileges than regular patients by getting a faster queue due to health, age, and other factors.

According to the research, 202 regular and 196 express patients visited health clinics for treatment. While there were 202 express patients treated, there were 183 regular patients treated. There were 19 patients for regular patients, compared to 2 express patients who were still in the system between 8:00 am and 5:00 p.m.

Based on the simulation model that has been developed, the researcher found that the waiting time for express patients is 71.6728 minutes, while the waiting time for regular patients is 133.19 minutes. The waiting time for express and regular patients exceeds the waiting time set by the Ministry of Health, which is less than 60 minutes. The total time for the express patient and the regular patient should be less than 90 minutes, but the total time of the express patient is 91.4298 minutes, while the total time of the regular patient is 150.91 minutes. So, KPIs of waiting time and total time still need to be achieved.

In conclusion, the objective of the study, which is to simulate and analyse patient waiting time in the outpatient department at a public clinic in Johor, is achieved. Observing the patient flow and queuing system can also determine the patient's waiting time. This is crucial for enhancing the quality of healthcare. This research is an initiative to meet the government's requirements. The government establishes a 60-minute key performance indicator for each patient seeking care at a public health facility (Aziati & Hamdan, 2018). It is also an effort for the parties involved, such as the health clinic management, to look more deeply into this problem. The study's outcome can be a reference source for outpatient wait time issues. Moreover, it can facilitate outpatient clinic management in reducing patient waiting time.

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