

Simulation Based Approach for Improving Outpatient Clinic Operations

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RECEIVED ON 25.10.2018, ACCEPTED ON 19.02.2019

ABSTRACT

The aim of this study is to suggest the optimum number and schedule of doctors at the OPD (Out-Patient Department) of Gastrology of a hospital in Pakistan. In order to achieve this aim, the discrete event simulation model is developed to minimize waiting time of patients. Data is collected for one week from the OPD; Data collection variables are arrival and service rate of patients, their salaries/income, patient's OPD fee, doctor's charges/patient, service time of patients at each of service channel i.e. reception, triage and doctors' cabin. Stop watch is used for recording the service time of patients. Input analyzer is used to reveal the distribution of the data. Rockwell arena software version 14.5 is used to model and simulate the queuing system of the outpatient department. Scenario analysis is conducted in four scenarios; in each of the scenario doctors were assumed to be seated for one additional hour. During the period of data collection, it is observed that most of the patients are coming with an appointment of doctors therefore, it is not justified to suggest the hiring of new doctor; especially when patients are coming for the particular doctor; therefore, already available doctors are suggested to be seated longer in the OPD; that is the way to serve the maximum number of patients in the virtual queue of patients that has been kept waiting for having an appointment and for their turn to see the doctor.

Key Words: Optimization, Simulation, Outpatient Department.

1. INTRODUCTION

Provision of the good medical care has always been expected from the healthcare providers so that the population can be served effectively and efficiently. Healthcare service improvement is one of the important and urgent issue for Pakistan [1]. One of the essential role of healthcare systems is the improvement of health of the citizens of country [2]. It is essential for the people to have good health for the development and improvement of economic state of the country. In the

comparison of service deliveries, healthcare care delivery is a kind of delivery in which the customer is more involved in the process of consumption. The patient can be harmed by the provision of bad service delivery and may lead to loss of life. In this regard, satisfaction of patients is necessary to be investigated for the sake of improvement in healthcare delivery system [3]. The side of patient satisfaction has been targeted attentively in the health care recently [4]. Patients' satisfaction is more important

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to produce retaining customers/patients [5]. Patient satisfaction and the service quality are in a close association, good service delivery yields the retaining customers [6]. According to Suryadana [6], service quality is the difference between actual and perceived service delivery quality by the customer.

Outpatient and Emergency Departments are the most visited departments by the patients and they are also the initial contact of patients with the hospital's staff [7]. Literature indicates that in the past decade of developing countries, emergency departments are stressed on congestion and its influence on service time; furthermore, hospitals were paid attention in terms of their ability to meet the emergency needs [8]. Because of the lacking on the side of control over the customer services, the capacity planning can be complicated by service demands in the particular department. Research shows that Pakistan is also facing shortage of doctors which may be the reason of long waiting lines [9]. Nowadays, Congestion of patients in OPDs, ICUs (Intensive Care Unit), emergency departments and waiting areas is the big problem. Because of the congestion, planned queuing system do not work effectively. In daily life, queue is basically the common occurrence [10] e.g. at Hospitals, superstores, petrol pumps and CNG (*Compressed Natural Gas*) filling stations. When the available resources are less than entities then the queue is formed. The term delay is defined as the difference in demand of service and the associated available capacity of meeting the demand [11]. Waiting cost is associated with queues, when the patients wait in the system for getting service [12]. Waiting for long the queue often has negative influence on the satisfaction of the patient [13]. Because of the long waiting lines doctors are put to stress and due to the congestion they try to get the patients free without any deep examination, which yields customers dissatisfaction [2,13-14]. Dissatisfaction incurs cost to the organizations i.e. cost of customer dissatisfaction.

In chain of health care services, hospitals are considered as one of the most important links which have impact on lives of the people. Hospitals have major influence on the prevention of diseases, early diagnosis of the diseases, management and treatment of patients [8]. The major area of focus for the hospitals is the occupancy and discharge of patients; so that the executive capacity of the system can be managed. A number of research studies are available on the subject of reforms in healthcare but an explicit frame work is required in which the performance can be judged and quantified against the performance management system [15]. Operation research and the management sciences are the subjects by the help of which managers can plan and manage the resources effectively [16]. Queuing theory is the tool of operations research which is widely used for simplifying the problems of waiting lines. Mathematical approach such as queuing theory is only possible to be used when the queuing system already exists, then after the collection of data and calculation of performance measures the optimum queuing can be suggested. In contrast to the mathematical approach, simulation is more preferable. Most of the decisions are made on the results of simulation. It has been considered as more effective and more precise as compared to the mathematical model based calculations; because, in complex scenarios assumptions can be changed and behavior of the model can be observed in simulative analysis [8].

This study is aimed to suggest the optimum number/schedule of doctors at the OPD of Gastrologyat hospital of Karachi, Pakistan.

2. LITERATURE REVIEW

Several studies have been conducted to improve the hospital performance. Most of the studies focus on simulation optimization methods to reduce waiting time. Agyei et. al. [10] developed discrete event simulation

model of radiology and oncology departments to minimize the patients waiting time. Dawei et. al. [17] developed multi-objective optimization model to minimize patient’s system time. Rockwell Arena simulation platform is also used to improve the healthcare performance[18-19,21]. Kittipittayakorn et. al. [18] developed healthcare simulation model and suggested optimal allocation of resource to maximize the equipment utilization. Lade et. al. [19] developed emergency services model in ARIS and Arena software. This software was used to test two assumed scenarios for the reduction of waiting time, implementing the improvement of doctor’s efficiency and the quick pass process for those patients who were suffering from the minor illness. This all was done so that the bottlenecks in the system could be rectified and the resources could be allocated optimally at different stages of service. Nuñez-Perez et. al. [20] suggested optimal number of beds in emergency departments. Rockwell Arena software was used for simulation and analysis. They indicated that 179 beds should be there instead of 81. Furthermore, the patients having high degree of illness were given the priority. Table 1 summarize the literature.

In this study not only waiting time of patients was focused but the increased percentage of served patients was computed along with the service cost, revenue and the profit so that the operational managers have enough information to improve the queuing system at the OPD.

