A Simulation Approach: Improving Patient Waiting Time for Multiphase Patient Flow of Obstetrics and Gynecology Department (O&G Department) in Local Specialist Centre

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Abstract: - An outpatient clinic is a very complex department to manage. The management of the outpatient department should given greater emphasis on its medical facilities in order to ensure the services provided are in high quality, which conforms to customer or patient satisfaction. Long waiting time for treatment at the department is always the main problem faced by the management, and even worst the consultation time is tremendously shorter than the waiting time. This situation has been a common complaint by the patients and remains to occur even though an appointment system is implemented. The implementation of inefficient appointment and inconsistent service time contributes to the dissatisfaction among patients as well as giving a huge impact to the healthcare's overall operations. Therefore, the purpose of this study is to analyze the multiphase patient flow system in Obstetrics and Gynecology Department (O&G Department) of a specialist centre by developing a simulation model that illustrates the actual patient flow in the department. The Arena 7.0 software package is used to develop the simulation model in order to examine the patient flow, especially the waiting time involved. In addition, 120 questionnaires were distributed to patients to gather direct responds and opinions towards the services provided. The information gathered was used to aid the model improvement process. The result obtained from the simulation model shows that a long waiting time does exist in the system. Based on the developed simulation model, two proposed experimentation are being done to find the right solutions to reduce the patients' waiting time and at the same time enhanced the quality of services of the O&G Department. The proposed experimentation model can be effective to the system and is possible to be implemented in the department.

Key-Words: - Arena, multiphase patient flow, simulation model, simulation technique, lengthy waiting time, service time

1 Introduction

The challenge for improving healthcare organizations is stronger than ever. Issues such as expanded access to healthcare, a growing aging population, technological advancement, and the rise of the price of healthcare have placed major pressures on these organizations [1]. Frequently, in order to get a quality service, the waiting time and the treatment time are put into consideration and set as a high priority. Many patients had chosen private healthcare providers because of the high quality of services provided. In addition, most of them want to avoid congestion and long waiting times which occurred in most public healthcare.

This disproportionately long waiting time in the consultation room has over the years been the focus of study among academicians and practitioners. Most of them have stressed the major cause to long waiting time as due to the poor patient appointment system in place [2]. Dissatisfaction among patients is often associated with a problem of lengthy waiting times wherein this is also decisive factor of selecting a healthcare provider that can deliver better quality of services.

Time is always a valuable asset for patients in seeking treatment at any healthcare centre, either public or private provider, and even more valuable for patients who are in critical conditions. Doctors and specialists also need to maximize their service time since some of them are assigned with administrative works, reading medical reports, and keep moving from one department to another department. Waiting idly in the waiting room is not a productive situation where patients can spend their waiting time to do other activities that might benefit them rather than sitting for nothing.

The waiting problem is listed as one of the indicators of quality assurance for the health care system in several papers [3]. Reference [4] considered punctuality and consultation time as two main factors affecting the scheduling system for an out-patient department because many patients are unsure about the time of their appointment, they tend to arrive earlier then they should. In addition, because many physicians are late, patients' waiting time increase even more.

Reference [5] studied using computer simulation on patient flow in an appointment based, outpatient internal medicine clinic involving multiple, sequential providers; registrar, triage nurse, physician, and discharger. Reference [6] described a study that focused on the utilization of doctors and staff in the outpatient department, the time spent in the hospital by an outpatient, and the length of the outpatient queue.

There are a variety of techniques available today that can be applied for the analysis of existing systems. Presently, the simulation approach is the popular technique used in the management of healthcare. Simulation has been applied successfully in many different areas such as manufacturing, system services, medical sector, transportation, supply chain and so on. In addition, simulation approach is one of the best techniques for decision-makers to review, analyze and evaluate any operating systems from the simplest to the most complex condition to be solved [7]. Researchers have used simulation models of outpatient clinics to address problems in clinic queuing and patient flow, clinic staffing and facility sizing problems [8]

2 Literature Review

2.1 Patient Flow Concept

From birth until death, human beings are part of the healthcare system. Human rely on government or private organizations to provide preventive care and to treat illnesses, diseases and injuries. For all countries in the world, health care is a major contributor for the economic growth rate. Therefore, this area is often discussed as a main topic of many countries [9].

