Application Of Queuing Theory Model And Simulation To Patient Flow At The Outpatient Department

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Abstract

Long waiting time to be served at the outpatient counter is always the main problem faced by the public clinic. Outpatient department at public health clinic had the greatest queuing challenge compared to the other units. This situation has been a common complaint by the patients. Therefore, the purpose of this study is to determine the waiting arrival time and service time of patients at the outpatient counter and to model suitable queuing system by using simulation technique. This study was conducted at one of the Public Health Clinic in southern Malaysia. This study employed descriptive analytical and simulation method to develop suitable model. The collection of waiting time for this study is based on the arrival rate and service rate of patients at the outpatient counter. The data calculated and analyzed using Microsoft Excel. Based on the analyzed data, the queuing system of the patient current situation was modeled and simulated using the ARENA software. The result obtained from the simulation model shows that average waiting time of patients in queue is 54.295 minutes with the average total exit patient is 327 patients. Thus, the average service time is 13.481 minutes. This study proved that the clinic has achieved the target adopted by Ministry of Health patient charter with the target of waiting to see the doctor within or less than 60 minutes. The study also addressed a few problem found during the observation and appropriate strategies were formulated to improve the waiting time and utilization percentage were carried out including rearrange the schedule of resources. The outcome of this study can be used by Ministry of Health to improve public health clinic services and plan their resources wisely.

Keywords
Queuing theory, waiting time, outpatient, simulation, patients

1.0 Research Background

Time management at the outpatient counter is important especially to the patient with bad injures and diagnose with critical illness (Mittal, Chatterjee, Hasnain, & Varshney, 2016). There are two most common factors cited that impact patient flow and department load in the hospital; (i) patient arrival rate and (ii) in-hospital flow. These factors affect longer waiting time that will caused patients to be dissatisfied (Hassan, Rahman, & Lumpur, 2015). Although the patient has an appointment with the doctor, the long waiting time has made the patient feel bored and depressed. Additionally, long wait times lead to patient forgoing scheduling appointments, increase no-shows, and limit access to care for patients who really need it. Nonetheless, the most paradoxical situation emerges are; longer waiting time, yet capacity is underutilized.

Waiting time is define as the time spent by the customer in the queue before the commencement of the services (Shanmugasundaram & Umarani, 2015). Unfortunately, this case happen at many developing countries public clinics. Public clinics received a large number of patients every day and this generally results in long patient waiting times (Afrane & Appah, 2014). Based on the study done by C & Appa Iyer, (2013), sixty-one percent of the patients waited for 90-180 minutes in the clinic, whereas 36.1% of the patients spent less than 10 minutes with the doctor in the consulting room. The commonest reason for the long waiting time in the general outpatient department was the large number of patients with few health care workers.

In this research, the main focus is to the time spent by the customer in the queue before the commencement of his service. Based on study done by Abdul Manaf, (2006), patients that have to wait more than 15 minutes are consistently dissatisfied with the waiting time. The Malaysian health ministry has set the patient's waiting time for 60 minutes. This guideline is as noted in the management of government hospitality and customer charter. However for the outpatient hospital departments, Bahadori, Mohammadnejhad, Ravangard, & Teymourzadeh, (2014) suggested the best waiting time is between 8-10 minutes. This situation clearly demonstrates the optimum waiting time difference between the Malaysian Health Ministry customer charter with the proposed standard. Although many patients have chosen a private health center rather than a government health clinic for treatment because of the quality of service and doctor's expertise, government clinics are still plagued with long waiting times. Long waiting times in health centers can lead to increase the severity of disease and cause socioeconomic costs (Bahadori et al., 2014). In most cases, outpatient counters will often be crowded especially during their registration early in the morning and after the break in the afternoon. In practice the total number of effective hours of work at the outpatient department by the eight doctors is 49 hours (Afrane & Appah, 2014). (Oche & Adamu, 2013) claimed that lack of staffing problem is a known contributor to lengthy waiting time in outpatient department.

In the context of Public Health Clinic selected in the study, the clinic provides personal medical services to a wide population. The outpatient department was selected because it had the greatest queuing challenge (Afrane & Appah, 2014). Additionally, Utusan Online news portal also reported that the Health Ministry is in the process of addressing the problem of overcrowding at the public health clinic (Utusan Online, 2016) involved in the study. Normally, the distribution numbers of patient attend to the clinic is more than 200 patients per day. The clinic provides medical services, rehabilitation and prevention of qualified, efficient and effective. Moreover, the clinic provides the expertise in mufti-disciplinary treatment for patients. Due to its location, the clinic has received referrals from all peripheral clinics and hospitals. As a result, the clinic is generally busy with an ever increasing workload (Pitchaimuthu, 1997). Based on these factors, this study has been carried out in the clinic using the queuing model with the main objectives of this study are (i) to determine the waiting arrival time and service time of patients and (ii) to model queuing system by using simulation technique.