3. RESEARCH METHODOLOGY

3.1 Data Collection

OPD of Gastrology was selected for the data collection. Duration for data collection activity was 7 days. Data collection variables included arrival rate, service rate, service time taken by each resource (Doctor, Nurse, and Receptionist) per patient, income of doctor per patient, fee paid by the patient for getting served by the doctor.

3.1.1 Arrival of Patients

The arrival distribution of patients was not known, the inter arrival time of patients changed independently; therefore, the arrival time of patients was got down on the paper at the study area. The arrival time of patients was necessary to be noted in order to reveal the distribution that patients’ arrival followed.

3.1.2 Patients’ Service Time

The time taken by the doctor to serve the patient is called as service time. Since, resources at the OPD were receptionist = 1, nurse = 2, doctors = 6; so the service time of each resource was noted with the help of stop watch.

3.1.3 Capacity of the OPD

Capacity of the OPD was calculated by adding up the resources available at the facility. There was one receptionist, two nurses and six doctors. Collectively, there were nine resources.

TABLE 1. SUMMARY OF LITERATURE

Literature	Methodology		Decision Variable(s)	Objective Function		
	Simulation	Analytical		Waiting Time	Service Cost	Waiting Cost
Agvei et. al. [10]	X		Resource allocation	X		
Dawei et.al. [17]		X	Resource allocation	X		X
Kittipittayakorn et. al. [18]			Resource allocation	X		
Lade Ishan et.al. [19]	X		Resource allocation	X		
Nuñez-Perez et.al. [20]	X		Hospital bed requirements	X		
Mwafak Shakoore et.al. [21]	X		Resource allocation			
This Research	X		Doctor and triage scheduling	X	X	X

3.1.4 Queue Discipline

There are various queue disciplines e.g. FCFS (First Come First Served), FCLS (First Come Last Served), LCFS (Last Come First Served), SIRO (Service in Random Order); but in this study, FCFS queue discipline was preferred.

3.1.5 Input Analysis

Analysis of the input variables i.e. arrival and service times was conducted into input analyzer of the Rockwell arena software version 14.5. After the input analysis, the arrival and service distributions of the data were revealed which were put into the several processes in the simulation model.

3.2 DEVELOPMENT OF SIMULATION MODEL

After the input analysis of the collected data, the queuing system of the OPD was modelled from the reception to the service by the doctors (Figs. 10-11).

3.2.1 Cost Analysis

Cost analysis was conducted in which, cost of hospital, earning of doctors, waiting cost of patients, total revenue and hospital's profit were calculated for each scenario.

N = Number of Working Hours of the OPD

n = Number of Patients

Total Amount charged per patient by the hospital = **Rs.300/-**

Rs.300/- was the amount which was supposed to be paid by the patient at the OPD in order to see the doctor.

Service cost of Doctors/patient= **Rs.70/-**

Rs.70 was amount which was supposed to be paid to the doctor for consulting one patient.

Receptionist Service Cost: Monthly salary i.e. Rs. 12000 of receptionist was collected from the OPD and the service cost per minute was calculated: because it was the part of analysis to calculate the cost of receptionist per patient and the time taken by receptionist to serve the patients was in minutes.

Nurse Service Cost: Similarly, to the receptionist's cost, nurse's cost was calculated in the same way. The salary of the nurse (Rs.10000/-) was collected from the OPD. Since the customer had to pass from the triage therefore the cost of nurse per minute was necessary to be calculated.

Total Service Cost: This cost was calculated by summing up the doctors cost, receptionist's cost, nurse's service cost and on the multiplication of whole sum with the number of patients coming at the OPD, total service cost was taken out.

Patient's Waiting Cost: Salaries/monthly income of patients was collected from the patients. This was the cost of time that they had to wait in the queues (reception, triage, doctor).

Patients' Total System Cost: This cost was calculated by multiplying the time that patients spent at the OPD by the income that could have been generated if he/she would be at his/her work.

Total Revenue: Revenue was calculated by multiplying the number of arriving patients with the amount of Rs. 300/- (The amount charged by the OPD per patients).

Total Profit: Profit was calculated by subtracting the total incurred cost from the total generated revenue.

Receptionist's service cost/minute = salary of month/
(30 x N x 60) (1)

Nurse's service cost/minute = salary of month/
(30 x N x 60) (2)

Each patient's service cost = 70 +receptionist's service time (min.) x receptionist's service cost/patient + Nurse's service time (min.) x Nurse's service cost/patient (3)

Total service cost/patient = n x Each patients' service cost (4)

Patient's waiting cost/minute = Monthly salary of patient/ (30 x 8 x 60) (5)

Patient's total system cost = Total System time x Patient's waiting cost/minute (6)

Total revenue = n x amount charged by the hospital/patient (7)

Hospital's profit=Total revenue-(total service cost) (8)

4. ASSUMPTIONS OF THE RESEARCH

Assumptions play a vital role in bridging the real world to mathematical world. Mathematical models are good only because of the good assumptions. In the case of incorrect assumptions or not explicitly described; results would be difficult to assess and misleading as well [22]. Following assumptions were made during the development of the model:

- All of the six doctors were there at the OPD for five hours.

- Breaks e.g. tea and prayer were not kept into the consideration.
- Occasional non-availability of resources was not considered in this research.
- Only the waiting cost of patient was included in the study; waiting cost of those people who came along was not considered.
- Until the patient was in the OPD, his/her waiting cost was counted.
- Service cost was calculated by summing up the salaries of resources.

5. RESULTS

5.1 Input Analysis of the Collected Data

5.1.1 Arrival Distribution of Patients at the OPD

As discussed earlier, input analysis was conducted in the input analyzer of Rockwell arena. Arrival distribution of patients was indicated to be poison distribution (POIS (19.9)) with the square error=0.002798 which can be seen in Fig. 1.