One of the important elements in improving efficiency in the healthcare services is managing the patient flow. The patient flow represents the ability of healthcare system to serve patients quickly and efficiently throughout the treatment period. When the flow of the system operates properly, then the flow of patients becomes smoother and all the processes involved can be resolved with minimum delay. A good patient flow indicates that a patient queuing can be reduced or minimized, while the inefficient patient flow contribute to the problem of long and outstanding queue.

2.2 Queuing Concept

In everyday life, it is seen that a number of people have to queue to get the desired service. If the arrival of people is frequent, they will have to wait for getting the services provided. Thus, the queuing system was introduced in order to facilitate the customer whereas eliminate congestion occurred during the period of service.

The queue process or waiting lines are not only involve the lines of people, but also includes works such as aircraft seeking to land at a busy airport runways, ships to be unloaded, cars waiting to pay tolls or waiting for the traffic light to turn green, calls arriving at a telephone switch-board, jobs or documents waiting for processing by a computer, and anything else that associated with time delays.

Various studies have shown that the queuing theory is very useful in the medical field. Reference [10] has made a review of previous studies of the model to assess the impact of settlement policy in hospital beds, the waiting time for services, and the probability of a patient exit from the queue.

Reference [11] has also made a study on the use of the queuing theory in pharmaceutical area with emphasis on customer satisfaction. According to them, customer satisfaction can be improved by predicting and reducing the waiting time and rearrange the placement of staff.

Queuing theory have been widely employed in many areas of healthcare such as emergency care center planning [12], and waiting lists for transplants and surgery [13].

2.3 Simulation

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 [14].

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.

Over the past four decades, simulation has proven to be a significant tool in the analysis of a wide variety of heath care delivery systems, mostly focusing on capacity planning and scheduling. It started as early as in the 1960's [15]. Reference [16] applied simulation to study the operating behavior at a maternity suite, an outpatient clinic, and a surgical pavilion. Reference [17] applied simulation technique to model patient's scheduling and other hospital operational problems.

Reference [18] also outlines a general framework for modeling outpatient clinic in order to explore the issues related to demand, appointment scheduling, patient flow and placement of the staffs.

Reference [19] has developed a simulation model for the process of constructing a new services center based on the historical data to determine minimum facility design requirements, such as waiting room size based on the expected demands. Reference [20] discussed the use of simulation analysis for studying and assessing trade-offs between resource utilization, service and operating costs grows in importance.

Reference [21] studied using computer simulation approach on patient flow in an appointment-based. Reference [22] used simulation techniques to study the utilization rate of rooms and doctors of ophthalmology service, and to increase its quality of services. Simulation is not only used in health industry but includes other different areas such as manufacturing, service system, transportation, supply chain etc [7]. Reference [23] used simulation technique to study a batch chemical process, which can evaluate changes in plant operating conditions where productivity could be improved.

Reference [24] used simulation technique in order to evaluate the performance of balanced surface acoustic wave (SAW) filters, which helping in finding an optimum design technique for balanced SAW filters. Reference [25] conducted simulation study for consolidated transportation in reducing the costs of operations. This study used Arena of Rockwell Automation simulation program package to analyze the efficiency of consolidated transportation.

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 [26].

2.4 Simulation Software

There are many commercial of the 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 reengineering, simulation based scheduling, animators, and simulation support software [27]. The general-purpose software includes GPSS/H, SLX, SIMSCRIPT II.5, AweSim, SIMPLE++, and Extend. While the manufacturing-oriented software consists of ProModel, AutoMod, Taylor II, FACTOR/AIM, Extend+Manufacturing, and ARENA. The business process reengineering includes BP$im, ProcessModel, SIMPROCESS, Time Machine, and Extend+BPR. Under simulation based scheduling, software package that available are Tempo, AutoSched, and FACTOR. For animators, available software is only Proof Animation.

ExpertFit, and Stat::Fit are example of simulation support software which is used for input data analysis [28].