The most common combination of models in determining the patient's flow are patients's inflow model and queuing model or Markov Chain Model. According to Boyce, Kraft, Svenonius, & Borko, (1991) queuing theory is a branch of operation research because the findings can be used in decision-making and to determine the resources needed to provide better services. Additionally, customer satisfaction can be improved by reducing waiting times besides providing best service. Queuing theory can be useful in real-world health care situations based from previous studies related to the same issue. Application of queuing theory to model clinic settings has been widely published in most health care settings, unless an appointment system is in place, the queue discipline is either first-come-first-serve or a set of patient classes that have different priorities (Afrane & Appah, 2014). It is clear that queuing models are simpler, require less data and provide more generic results than simulation (Green, 2006a). In this study, the existing waiting time will be examined. Further, the study modeled suitable queuing system by simulation technique to improve the existing waiting time and utilization of resources.

2.0 Literature Review

2.1 Queuing Theory In Health Care

Works on the theory and applications of queuing systems have grown exponentially since the early 1950s (Green, 2006a). Queuing Theory (QT) is the mathematical study of waiting lines, or queues. QT can be applied in various fields, yet most of previous studies are well documented in the literature of Probability, Operations Research, and Management Science. Some of the applications are machine repair, tool booths, inventory control, the loading and unloading of ships, scheduling patients in hospital clinics and in computer fields. Queuing theory has been applied to computer simulation models to help with decision making of numbers of hospital server, resource utilization and to reduce waiting time. QT has been extensively utilized in industrial settings to analyze how resource-constrained systems respond to various demand levels, and thus is a natural fit for modeling patient flow in a health care setting (Boyd & Gupta, 2006), (Xia, Sean, & Bruce, 2018). The theory enables mathematical analysis of several related process, including arriving at the queue, waiting in the queue, and being served at the front of the queue. The theory permits the derivation and calculation of several performance measures including the average waiting time in the queue or the system, the expected number waiting or receiving service, and the probability of encountering the system in certain states, such as empty, full, having an available server or having to wait a certain time to be served (Boyce et al., 1991).

Queuing is well develop field that has produced an enormous body of research on queuing networks. A queuing network encapsulates the operational dimensions of patient flow in a hospital, with the medical units being the nodes of the network; patients are the customers, while beds, medical staff and medical equipment are the servers. Queues arise when the short term demand for service exceeds the capacity which most often caused by random variation in service times and the times between customer arrivals. The long term demand for service will affect more capacity and the queue will explode. The components of a queuing process are the calling population, the arrival process and the queue configuration. A queuing system can be described as customer arriving for service, waiting for service if it is not immediate, and if having waited service, leaving the system after being served. There are two type of method are suitable to solve the queuing problem, the first one is analytical method and the other is simulation method. In this study, a simulation model was implemented to search for good feasible solutions. The purpose of simulation model is analyzing scenarios under centralized admission management and comparing the results against the current scenario and those obtained by the queuing model. Hence combination between QT and simulation model, is one of the option available to give more accurate result.

2.2 Queuing system of patient flow

A basic queuing system is a service system where "customers" arrive to a bank of "servers" and require some service from one of them. "Customer" is referring to the entity that waiting for the service and that entity is not necessarily human. Similarly, a "server" is the person or thing that provides the service (Green, 2006a). In the case of hospital or clinic, a queuing system can be described as patient's arrival time for the service, waiting for service if it is not immediate, utilizing the service, and leaving the system after being served (Johnson, 2008). A queuing system is characterized by arrival pattern of those requiring service, service pattern of servers, queue discipline, system capacity, number of service channels, and number of service stages (Mital, 2010). Queue discipline refers to the order in which customers are processed. The assumption that service is provided on a first-come, first-served basis is the most commonly encountered rule. This outpatient department operates with two types of patients: appointment and non-appointment patients. Non appointment patients include new patients who first arrive at the hospital, walk-in patients and no-show patients who missed their appointments. All appointment patients must refer to the reception deck to identify the appointed clinic and check if there is any laboratory test required. Meanwhile, all non-appointment patients, need to pass registration process. After all consultation process completed, patients may get drugs from a pharmacy before leaving the clinic.