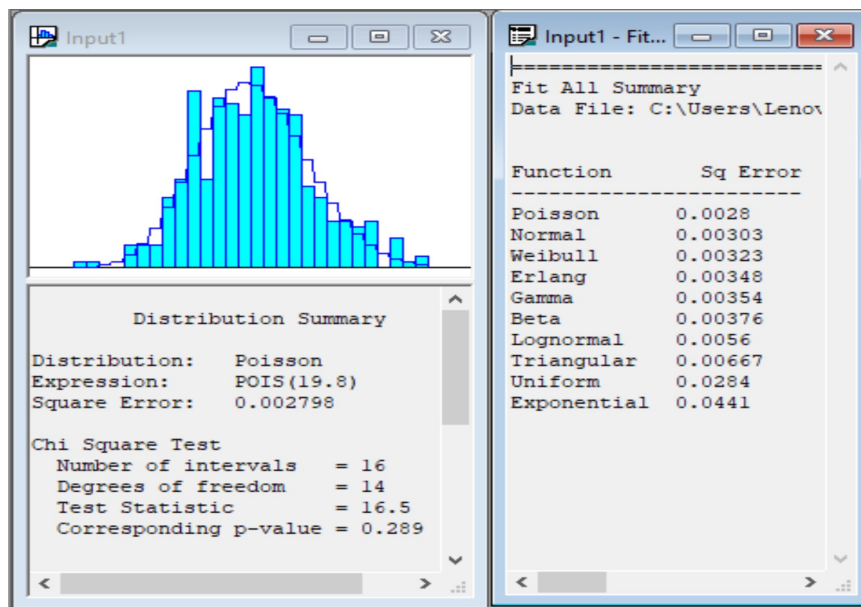


FIG. 1. DISTRIBUTION OF ARRIVING PATIENTS

5.1.2 Patients' Service Distribution at Reception

Patients' service distribution at reception counter came out to be triangular distribution (TRIA (1.8, 3.15, 3.18)) with the square error=0.002798 which can be seen in Fig.2.

5.1.3 Patients' Service Distribution by Nurse

Distribution of service of patients by nurse was taken out to be normal distribution (NORM (2.14, 0.442)) with the square error=0.002798 which can be seen in Fig.3.

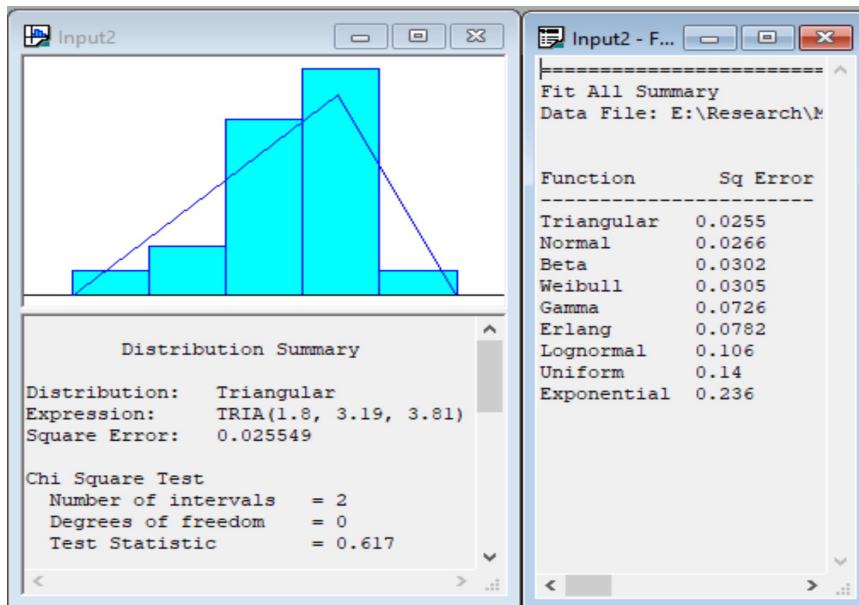


FIG. 2. SERVICE DISTRIBUTION OF PATIENTS BY THE RECEPTIONIST

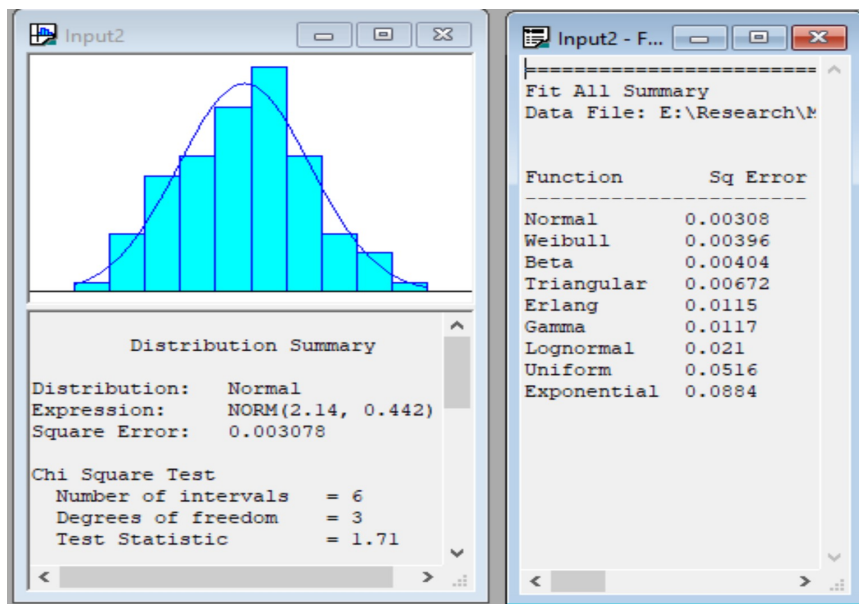


FIG. 3. DISTRIBUTION OF SERVED PATIENTS BY NURSE

5.1.4 Patients' Service Distribution by Doctor1

Distribution of patients' service by doctor1 was taken out to be beta distribution (1+4 x beta (1.57, 1.81)) with the square error=0.002798 which can be seen in Fig. 4.

5.1.5 Patients' Service Distribution by Doctor2

Service distribution of patients in case of doctor1 came out to be triangular (TRIA (3, 9.13, 14)) with the square error=0.002798 which can be seen in Fig. 5.