In this research study, a simulation model is developed using ARENA 7.0, a product of Systems Modeling Corporation. This software is an extendible simulation and animation software package. It provides a complete simulation environment that supports all steps in a simulation study. Arena combines the modeling power and flexibility of the SIMAN simulation language, while offering the ease of use of the Microsoft Windows and Microsoft NT environments [29].

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 [30].

3 Description of Patient Flow

This study focuses on the Department of Obstetrics and Gynecology (O&G Department) in a local healthcare specialist centre. The O&G Department operates five days a week starting from 8.00 am to 6.00 pm. Most patients who come to the O&G Department are based on the appointment set from the previous visit. Patients without an appointment will not be entertained. New patient (walk-in patient) have to go to the new patient registration desk to fill out application form, to show their health insurance certificate or other related documents and will be given an appointment for another day. Therefore, patient who have been scheduled and given an appointment are admitted to the clinic. No walk-in patients are allowed in the system.

There are several stages or phases that need to be held by each patient during treatment period. Firstly, every patient has to go to the registration counter and give their appointment card to the counter staff. This helps the staff to obtain the patient's information or data of the last visit.

Patients who require a laboratory test will head to the provided laboratory and making related tests. While patients who do not required performing a lab test are conveyed to the waiting room near to the consultation room and wait to be called.

There are four tests performed in the laboratory; the urine test, blood test or blood pressure checks, weight scales and a height measurement. The needs of the laboratory tests are subject to the specialist requirement and pregnant women are frequently had to undergo all tests or examinations as a prerequisite before getting a consultation from the specialist. Once completed, the patient will be waiting at waiting room until called. The patient's arrangement to enter the consultation room is based on the first in first out (FIFO) rule.

Although the patient has a predetermine appointment, the appointment however does not specify the required time of arrival, instead an open appointment system is applied, which means that each patient is able to attend at any time within the operation time of the clinic. After finished the consultation with the specialist, patients will be waiting at the payment counter area to make a payment.

Patients who are prescribed with a supply of medication by the specialist will be waiting at the pharmacy waiting area for medical supplies. Finally, the patient will leave the system. Fig. 1 shows the generalized multiphase patient flow diagram.

Common problems to be encountered in clinic system are as follows:

1) Large number of patients waiting to be served at the clinic potentially to create noise, and congestion.
2) The increasing of patient dissatisfaction due to the lengthy waiting time for treatment, and the treatment and consultation time given is not commensurate with the waiting time experienced.
3) Patients may choose another healthcare center due to the poor quality of service delivered.
4) Dissatisfaction among doctors and patients will increase the pressure to the management.
5) The delays in treatment will result in doctors and staffs have to work exceeding the normal working hour (overtime) in order to complete treatment to all patients who attended for the day and it may increase the operation costs.

6) The inefficient appointment system causes patients to congest the consultations' waiting room area, payment counter, pharmacy counter, and test laboratory. This is because the patient hastening to get the desired services earlier than others.