The process of patient flow at selected Public Health Clinic is recorded based on the flowchart as illustrated in Figure 1. The process starts with the patient's time arrival and pushed the queue management system (QMS) button allowing the time to be captured in the QMS queuing slip. When the patient was called to the registration counter by the QMS number, they would then be given a timing sheet containing his demographic details and time in and out to be filled by the dedicated staff at every station/server. The timing sheet will then stapled onto the patient's registration card and carried along to every station he/she attended. The pre-consultation waiting time was recorded by the nursing staffs at the vital signs assessment room. Meanwhile, the consultation waiting time was recorded by the doctor family medicine specialists (FMS) or medical officers (MO). The waiting time for appointment and payment was recorded at the registration and payment counter respectively. The completed timing sheet was then kept by the staff at the payment counter and collected for data entry. The timing for medication collection at the pharmacy was recorded by the electronic pharmacy record of the pharmacy information system. Data on demography and relevant clinical information were accessed via the electronic medical record system. All relevant data were recorded manually before being entered into the Excel to be analyzed. The simple Excel functions are the basis for creating data tables and graphs which show the effects of changing staffing, arrival rates, and service times on utilization, wait times, and time patients spend in the "system" (Johnson, 2008).

A queuing system is called one server model when the system has server only and multi-server model when the system has a number of parallel channel each with one server. Single queuing models with infinite queues are the workhorses of QT and among this class models, the most commonly studied models are the M/M1, M/G/1 and GI/G/1 models (Chan & Green, 2013). In health care settings, the M/M/1 model proved to be useful either because if fits reality well because it serves as a reasonable approximation for first-pass analysis and M/G/1 model may be more appropriate for calculating queue length and waiting time statistic. Hence the study employed M/M/1 model. This study considered the waiting of patients in public health clinics as a single-channel queuing system with Poisson arrivals and exponential service rate where arrivals are handled on a first-come first-served basis. Using an M/M/1 queuing system, the study obtained the average number of patients and the average time spent by each patient as well as the probability of arrival of patients into the system. One advantage of using the M/M/1 model is that it requires only three parameters and so it can be used to obtain performance estimates with very little data.

Given an average arrival rate, an average service duration, and the number of servers, easy-to-compute formula are available to obtain performance measures such as the probability that an arrival will experience a positive delay or the average delay (Green, 2006).

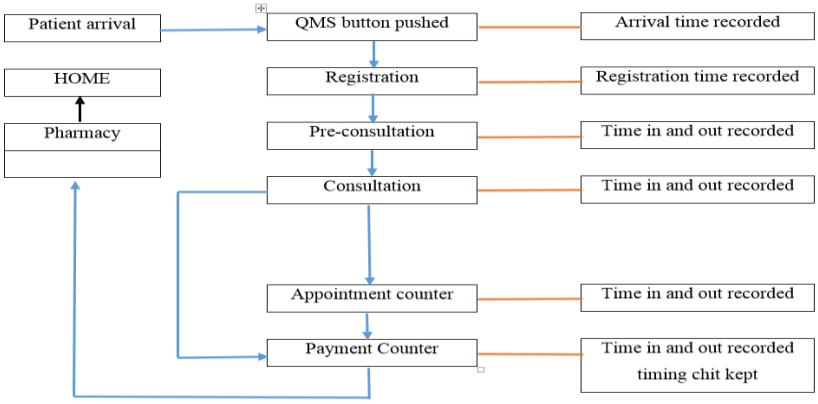

Figure 1: Queuing system of patient flow

2.3 Waiting time and Utilization Analysis

Waiting time and utilization is an overview of research into using queuing theory as an analytical tool to predict how particular health care configurations affect delay in patient service and health care resource utilization (Fomundam & Herrmann, 2007). In a queuing system, minimizing the time that customers (in health care, patients) have to wait and maximizing the utilization of the servers or resources (in health care, doctors, nurses, hospital beds, for example) are conflicting goals. Lakshmi & Appa, (2013) divided them into four categories: leaving without treatment ratio (LWTR), variable arrival rate (VAR), priority queue discipline (PQD), and minimum waiting time (MWT). LWRT is define as when a patient is waiting in a queue, he/she may decide to forgo the service because he/she does not wish to wait any longer. The probability that a patient reneges usually increases with the queue length and the patient's estimate of how long he/she must wait to be served. It is possible to redesign a queuing system to reduce reneging. A common approach is to separate patients by the type of service required. For example separate the non-acute patients with acute patients and treat them in dedicated fast-track areas.

2.3.1 Variable Arrival Rate (VAR)

Although most analytical queuing models assume a constant customer arrival rate, many health care systems have a variable rate. In some cases, the arrival rate may depend upon time but be independent of the system rate. For instance, arrival rates change due to the time of day, the day of the week, or the season of the year. In other case, the arrival rate depends upon the state of the system. The arrival rate may increase over time due to population growth or other factors. Lengths of the intervals between arrivals are independently and identically distributed and described by a continuous density function. It is assumed that inter-arrival times and service times follow the exponential distribution or equivalently that the arrival rate and service rate follow a Poisson distribution (Mital, 2010).