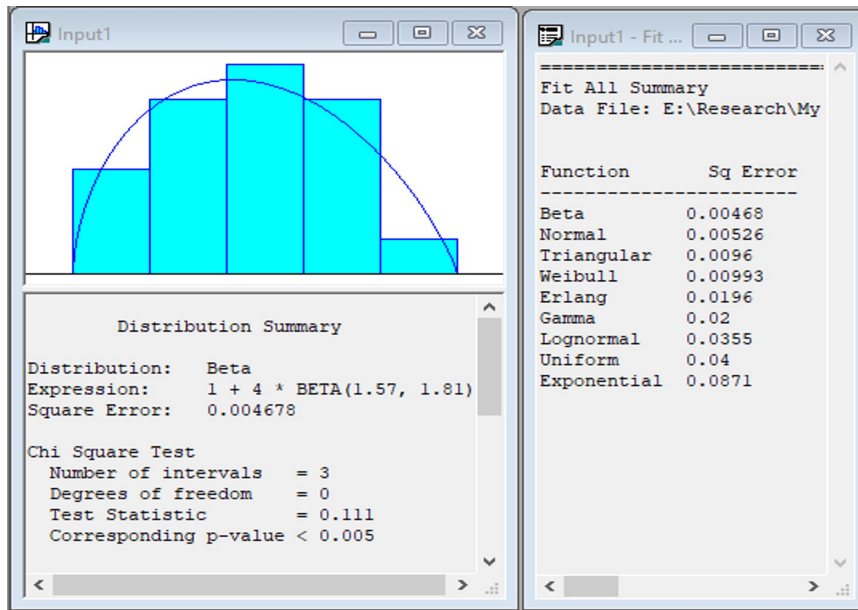


FIG. 4. DISTRIBUTION OF SERVED PATIENTS BY DOCTOR1

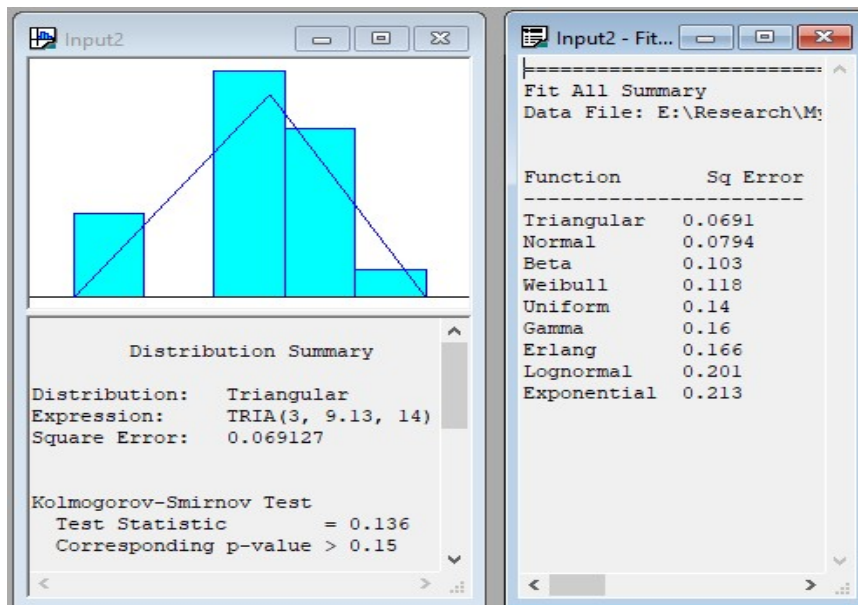


FIG. 5. DISTRIBUTION OF SERVED PATIENTS BY DOCTOR2

5.1.6 Patients' Service Distribution by Doctor3

Service distribution of patients in case of doctor3 came out to be normal distribution (NORM (12.2, 1.66)) with the square error=0.002798 which can be seen in Fig. 6.

5.1.7 Patients' Service Distribution by Doctor4

Service distribution of patients in case of doctor4 came out to be uniform distribution (UNIF (3.29, 10.9)) with the square error=0.002798 which can be seen in Fig. 7.