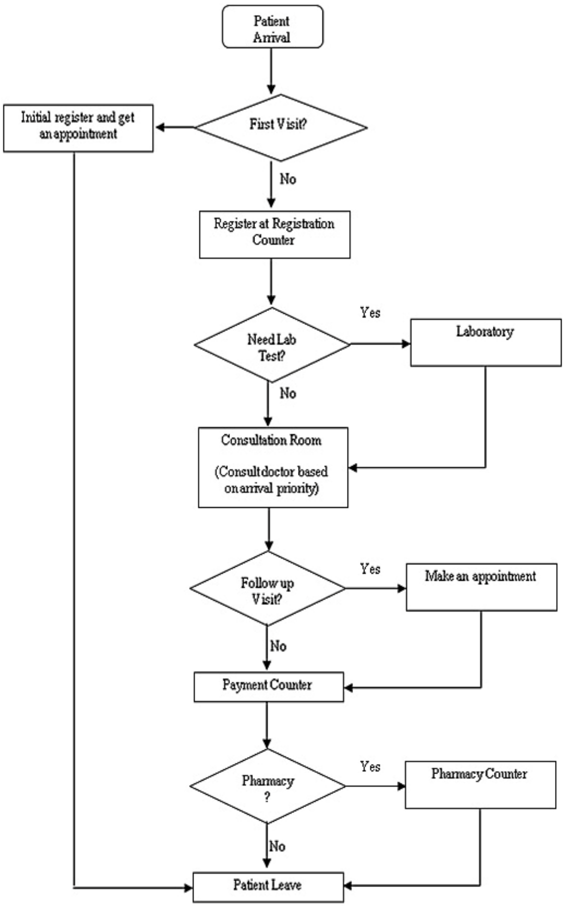

Fig. 1: Multiphase Patient Flow Diagram

4 Data Collection

Data was collected via interviewing the O&G Department management, staffs, patients, reviewing the appointment recorded files, and observing the daily operations. The data required to develop the multiphase patient flow are as follows:

1) Patient arrival times.
2) Inter-arrival time between patients. Inter-arrival time is the time between the arrival times of second patient with first patient.
3) 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.
4) Service time at the test laboratory.
5) Service time at the consultation room
6) Service time at the payment counter.
7) Service time at the pharmacy counter.
8) The number of patients (at each phase).
9) The number of doctors, and staffs involved at each phase.

The total number of patient was over 150 patients per week (Monday to Friday). The collected data are entered into the Input Analyzer in the Arena^{TM} Simulation software to determine the statistical distribution of the data as shown in Fig. 2 and the statistical distribution of the data are shown in Table 1. Input analyzer in the Arena allows user to enter raw data and obtain the statistical distribution for the data as needed.

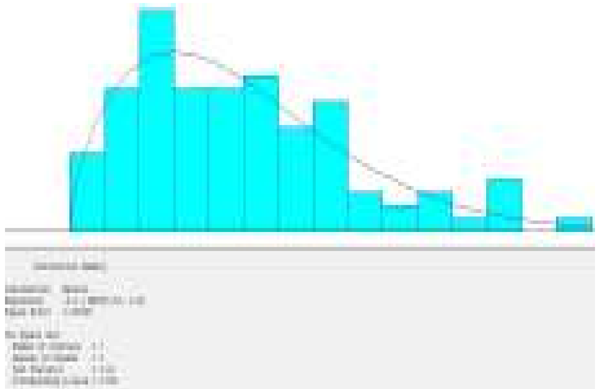

Fig. 2: Patient Arrival Distribution

The description of the resources involved shown in Table 2. There are four doctors allocated or scheduled for O&G Department per week but only two doctors available per day. Twelve nurses are scheduled for working at the department. Four nurses are allocated at the registration counter (two nurses at appointed patient registration counter, whereas the other two nurses allocated at the new patient registration counter), two nurses at the payment counter, three nurses at the pharmacy counter, one nurse at the test laboratory, and the other two nurses allocated at the consultation room.

Table 1: Statistical distribution for each phase

Items	Distribution	Expression/Time (minutes)
Patient Arrival (inter-arrival time)	Weibull	-0.5 + WEIB(5.53, 1.61)
New Patient Registration	Lognormal	20 + LOGN(2.02, 3.82)
Appointed Patient Registration	Lognormal	0.5 + LOGN(0.875, 0.599)
Laboratory	Beta	-0.001 + 12*BETA(0.521, 1.23)
Consultation Room	Lognormal	5.5 + LOGN(8.18, 4.37)
Follow up appointment	Lognormal	0.5 + LOGN(1, 0.696)
Payment	Lognormal	0.5 + LOGN(0.876, 0.561)
Pharmacy	Lognormal	0.5 + LOGN(0.664, 0.325)

Table 2: Available resources

Location	Number of Worker
New Patient Registration	2 staffs
Appointed Patient Registration	2 staffs
Payment	2 staffs
Pharmacy	3 staffs
Consultation Room	2 staffs
Laboratory	1 staff

5 Simulation Model

The original patient flow system is studied in detail and modeled in a computer simulation program using the Arena simulation package to mimic the actual operations of the O&G Department. With Arena, the user can interactively build models by creating or inserting animations to the system, collecting data from the developed simulation model, and view the statistical reports output generate by SIMAN.