2.3.2 Priority Queuing Discipline (PQD)

In most health care settings, unless an appointment system is in place, the queue discipline is either first-in-first-out or a set of patient classes that have different priorities as in an emergency department, which treats patients with life-threatening injuries before other (Fomundam & Herrmann, 2007). The discipline describes the manner in which the patients are served after a queue has formed (Johnson, 2008). The common disciplines are First Come First Served (FCFS), Last Come First served (LCFS) and Random Selection Service (RSS).

2.4 Simulation Model

The queuing theory and patient flow systems are often associated with simulation techniques. Simulation is a powerful tool for the evaluation and analysis of a new system designs, modifications to existing systems, and

proposed changes to control systems and operating rules. Simulation involves the methodology to provide the information from the model by observing the flow of the model using a digital computer. There are many studies conducted previously on the use of simulation techniques as a tool in the analysis of patient flow systems and queuing theory. A study done by Najmuddin, Ibrahim, & Ismail, (2010) reported that simulation model does improved patient waiting time for multi phases patient flow of obstetrics and gynecology department in local specialist center. This study used ARENA of systems modeling corporation to provide a complete simulation environment that support all steps in a simulation study. Simulation has an advantage over analytical or mathematical models for analyzing complex systems since the basic concept of simulation is easy to comprehend and hence often easier to justify to management or customers than some of the analytical models (Najmuddin et al., 2010). There are many commercial of the on-shelf software that can be used to develop a simulation model. The software package divided into six types: general-purpose software, manufacturing-oriented software, business process re-engineering, simulation based scheduling, animators, and simulation support software (Chan & Green, 2013). ARENA is graphical modeling or animation system that is based on hierarchical modeling concepts. It allows users to create new modeling objects called modules, which are the building blocks of model creation. It also offers Application Solution templates that can be used to tailor the software to a specific animation. Besides that, Arena also includes the input analyzer, designed to give users the ability to read raw input data, and output analyzer for simulation data viewing and analysis (Davis & Williams, 1994).

3.0 Methodology

This study was carried out at one of the Public Health Clinic located at southern Malaysia. The method of this study was a descriptive-analytical study focused at the outpatient clinic. Collection data are from the patients who have registered the medical checked at the outpatient counter until the pharmacy counter. The researchers started design the pre-planned form to collect data of patient at the outpatient counter. Once the data collection finished, researchers then calculated and analyzed the data using Microsoft Excel. Based on the calculated data, the queuing system of current situation was modeled and simulated using the software ARENA. Descriptive analysis and observations study was used to determine the time taken of patients from the registration until seen by pharmacist at the outpatient clinic. In order to get better results, this study reconfirmed the patient's process flow with the clinic management together with on-site observation few times to get the correct flow. The collected date were the arrival time (λ) which was the number of patients entered to the outpatient counter during standard study time (30-munites intervals) and the service time (μ) which was the time period of giving services to each patient per 30 minutes. Data were collected randomly among the patients without any specific patient classification of treatment. This is because the study focuses on determining the waiting time of patients at outpatient counter. Data was collected via record the waiting time of patients in the pre-planned form at the outpatient clinic. The data required to develop the patient flow as follows:

1. Patients arrival times
2. Service time at the registration counter (new patient registration counter and appointed patient registration counter). Service time is the time taken at the beginning of the service until the end of the service for each patient.
3. Service time at the pre-consultation room.
4. Service time at the consultation room.
5. Service time at the pharmacy counter.
6. The number of patients (at each phase).
7. The number of doctors, staffs involved at each phase.

Lengths of the intervals between arrivals are independently and identically distributed and described by a continuous density function. It is assumed that inter-arrival times and service times follow the exponential distribution or equivalently that the arrival rate and service rate follow a Poisson distribution. Description of different variables and characteristics used in these case are as follows:

- λ = the arrival rate (outpatient arrival rate)
- μ = the service rate
- S = the number of serves (doctor)
- n = the number of patients in system awaiting service or being served.

The collected date were entered into the ARENA Simulation software to determine the statistical distribution of the data. Input analyzer in the ARENA allows user to enter raw data and obtain the statistical distribution for the data as need.