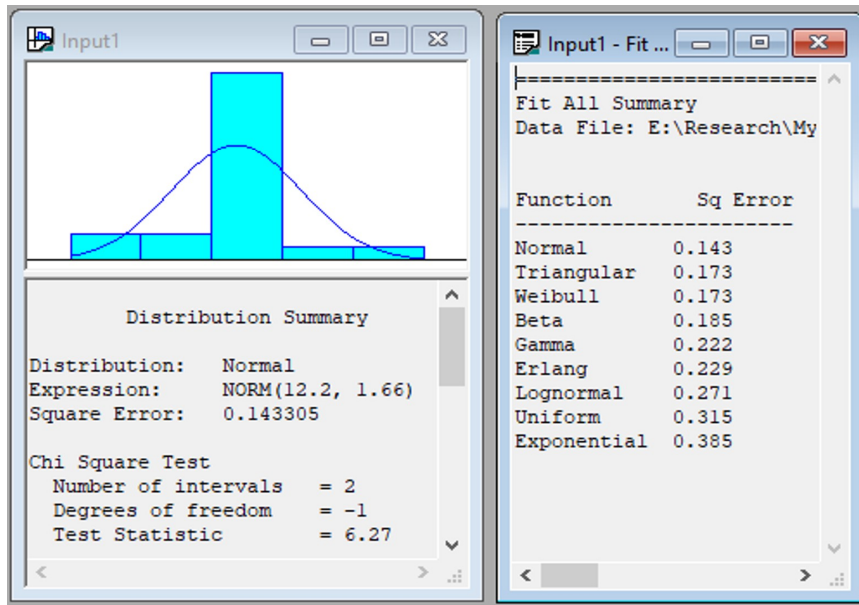


FIG. 6. DISTRIBUTION OF SERVED PATIENTS BY DOCTOR3

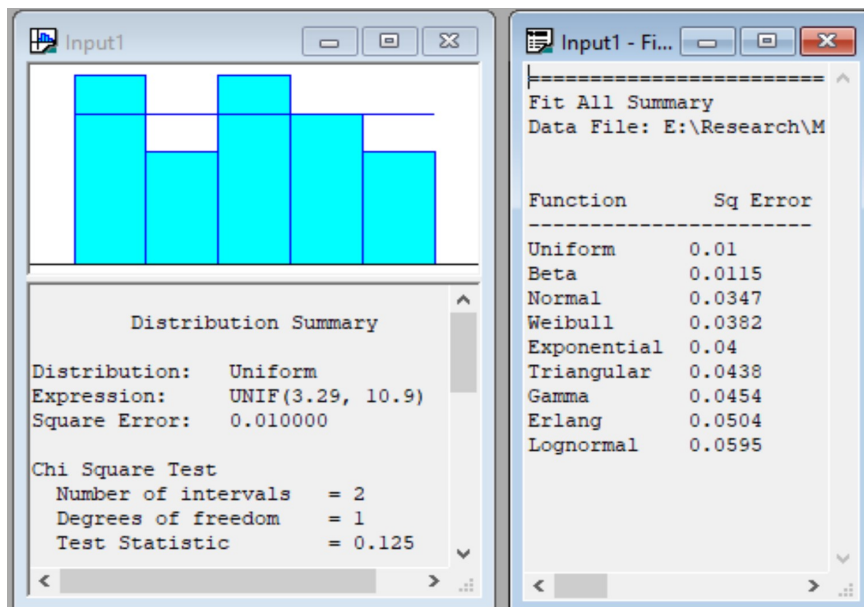


FIG. 7. DISTRIBUTION OF SERVED PATIENTS BY DOCTOR4

5.1.8 Patients' Service Distribution by Doctor5

Service distribution of patients in case of doctor5 came out to be triangular distribution (TRIA (7.18, 11, 13.6)) with the square error=0.002798 which can be seen in Fig. 8.

5.1.9 Patients' Service Distribution by Doctor6

Service distribution of patients in case of doctor6 came out to be beta distribution (11+7xBeta (1.45, 1.47)) with the square error=0.002798 which can be seen in Fig. 9.

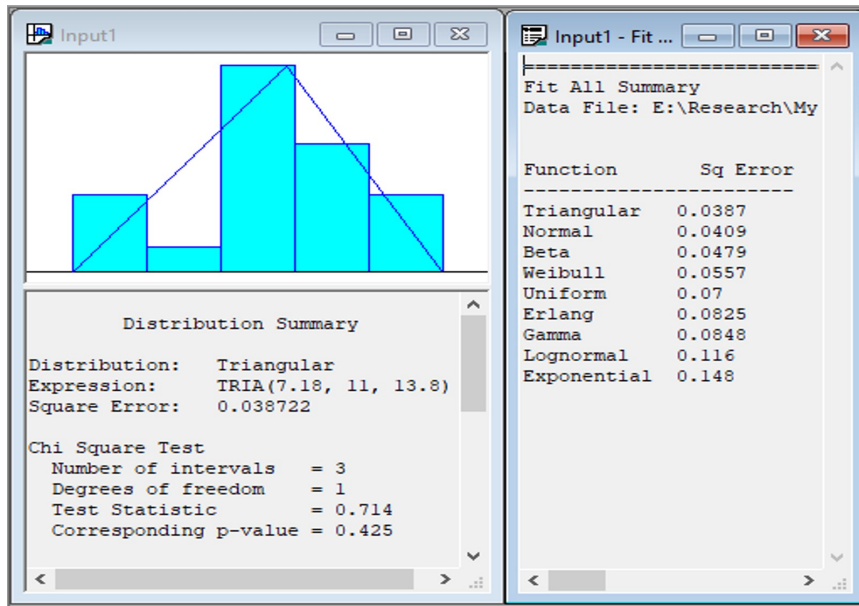


FIG. 8. DISTRIBUTION OF SERVED PATIENTS BY DOCTOR5

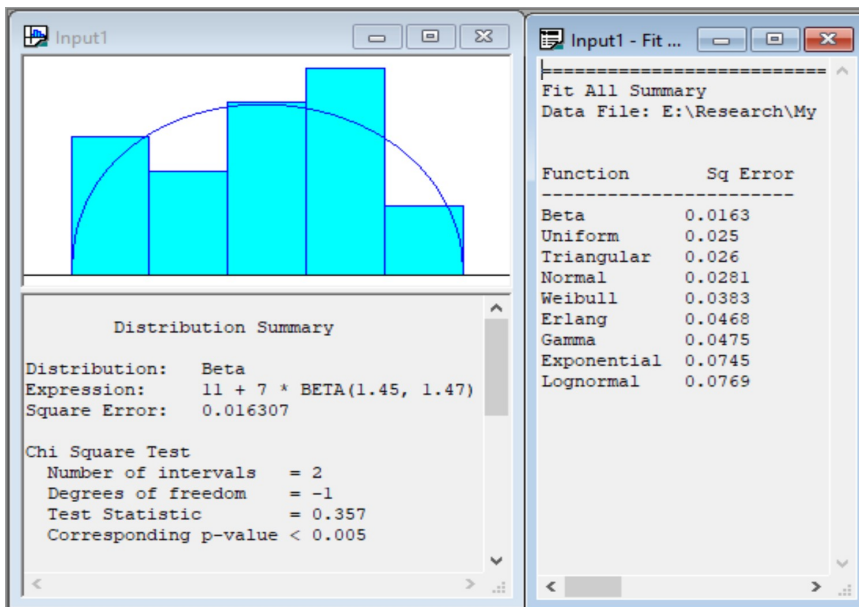


FIG. 9. DISTRIBUTION OF SERVED PATIENTS BY DOCTOR6

5.2 Modelling of the Queuing System of OPD

In the development of queuing system model, patients were considered as entities, OPD was considered as system, receptionist, nurses and doctors were considered as resources.

5.2.1 Simulation of Model for the OPD

Queuing system of the OPD was modelled which can be seen in Fig. 10. In creating module (Patient Arrival) patients were created in the system. As figured out from the collected data that arrival distribution of patients at the OPD was poison distribution (POIS (19.8)). As discussed earlier, there were six doctors and the patients were coming for the specific doctors; all the arriving patients were identified with the help of assign module (DISC (0.37, 1, 0.53, 2, 0.64, 3, 0.79, 4, 0.88, 5, 1, 6)). Furthermore, assign module was used to note the entrance time (MyArrivalTime=TNOW()) of the arriving patients. For the service of patients at the reception, process module was used and the service distribution of patients at the

reception came out to be triangular distribution (TRIA (1.8, 3.19, 3.81)) as shown in the Fig. 2. When the patients got free of the reception, time spent by them at the reception was recorded (TNOW-MyArrivalTime) by the use of record module (Record Reception Time).