Therefore, the analysis of the model can be done based on the reports generated. A snapshot observation of part of the subject area is shown in Fig. 3.

6 Results and discussion

In order to investigate the waiting time and the service time at consultation room, the simulation model runs in five replications. The average waiting time and the average consultation time was recorded by looking at the reports output generated by SIMAN.

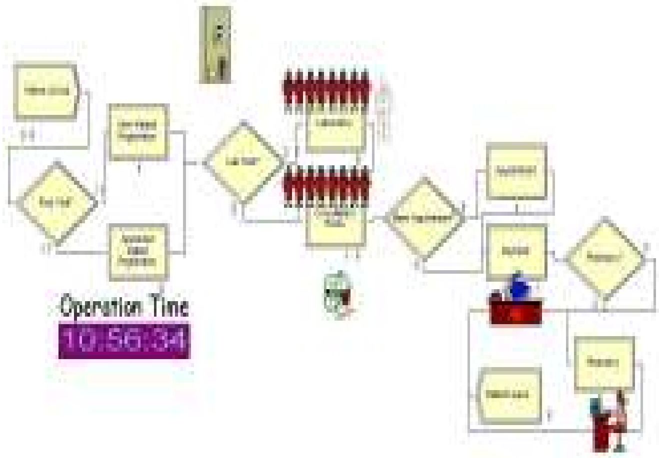

Fig. 3: Simulation Model at O&G Department using Arena

6.1 Questionnaire Results

We discussed here the results obtained from distributed questionnaires. The questionnaire was constructed based on several interviews with operation manager, staffs, and patients. There are five yes/no question need to be answered by the respondents. Fig. 4 shows the result obtained from the survey. A total of 120 respondents agreed that long waiting time does exist especially at consultation room, and 60 respondents agreed that inconsistent service time contributes to the long waiting time.

A total of 85 respondents agreed that glitches in appointment system also contribute to the long waiting time. The two other factors are insufficient facilities addressed by 50 respondents, and insufficient staff addressed by 36 respondents.

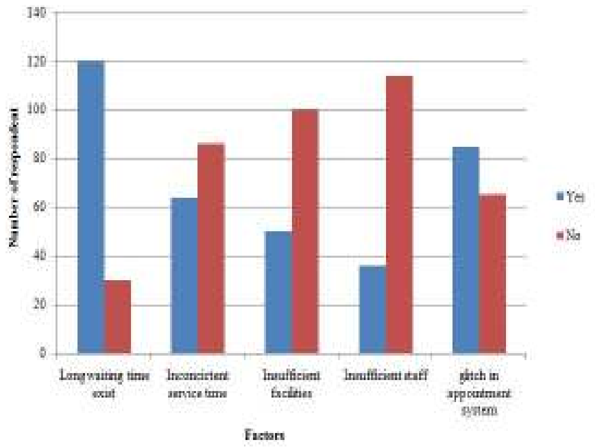

Fig. 4: Contributing factors to patient's dissatisfaction and number of respondent for each factor

Fig. 5 shows the number of respondents based on waiting time period question. A total of 50 respondents stated that they have to wait for more than 60 minutes to get the consultation from the specialist, while the average waiting time period is 60 minutes with the total of 80 respondents.

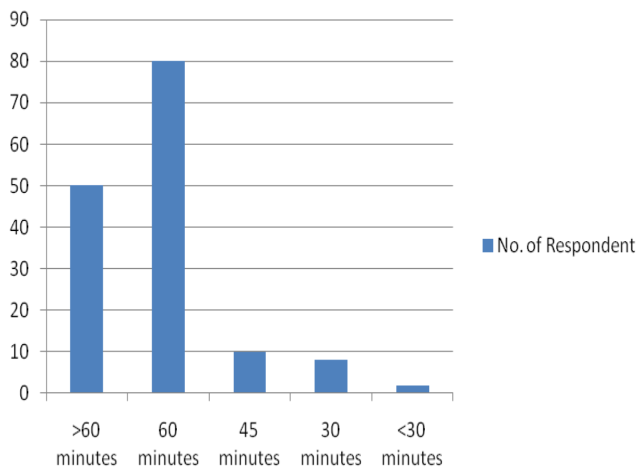

Fig. 5: Number of respondents for waiting time period

Fig. 6 shows the number of respondents respond towards the idea of implementing the standardize service time for all patients in the healthcare department. The result proves that 92 respondents or 77% of overall respondents agreed to standardize the service for all patients while the rest responded otherwise.