4.0 Data Analysis, Simulation and Result

4.1 Descriptive Data Analysis

Based on the descriptive analytical data, the total number of patient was over 200 patients per week (Monday to Friday). However, the distribution of the patient's attendance was busiest on Mondays and Tuesdays. Figure 2 is the graph of the number of patients arrived to registration counter. From the graph it shows that on Mondays at the times between 8.00am until 10.00am which is placing the highest number of patients arrived to the registration counter. The largest average number of patients arrived to the registration counter from 8.00am until 10.00am is about 131 patients. Meanwhile, on Thursday which was the lowest number of patients arrived at time between 12.00pm until 2.00pm for average number of 80 patients as shown at the lowest part of table. However, on the lowest number of patients arrived at this time will make the utilization of nurse or doctor is low. The Public Health Clinic is open from 8.00 am. The clinic has no regular break time. The medical staff will relax in turns as appropriate and depending on the number of patients waiting. Based from the observation, the operation hours for the clinic is about 10 hours per day. However, it is important to note that after 6.00 pm there still an emergency outpatient clinic but for the purpose of this study that aspect was excluded. Based on the descriptive date, the maximum and minimum service time of patients in registration counter are 1.25 minutes and 1.98 minutes respectively. Figure 3 shows the graph of service time against the number of patients enter the outpatients department. From the graph, it shows that consultation room which is placing the highest service time to be served. However, pre-consultation room and pharmacy counter giving the approximately same time.

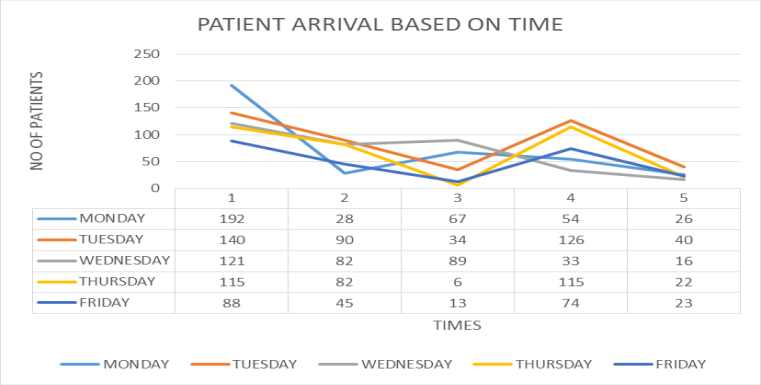

Figure 2: The graph of the number of patients arrived to registration counter.

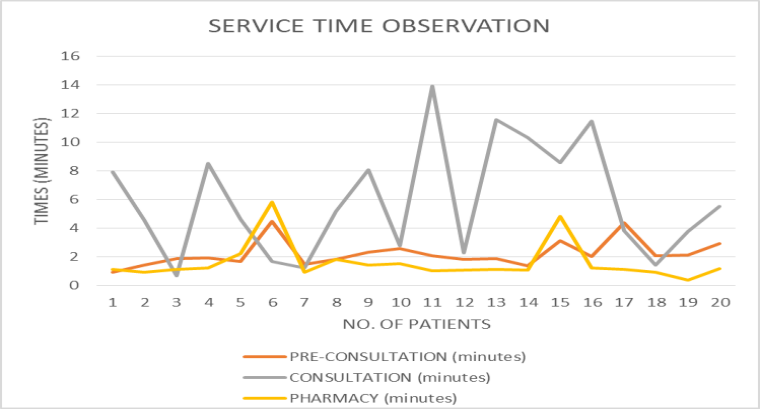

Figure 3: The graph of service time.

4.2 ARENA Simulation Queuing Model

4.2.1 Simulation Model

The data from the previous observation, charts, tables and graph was codded into the ARENA software. In this queuing system at the Public Health Clinic process the modules, a characters of patient flow was placed on the ARENA canvas. Figure 4 shows the simulation model of the patients at outpatients department from the processes module that can be altered and coded from the data of the observation.

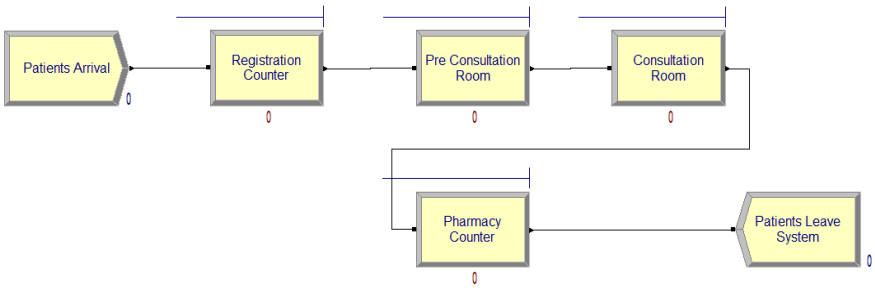

Figure 4: Simulation model for the outpatient department system

From the column in basic process as shown in Figure 5 include the name, type, action, resources, delay type, units, allocation, minimum value, average value, and maximum value of the data. Figure 5 shows the basic process of service time value in the ARENA software. However, in this study the row consist of four basic process as it represented the four stations in queuing theory model that the patient would be serve from the nurse or doctor.