Similarly, before triage the time of patients was noted by the use of assign module. Service distribution of patients by the nurse was found to be normal (Norm (2.14, 0.442)) as shown in the Fig. 3. Triage time of patients was recorded thereafter by the use of record module (Triage Time) as shown in the Fig. 10.

5.2.2 Sub Model

Since the patients were coming for the specific doctors that's why it was necessary to send them to the doctor of their interest. Sub model (Fig. 11) was initiated to model this mechanism of queuing system. Decide module (N-way by chance) was used for sending the patients to the specific doctors. Percentage of patients was calculated for each of the doctor (Doctor1 = 37%, Doctor2 = 16%, Doctor3 = 11%, Doctor4 = 15%, Doctor5 = 9%, Doctor6 = 12%).

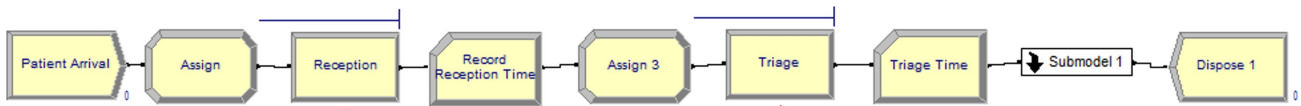


FIG. 10. MODEL OF THE QUEUING SYSTEM OF OPD

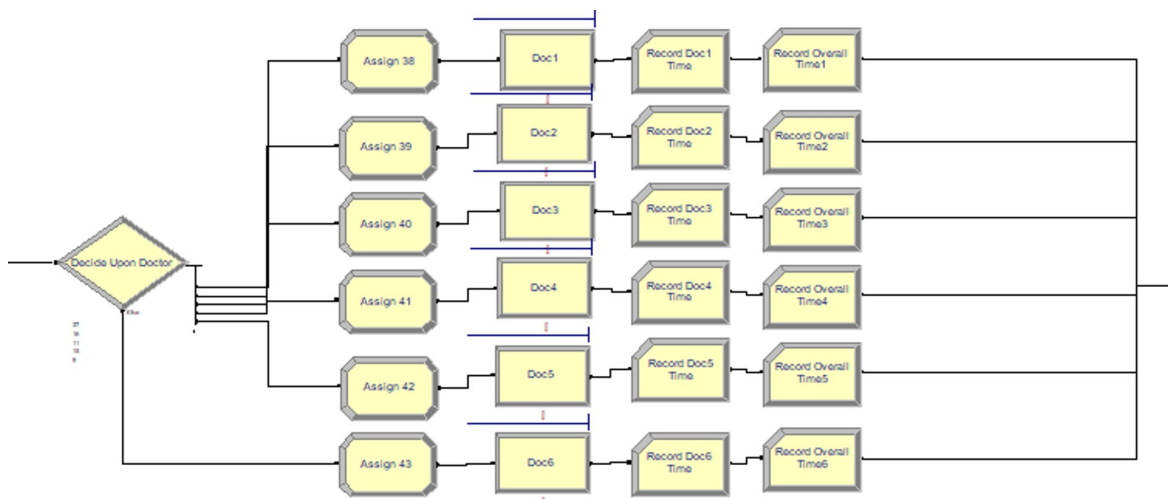


FIG. 11. SUB MODEL DEVELOPED FOR THE REPRESENTATION OF SERVICE MECHANISM OF PATIENTS BY THE DOCTOR AT THE OPD

After deciding upon the patients to be sent to the specific doctor, the time of patients was noted by using the assign modules as shown in Fig. 11. Service distribution of patients by the doctors as collected from the OPD were: ‘Doctor1: $1 + 4 \times \text{Beta} (1.57, 1.81)$ ’, ‘Doctor2: TRIA (3, 9.13, 14)’, ‘Doctor3: NORM (12.2, 1.66)’, ‘Doctor4: UNIF (3.29, 10.9)’, ‘Doctor5: TRIA (7.18, 11, 13.6)’, ‘Doctor6: $11+7 \times \text{BETA} (1.45, 1.47)$ ’. When the patients got free from the doctor, their time was recorded by using record module (Record Doc1 Time) and in last, total system time of patients was recorded by using the record module. Since the time of doctors to serve the patients was different that is why the total system time of patients coming for different doctors was independently different.

5.2.3 Replication Parameters

It is required to set replication parameters as given in Table 2. The model was simulated for half year. OPD time was set to 4 hours and the unit of time in output was set to be in minutes.

5.2.4 Results of Existing Queuing System

Results which were obtained after simulating the model are presented in the below given headings.

5.2.5 Number of patients Served by Each Doctor

In the duration of 4 hours, 71 patients were served by the doctor1 and it was the maximum number of patients and on the contrary 17 patients were served by the doctor5 as shown in Table 3. The number of patients served by each doctor depended on the service time of patients and the minimum service time was doctor1.

5.2.6 Awaiting Patients in the Waiting Line

In the queuing system of OPD, number of queues was eight. The number of awaiting patients in the various queues is presented in Table 4. It can be seen in the table that the maximum number of patients (i.e. 80) was awaiting at the reception. Average number of awaiting patients (16.75) at the reception is also greater than all the averages.