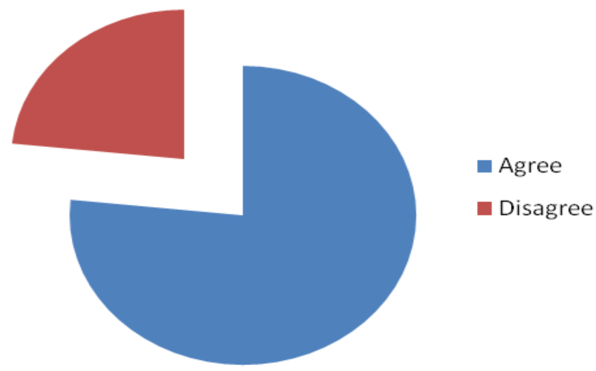

Fig. 6: Patient's responds towards standardization of the service time

6.2 Simulation Result

Waiting time is the time required for a patient to wait for the services needed. Table 3 shows the results of simulation model obtained from SIMAN reports which indicates the existence of a long waiting time at the consultation room with an average of 164.53 minutes per patient (more than two hours) which is often a common complaint by patients than in the other phases.

Table 3: Average waiting time at consultation room

Replication	Time (minutes)	Maximum Time (minutes)
1	156.93	255.93
2	157.13	209.26
3	184.96	265.95
4	145.14	209.12
5	178.47	273.46
Average	164.53	242.74

The maximum average waiting time for received consultation is 242.74 minutes per patient. Meanwhile, Table 4 shows the results indicated the average of service time per patient with an average of 12.324 minutes. These results shows that some patients have to wait for a long period of time to get a treatment or consultation, which may only take an average of service time, 12.324 minutes.

The maximum average service time is 34.376 minutes per patient. With this unbalanced treatment duration resulting unsatisfied patient in hurry to get treatment. They have no opportunities to ask questions and get details information about their medical problem because there are still many patients waiting in queue outside the consultation room.

Table 4: Average service time at consultation room

Replication	Time (minutes)	Maximum Time (minutes)
1	12.282	35.459
2	11.915	30.110
3	12.947	37.038
4	12.327	32.362
5	12.237	36.913
Average	12.342	34.376

The results of average waiting time and service time for each stage are shown in Table 5, Table 6, Table 7, Table 8, and Table 9. Table 5 shows that average waiting time per patient for new registration only took 1.02 minutes and the average service time is 5.73 per patient.

Table 5: Average waiting and service time at new patient registration

Replication	Average Waiting Time (minutes)	Average Service Time (minutes)
1	1.25	6.08
2	0.72	5.04
3	1.46	5.49
4	0.29	5.58
5	1.37	6.44
Average	1.02	5.73

Table 6 below shows that the average waiting time for appointed patient registration is only 0.64 minutes (almost no waiting time exists) and the average service time per patient is 2.12 minutes.

Table 7 shows that the average waiting time at laboratory is 11.32 minutes per patient and the average service time is 6.06 minutes per patient. The average waiting time and service time per patient for payment counter is 0.94 minutes and 6.05 minutes, respectively.

Table 8 shows that the average waiting time at payment counter is 0.94 minutes per patient, which is less than one minute, and the average service time is 6.05 minutes per patient.

Meanwhile, Table 9 shows that the average waiting time and the average service time for pharmacy counter. It indicates that the average waiting time is only 1.18 minutes per patient and the average service time is only 5.87 minutes per patient.