Process - Basic Process

	Name	Type	Action	Priority	Resources	Delay Type	Units	Allocation	Minimum	Value	Maximum	Report Statistics
1	Registration Counter	Standard	Seize Delay Release	Medium(2)	1 rows	Triangular	Minutes	Value Added	1.25	1.71	1.98	☑
2	Pre Consultation Room	Standard	Seize Delay Release	Medium(2)	1 rows	Triangular	Minutes	Value Added	.93	2.20	4.44	☑
3	Consultation Room	Standard	Seize Delay Release	Medium(2)	1 rows	Triangular	Minutes	Value Added	.67	5.88	13.91	☑
4	Pharmacy Counter	Standard	Seize Delay Release	Medium(2)	1 rows	Triangular	Minutes	Value Added	.37	1.59	5.83	☑

Figure 5: Basic process of service time value

According to this research, the type of basic process is based on the schedule. This is means that the utilization of the nurse and doctor at the outpatient department are based on the times schedule. The number of server at the Public Health Clinic are shown in Table 1 below.

Table 1: Number of Server

STATIONS	NUMBER OF SERVER					
TIME	0800 - 1000	1000 - 1200	1200 - 1400	1400 - 1600	1600 - 1700	1700 - 1800
REGISTRATION	2	2	1	2	1	1
PRE-CONSULTATION	2	2	1	2	2	1
CONSULTATION	5	4	3	5	4	3
PHARMACY	2	2	1	2	2	1

There are six doctors allocated or scheduled for outpatients department per week but only five to three doctors available per day. Meanwhile, several nurses are scheduled for working at the department, but two or one nurse allocated at the registration counter, pre-consultation room and pharmacy counter based on the schedule in Table 1. However, the meaning number of server at registration counter from 4.00 pm to 5.00 pm and 5.00 pm to 6.00 pm are two and one server respectively.

4.2.2 Simulation Results

4.2.2.1 Average Waiting Time in queue

Waiting time is the time required for a patients to wait for the service needed. Table 2 shows the results of simulation model obtained from SIMAN reports which indicates the existence of a long waiting time on Monday with an average of 87.936 minutes per patient which is often a common complaint by patients than in the other days. Whereas the lowest average waiting time is on Friday of 5.454 minutes. Thus, the maximum average waiting time for received service is 144.4848 minutes per patient whereas the average waiting time in queue is 54.2952 minutes.

Table 2: Average waiting time in queue

Day	Time (minutes)	Maximum Time (minutes)
Monday	87.936	207.624
Tuesday	81.642	197.886
Wednesday	61.236	149.79
Thursday	35.208	137.922
Friday	5.454	29.202
AVERAGE	**54.2952**	**144.4848**

4.2.2.2 Average Service Time of Patient

Table 3 shows the results indicated the average of service time per patient with an average 13.324 minutes. These results shows that some patients have to wait for a long period of time to get a treatment, which may only take an average of service time, 13.4808 minutes. Meanwhile, the maximum average service time is 23.724 minutes per patient that is less than 30 minutes. With this service duration resulting unsatisfied patient. They have no opportunity to ask question and get detail information about their medical problem because there are still many patients waiting in queue outside.

Table 3: Average Service Time

Day	Time (minutes)	Maximum Time (minutes)
Monday	13.506	24.636
Tuesday	13.488	23.46
Wednesday	13.5	23.7
Thursday	13.506	23.37
Friday	13.404	23.454
AVERAGE	**13.4808**	**23.724**

4.2.2.3 Average Total Time in system

Table 4 shows the result indicated the average of total time per patient with an average of 68.3148 minutes. These result stated that patient have to spend the time in outpatient department from the registration until dispose. The maximum average total time in system is 156.7176 minutes (more than two hours) per patient. But based on total time in system on Monday is the highest average total time and maximum time. With this unbalanced treatment duration resulting unsatisfied patient in hurry to get treatment.

Table 4: Average Total Time in System

Day	Time (minutes)	Maximum Time (minutes)
Monday	117.642	223.812

Tuesday	81.642	197.886
Wednesday	74.736	165.45
Thursday	48.696	152.694
Friday	18.858	43.746
AVERAGE	**68.3148**	**156.7176**

4.2.2.4 Total exit of patients

Table 5 shows that the result between ten replication of the total exit of patients at Ayer Keroh Public Health Clinic based on the difference day. The average number of patients arrived for one week is 348 patients and the average number of patients that were serviced is 327 patients, the rest remained in the system at average 21 patients. The highest arrival patient is on Monday and Tuesday with assuming the patients have an appointment at outpatient Health Clinic.