TABLE 2. REPLICATION PARAMETERS SET FOR THE SIMULATION OF MODEL

Replication Time	Durationof OPD/Day	BaselineTime
182 Days	4 Hours	Minutes

TABLE 3. PATIENTS SERVED/HR AND PER DAY BY THE DOCTORS SPECIFICALLY

Doctor	Number of Served Patients/Hour	Total Served Patients/Day
Doctor 1	18	71
Doctor 2	8	30
Doctor 3	5	21
Doctor 4	7	28
Doctor 5	4	17
Doctor 6	6	22
Total	48	190

5.2.7 Waiting Time of Patients in the Queues

Waiting time of patients in the various queues is presented in Table 5. On an average, the waiting time patients in different queues is quite less but in the queue of reception it was simulated to be 50.69 minutes. Maximum time of patients in the reception queue was 233 minutes. Secondly, the waiting time of patients in the queue of doctor 6 was 69.840 minutes; this time was more because of more service time (22.368 minutes (Table 8)) of doctor6. Furthermore, waiting time of patients in

the remaining queues was comparatively lesser as shown in Table 5.

5.2.8 Instantaneous Utilization of Resources

In Table 6 instantaneous utilization of the available resources is presented. The maximum utilization was of the receptionist (96.9%). Secondly, maximum utilization of the resource was of the doctor6 (55.8%). However, the instantaneous utilization of other resources was comparatively less in the comparison of receptionist and doctor6.

TABLE 4. QUANTITY OF AWAITING PATIENTS IN THE WAITING LINE

	Average Number	Minimum	Maximum
Quantity of awaiting patients in queue of Doctor1	0.027	0	2
Number of awaiting patients in queue of Doctor2	0.163	0	6
Number of awaiting patients in queue of Doctor3	0.132	0	4
Number of awaiting patients in queue of Doctor4	0.070	0	3
Number of awaiting patients in queue of Doctor5	0.049	0	3
Number of awaiting patients in queue of Doctor6	0.304	0	5
Number of awaiting patients in reception queue	16.75	0	80
Number of awaiting patients in triage queue	0.000	0	0

TABLE 5. PATIENTS WAITING TIME IN DIFFERENT WAITING LINES

	Average Number	Minimum	Maximum
Patients' waiting time in Doctor1's queue	0.218	0.00	7.0753
Patients' waiting time in Doctor2's queue	3.082	0.00	49.867
Patients' waiting time in Doctor3's queue	3.593	0.00	46.995
Patients' waiting time in Doctor4's queue	1.433	0.00	22.317
Patients' waiting time in Doctor5's queue	1.673	0.00	19.489
Patients' waiting time in Doctor6's queue	7.89	0.00	69.840
Patients' waiting time at reception queue	50.69	0.00	233.00
Patients' waiting time in triage queue	0	0	0

5.2.9 Recorded Time of Patients

In Table 7 the recorded service time of doctors to serve the patients is presented. On the same time, total system time of patients coming to six different doctors was recorded separately as shown in Table 7.

5.3 Scenario Analysis

Analysis was conducted in four scenarios; in each scenario the working time of resources was increased by one hour. Scenario analysis was conducted because of the existence of two queues. First was the queue of

TABLE 6. RESOURCES' INSTANTANEOUS UTILIZATION AT THE OPD

Resource	Average Instantaneous Utilization	Minimum	Maximum
Doctor1	0.3502	0	1
Doctor2	0.4646	0	1
Doctor3	0.4468	0	1
Doctor4	0.3486	0	1
Doctor5	0.3185	0	1
Doctor6	0.5580	0	1
Nurse	0.3542	0	1
Reception	0.9693	0	1

TABLE 7. PATIENTS' SERVICE TIME AND THEIR TOTAL SYSTEM TIME

	Average Number	Minimum	Maximum
Service time of Doctor1	3.0576	1.0821	10.5460
Service time of Doctor2	11.871	3.0915	58.1861
Service time of Doctor3	15.767	7.1053	59.3339
Service time of Doctor4	8.5528	3.2907	29.3528
Service time of Doctor5	12.339	7.3612	29.7715
Service time of Doctor6	22.368	11.0240	87.4008
Patients' total system time who came to for Doctor1	58.912	4.9865	239.47
Patients' total system time who came to for Doctor2	68.1742	8.5383	242.94
Patients' total system time who came to for Doctor3	71.3172	14.0216	252.70
Patients' total system time who came to for Doctor4	63.6784	8.1104	238.77
Patients' total system time who came to for Doctor5	68.9699	11.8030	239.16
Patients' total system time who came to for Doctor6	77.5622	15.6033	250.58
Waiting time of patients at Reception	53.6307	1.8143	235.73
Waiting time of patients at triage	2.1449	0.1908	3.9295

patients which is in its way to see the doctor and another queue was virtual queue which was on hold to have an appointment. Therefore, second queue was required to be minimized so that more and more patients could be served.

5.3.1 Replication Parameters

Replication parameters were set before simulation. In scenario 1, simulation time period was 0.5 year and the time of the OPD was 4 hours. Replication length was kept constant but the duration of OPD was changed by one hour as shown in Table 8.

5.3.2 Patients Served by Specific Doctor in Different Scenarios

Total number of served patients per day was calculated for each of the doctor across all scenarios. The number of served patients kept on increasing with the increasing working time of the OPD. The degree of increment can be seen in Table 9.

5.3.3 Cost Analysis across all Scenarios

Cost analysis was also conducted across all the scenarios. It included, service cost per day, total revenue of the hospital and total profit of the hospital as shown in Table 10.

TABLE 8: REPLICATION PARAMETERS SET FOR SCENARIO ANALYSIS

Scenario	Length of Replication (Days)	Duration of OPD/Day (Hours)	Baseline Time
1	182	4	Minutes
2		5	
3		6	
4		7	

TABLE 9. PATIENTS SERVED BY EACH DOCTOR PER HOUR AT THE OPD

Scenario	Patients Served by Doctor1/Day	Patients Served by Doctor2/Day	Patients Served by Doctor3/Day	Patients Served by Doctor4/Day	Patients Served by Doctor5/Day	Patients Served by Doctor6/Day	Total Patients Served/Day
1	72	32	20	28	16	24	192
2	90	40	25	35	20	30	240
3	108	48	30	42	24	36	288
4	147	63	42	56	35	49	392

TABLE 10. COST ANALYSIS OF SERVED PATIENTS ACROSS ALL THE SCENARIOS

Scenario	Total Patients Served/Day	Service Cost/Day	Revenue of Hospital/Day (Rs)	Total Profit of Hospital
1	190.3	14454.3	57090	42635.67
2	238.1	16667	71430	54763
3	286.5	20055	85950	65895
4	390.1	27307	117030	89723

5.3.4 Increased Percentage of Served Patients at the OPD

In case of increasing sitting time of doctors at the OPD, the increased percentage of served patients was calculated which is presented in Fig. 12. In scenario, if the doctors' sitting time in the OPD is supposed to be 7 hours then, 105% would be the percentage of more patients who would be served at the OPD. Same case is with the revenue of the hospital it would certainly be increased in a way as number served patients. It can be seen in Fig. 12 that the revenue is increased up to 105% if the doctors are supposed to be seated in the OPD for 7 hours.