Table 6: Average waiting and service time at appointed patient registration

Replication	Average Waiting Time (minutes)	Average Service Time (minutes)
1	0.23	2.02
2	0.21	1.76
3	1.56	2.16
4	0.46	3.40
5	0.75	1.25
Average	0.64	2.12

Table 7: Average waiting and service time at laboratory

Replication	Average Waiting Time (minutes)	Average Service Time (minutes)
1	15.40	6.34
2	12.85	6.82
3	9.60	5.43
4	7.11	5.72
5	11.57	5.97
Average	11.32	6.06

Table 8: Average waiting and service time at payment counter

Replication	Average Waiting Time (minutes)	Average Service Time (minutes)
1	0.84	7.20
2	1.24	6.89
3	0.96	4.12
4	0.77	6.61
5	0.89	5.43
Average	0.94	6.05

Table 9: Average waiting and service time at pharmacy counter

Replication	Average Waiting Time (minutes)	Average Service Time (minutes)
1	0.25	8.18
2	2.17	5.29
3	1.56	6.23
4	0.96	4.05
5	0.94	5.59
Average	1.18	5.87

After analyzed the simulation result, the average waiting time and service time for simulated output is compared to the historical data output obtained from O&G Department outpatient 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 [19]. 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. This process is quite difficult to do but needs to be done in order to get a successful model.

Reference [21] stated that the output of the simulation model will be compared with the real system output. If the two set of data compared closely, the real world system is considered as a valid. Therefore, the output of a multiphase patient flow simulation model is compared with the output of the real system (historical data). 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 [31].

Table 10 shows the comparisons between simulated output and historical data for average waiting time, which is very close to each other, with maximum difference, 9.62%. Meanwhile, Table 11 shows the comparisons between simulated output and historical data for average service time for each phase, with maximum difference is 8.62%. Since the differences for each phase are less than 10%, which is within the standard total differences allowed, the simulation model developed is considered as valid and acceptable. The next step involved the proposed improvement model to the simulation model developed.

Table 10: Comparison between simulated output and historical data for average waiting time

Phases	Average Waiting Time (minutes)		
	Historical Data Output	Simulation Output	Differences (%)
New Patient Counter	1.11	1.02	8.12
Appointed Patient Counter	0.69	0.64	7.25
Laboratory	12.01	11.32	5.75
Consultation Room	176.34	164.53	6.69
Payment Counter	1.04	0.94	9.62
Pharmacy Counter	1.25	1.18	5.60

Table 11: Comparison between simulated output and historical data for average service time

Phases	Average Service Time (minutes)		
	Historical Data Output	Simulation Output	Differences (%)
New Patient Counter	5.87	5.73	2.39
Appointed Patient Counter	2.32	2.12	8.62
Laboratory	6.45	6.06	6.04
Consultation Room	13.01	12.34	5.15
Payment Counter	6.22	6.05	2.73
Pharmacy Counter	6.18	5.87	5.02

6.3 Proposed Experimentation Model

The proposed experimentation model is applied using "what-if analysis". This proposed experimentation model involves a number of changes made to input variables for the simulation model. Model experiment is a test or a series of test involves a number of changes made to input variables for the simulation model [32].

Here, two suggested experimentation scenario are implemented into the model to see whether the proposed experimentation able to reduce the average waiting time or not. Also, we want to determine which proposed scenario provides better improvement or reduction of patient's waiting time.

For the first scenario, changes are made to the specialist consultation time by setting the time to 15 minutes per patient with the interval between the arrivals of the patient every 15 minutes. This value is taken based on the average service time obtained from Table 4, which is 12 minutes per patient. The proposed experimentation model is executed with five replications and the average waiting time under those five replications is recorded in Table 12.

Based on the results obtained from Table 12, the new average waiting time for a patient in consultation room is 15.586 minutes compared to the previous original model (simulation output) result with total reduction of 148.94 minutes per patient. The maximum average waiting time per patient is 27.289 minutes which mean that the maximum time the patient needs to wait is only 27.289 minutes compared to previous simulation model with 242.74 minutes.

This shows that the average waiting time per patient can be reduced if the inter-arrival time between patient and specialists' consultations time is being standardized. This clearly represents that the proposed improvement model provides large and significant changes to the waiting time in the consultation room which has always been a complaint by the patients.