Table 5: Total exit of patients

Day	**Total exit of Patient**		
	In	Out	In System
Monday	373	356	17
Tuesday	435	359	76
Wednesday	344	341	3
Thursday	345	339	6
Friday	244	241	3
AVERAGE	**348**	**327**	**21**

4.2.2.5 Server Utilization

Based on the table below shows the utilization percentage. Table 6 exhibits the utilization for real situation of the working process at the Public Health Clinic. Based from the analysis, the largest utilization is shown at the consultation room is about 88.7% whereas the lowest at registration counter with the percentage of 59.7%. The utilization of server at pre-consultation room and pharmacy counter are almost significant about 84% and 83% respectively. Therefore, it is clear that utilization for registration counter is not reaching to 70%. If the utilization for every process reach 90%, that means that the number of patient enter to the Public Health Clinic increase from current situation. However, for current situation, the number of server for registration counter is one and two server based on schedule. If the scenario of the server at registration counter change to one server all the way, outpatient department cannot cope up the increasing number of patient and that impossible to give the best service to the patient.

Table 6: Server utilization at outpatient department

Stations	**Percentages of server utilization**					**AVERAGE**
DAY	Mon	Tue	Wed	Thu	Fri	
Registration	64.0	74.7	58.9	59.2	41.9	**59.7**
Pre-consultation	90.9	99.5	84.5	85.0	60.1	**84.0**
Consultation	97.7	98.1	91.8	91.9	64.0	**88.7**
Pharmacy	89.3	91.6	87.3	85.5	61.1	**83.0**

4.2.2.6 Summarization of the performance measure

The Table 7 below summarizes all the final output measures between ten replication together with their average and maximum time after run the simulation model. All the performance measures statistical results are got from ARENA simulation based on the schedule of server at Table 1 for registration counter, pre-consultation room, consultation room, and pharmacy counter at consultation room at the Public Health Clinic.

Table 7: Final output performance measure development

	Day					
Performance Measure	**MON**	**TUE**	**WED**	**THU**	**FRI**	**AVR.**
Total Patients	356	359	341	339	241	**327**
Average waiting time in queue	87.936	81.642	61.236	35.208	5.454	**54.295**
Maximum waiting time in queue	207.62	197.89	149.79	137.92	29.202	**144.48**
Average service time	13.506	13.488	13.5	13.506	13.404	**13.4808**
Maximum service time	24.636	23.46	23.7	23.37	23.454	**23.724**
Average total time in system	117.64	81.642	74.736	48.696	18.858	**68.315**
Maximum total time in system	223.81	197.89	165.45	152.69	43.746	**156.718**
Outpatients department Utilization	85.50	90.98	80.61	80.38	56.75	**78.84**

The results obtained from the ARENA simulation stated that the average waiting time of patient have to wait before get the treatment is 54.295 minutes whereas the maximum waiting time is 144.48 minutes. Then, the average service time for patient get the treatment is 13.48 minutes whereas the maximum service time for several patients is 23.724 minutes. Therefore, the average total time spend by patients in outpatient department is 68.315 minutes and maximum total time in system is 156.718 minutes. Total average number of patients arrived at outpatient counter is 327 patients per day. Thus, based on the result average total number of patient gives the utilization of server at outpatient department is 78.84%.

4.3 Discussion

4.3.1 Verification and Validation

After analyzed the simulation result, the average waiting time and service time for simulated output is compared to the historical data output obtained from outpatient department clinic records. The process is known as verification and validation process. This process needs to be done to ensure the simulation model developed is valid and acceptable before proceed to the next steps. Verification seeks to show that the computer program perform as expected and intended. Validation on the other hand, questions whether the model behavior validly represents that of the real world system being simulated (Afrane & Appah, 2014). A commonly used validation tolerance is 10% which means that the output obtained from simulation model must not exceeds 10% of the real system output. If the differences are less than 10%, which is within the standard total differences that can be allowed, a simulation model is considered as acceptable and valid (Najmuddin et al., 2010). Therefore, the comparison on this study is valid and acceptable with the total arrival of patients are not less than 10%.

4.3.2 Detail of average waiting time

Table 8 shows the detail of average waiting time of patients in queue at every station. The highest average waiting time is 28.096 minutes at pre-consultation room with the percentage of utilization is 84%. These results means that the patients have to wait for a long time at this station before to see the doctor. Based on the observation, the cause of long waiting time at this station is the clinic using the old system for getting the blood pressure. Therefore, the suggestion at pre-consultation room need to change the new technology to get the blood pressure of patient. Then, the lowest average waiting time of patients in queue is 4.031 minutes at registration counter with the percentage of utilization is 59.7%. Meanwhile the average waiting time at consultation room is 18.324 minutes with the highest percentage of utilization is 88.7%. The pharmacy counter has the average waiting time of 4.196 minutes while the percentages of utilization is 83%. The positive outcome from this study was that the clinic achieved the

target adopted from the Ministry of Health patient charter. A 2011 study of outpatient waiting time in 21 hospitals in Malaysia found that the average waiting time to see the doctor was 60 minutes (Ba, Khairatul, & Farnaza, 2017). In comparison, this clinic achieved a good average total waiting time of 54 minutes to see the doctor and 78% of server utilization achieved the target of waiting to see the doctor within or less than 60 minutes.