5.3.5 Hospital's Cost on Each Patient

The cost of the hospital on each of the arriving patient at the OPD was taken out. The amount which was charged by nurse per patient was Rs.51.07614; Amount charged

by the receptionist was Rs.3.269838/- and the amount charged by the doctor per patients was Rs.70/-. Collectively, the total average amount charged by the resources was computed to Rs.124.34/- as shown in Table 11.

5.3.6 Patients' Waiting Time and cost in Different Scenarios

During the simulation, some expression were formulated so that the total system time of patients could be recorded as shown in Table 6. Since, they wait in the system that's why cost is involved in it and that cost was termed as waiting cost/opportunity cost.

Waiting cost of patients across all the scenario was calculated and it was found to be minimum in the second scenario and was maximum in third scenario as shown in Fig. 13.

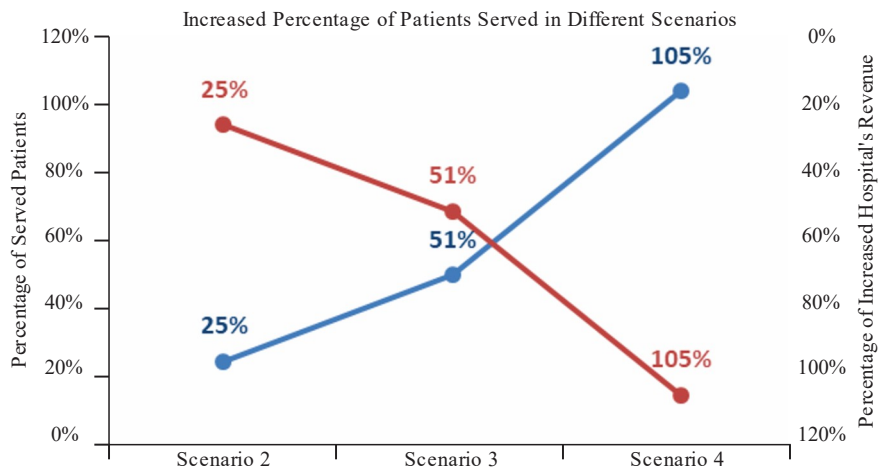


FIG. 12. PERCENTAGE OF SERVED PATIENTS WHEN THE DOCTORS' OPD TIME WOULD BE INCREASED

TABLE 11: AVERAGE SERVICE COST OF HOSPITAL SPENT ON EACH PATIENT

Cost	Amount (Rs)
Nurses' cost /patient	51.1
Receptionist's cost/patient	3.3
Doctor's cost/patient	70
Total cost/patient	124.34

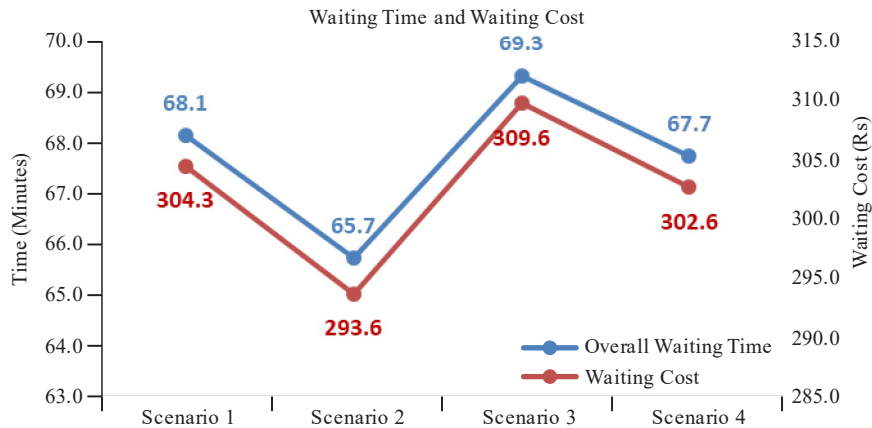


FIG. 13. PATIENTS' WAITING COST IN DIFFERENT SCENARIOS

6. CONCLUSION

It was not possible to increase the number of doctors at the OPD because the patients were coming for particular doctors at the OPD; since it was aimed to put the suggestion by which the maximum number of patients could be served, therefore, currently available doctors were suggested to sit for longer. If the doctors are supposed to sit for 7 hours in the OPD then 105% more patients would be served as compared to the existing service rate of the OPD.

7. FUTURE WORK

In this research, total system time of patients at the OPD was considered for the waiting cost. Time spent by the patients at the pharmacy was not included in this study therefore, it should be considered in the future studies. On the same time patients also spent the time on their way to hospital and the way back to their homes. This time was not also considered for the calculation of waiting cost of patients.

- (i) Instead of poison distribution, normal distribution can also be used for arrival of patients because both distributions are of the same square error.

- (ii) Tea breaks for the operational staff and occasional non-availability of the resources should be the consideration in future research.
- (iii) Whole data should also be collected two to three times a year in order to produce the justified results.

8. MANAGERIAL INSIGHTS

This study helps the hospital administration to improve the healthcare performance. It was revealed during this study that a few numbers of patients may shift to other doctors if they will properly guide by hospital administration. These patients are usually come first time to OPD. By doing this, patients waiting time may reduce as they may be shifted to doctors with shorter queues.

ACKNOWLEDGEMENT

This research could not have been conducted without the generous contribution of co-authors and Mehran University of Engineering & Technology, Jamshoro, Pakistan. Additionally, we thank the hospital administration for their good cooperation for permitting us to collect and providing the acquired data for research.

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