For the second scenario, changes are made to the specialist consultation time by setting the time to minimum 10 minutes, ideally 15 minutes, and maximum of 30 minutes per patient with the interval between the arrivals of the patient every 15 minutes. This value is taken based on the average service time obtained from Table 4, which is average of 12 minutes per patient with maximum average is 34 minutes per patient. The proposed experimentation model is also executed with five replications and the average waiting time under those five replications is recorded in Table 13.

Table 12: Comparison between average waiting time for proposed improvement model scenario 1 and simulation output

Rep.	Proposed Improvement Model (minutes)		Simulation Output (minutes)	
	Time	Maximum Time	Time	Maximum Time
1	16.895	26.931	156.93	255.93
2	12.727	21.873	157.13	209.26
3	16.703	26.315	184.96	265.95
4	16.445	30.243	145.14	209.12
5	15.158	31.081	178.47	273.46
Average	15.586	27.289	164.53	242.74

Table 13: Comparison between average waiting time for proposed improvement model scenario 2 and simulation output

Rep.	Proposed Improvement Model (minutes)		Simulation Output (minutes)	
	Time	Maximum Time	Time	Maximum Time
1	69.22	95.61	156.93	255.93
2	69.68	108.79	157.13	209.26
3	67.20	94.43	184.96	265.95
4	93.79	129.70	145.14	209.12
5	54.76	85.04	178.47	273.46
Average	70.93	102.71	164.53	242.74

Based on the results obtained from Table XIII, the new average waiting time for a patient in consultation room under scenario 2 is 70.93 minutes compared to the previous original model (simulation output) result with total reduction of 93.60 minutes per patient. The maximum average waiting time per patient is 102.71 minutes which mean that the maximum time the patient needs to wait is only 1 hour 42 minutes compared to previous simulation model with almost 3 hours of waiting time.

From those two tables, it can be concluded that proposed experimentation model for scenario 1 resulted better reduction of patient's waiting time at consultation room even though proposed experimentation model for scenario 2 also shows large reduction of patient's waiting time.

7 Conclusions

In this study, a multiphase patient flow model was developed for the O&G Department at an outpatient clinic with a focus on the patient waiting time for having a treatment. The main objective of this study is to model and simulate the operation or the patient flow system at the O&G Department, which can be used to improve the operating performance and also improving the quality of the services provided to the patients.

Based on the results of multiphase patient flow simulation model developed, it is proved that there is a long waiting period for a patient to gain a treatment even an appointment system is applied and there is unbalanced service time encountered.

Simulation model developed shows that long waiting time exist at consultation room. Therefore, two suggested improvement made to this phase with a view to reduce the waiting time of the patients.

A scenario 1 of improvements implemented on the model, by setting the consultation time to 15 minutes per patient with 15 minutes inter-arrival time. From this improved model, the average waiting time is reduced by 148.94 minutes (decreased from 164.53 minutes to 15.586 minutes per patient) while the maximum average waiting time is 27.289 minutes per patient.

Meanwhile, a scenario 2 of improvements implemented on the model, by setting the consultation time to minimum of 10 minutes, ideally of 15 minutes per patient, and maximum of 30 minutes with 15 minutes inter-arrival time. From this improved model, the average waiting time is reduced by 93.60 minutes (decreased from 165.43 minutes to 70.93 minutes per patient) while the maximum average waiting time is 102.71 minutes per patient.

This shows that the two proposed experimentation model can help reducing the waiting time for a patient in consultation room and also automatically reduce the whole average waiting time and the overall time taken to finish the treatment. The significant and large reduction of this waiting time indicates that the management of the specialist center should give more emphasis to the operation of the patient flow by implementing changes to the existing systems. This is to ensure the high quality of services is delivered as well as to maintain the loyalty of the patients.

FUTURE WORK

The next step in this research project is to test the applicability of simulation model developed that can be used by any outpatient department of either public or private healthcare. Furthermore, another improvement is by developing a flexible simulation model that can be applied into different type of systems and able to give more accurate result. In addition, more complex properties can be considered during the development and the full version of the software will be used, allowing more detailed model and a greater variety of performance which can be used to study resource allocation such as reducing doctor's idle time, staff allocation and scheduling, etc.

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