There were several problems identified from this study that need to be rectified. A low percentage of registration utilization an unnecessarily long time to be registered and to see the doctor. Registration should be a quick and simple process. This study identified that the long waiting time is due to low server utilization caused by the registration counter being manned. Lack of staffing utilization is a known contributor to lengthy waiting time in hospital outpatients and public health clinics (Ba et al., 2017). A recommendation need to increase the number of staff at outpatient department to reduce the waiting time of patient. But this recommendation cannot to be accept because will increase the cost of adding server. However, the waiting time of patients achieved the target adopted from the Ministry of Health patient charter. The set target criteria of total waiting time from registration to consultation should be within or less than 60 minutes.

Table 8: The detail of average waiting time

Days	**Average waiting time**					
	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**AVERAGE**
Registration	10.92	2.562	5.322	1.056	0.294	**4.031**
Pre-Consultation	45.348	50.214	26.634	16.284	1.998	**28.096**
Consultation	26.706	26.562	22.602	13.986	1.764	**18.324**
Pharmacy	3.906	5.688	6.402	3.612	1.374	**4.196**

5.0 Conclusion, Limitation and Recommendation

5.1 Conclusion

In this study, a multiple server channel model was developed for the outpatient department at the Public Health Clinic with a focus on the patient waiting time for having a treatment. The main objective of this study is to determine waiting time of patient's flow which can be used to improve the operating performance and also improving the quality of the services provided to the patients. The first objective to this study to determine the waiting arrival time and service time of patients at outpatient department. This results is shown at the Table 2, 3 and 4. The result stated that the average waiting time of patients in queue is 54.295 minutes with the average total exit patient is 327 patients. Thus, the average service time is 13.481 minutes. In comparison, a study in Malaysia found that the average service time in outpatients was 15 minutes (Ba et al., 2017). There is no specific guideline on the best service length but studies found that patients prefer to have more time with the doctor.

Meanwhile the second objective is proved that this study using the simulation technique for model queuing system. Based on the results of multiple server channel patient flow simulation model developed, it is proved that there is waiting time achieved with Ministry of Health patient charter. In this patient charter stated that patients should achieved the target of waiting to see the doctor within or less than 60 minutes. Simulation model result shows that longest waiting time exist at pre-consultation room about 28 minutes and the lowest utilization of server is at registration counter about 59%. Therefore, suggested improvement need to make to this stations with a view to reduce the waiting time and increase the utilization of server. This is to ensure the high quality of services is delivered. The outcome of this study is the better understanding of queuing theory and management service. In addition, the health care providers can make decision that increase the satisfaction of all relevant group besides optimizing the resources. This study further established that queuing theory and modelling is an effective tool that can be used to make decisions on staffing needs for optimal performance with regards to queuing challenges in clinics. This study therefore be replicated in other clinics or other countries in order to inform clinic administrators more on the usefulness of the application of queuing theory and modelling as a tool for improved decision making.

5.2 Limitation of the study

Researcher fined it is difficult to use the ARENA software in student vision. The weakness to using the ARENA student version is because unable to develop model more than 150 entities waiting and simulate difficult or

complex model. Then, student version of ARENA simulation software is not suitable for engineer or researcher, which these version have limitation compare to professional ARENA version. It is just only can be used the simple process and simple flow can be develop.

5.3 Recommendation

The number of population and community at selected population will be increased every year in the next few years. Thus, the study recommend the management should invest in using the new technologies or system that can be implement at the Public Health Clinic especially in outpatient department. For example, establishing a special counter for acute case and the elderly. Besides that, the number of server also should be reschedule in 10 hours working by which the capacity of server need to rearrange. Table 9 shows that the recommendation of server to reduce the waiting time of patients in queue at pre-consultation room and increase the percentage of utilization at registration counter. This schedule are known as the relocation of server at outpatient department even though the reducing number of server at registration counter will affect the waiting time of patients but still achieved with the patient charter. So that, the waiting time spend by patients at specific station will be reduce, will not affect the cost of utilization. This is because, if the number of waiting time of patients increase, the authorities of clinic should provide adequate waiting space for patients.

Table 9: Recommendation of the new capacity server

Station	**Number of Server**				
	8.00am - 10.00am	10.00am - 12.00pm	12.00pm - 2.00pm	2.00pm - 4.00pm	4.00pm - 6.00pm
Registration	2	**1**	1	2	1
Pre-consultation	**3**	2	1	**3**	2,1
Consultation	5	4	3	5	4,3
Pharmacy	2	2	1	2	2,1

6.0 Reference

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