

Modeling and Simulation Analysis of Outpatient Department of Sri Lankan Healthcare Sector using ARENA

B Aynul Sowmiya* and Thashika D Rupasinghe*
 *Department of Industrial Management, Faculty of Science,
 University of Kelaniya, Sri Lanka

Abstract—The aim of this study is to minimize the patient average waiting time in the clinic and to maximize the resource utilization of resources such as doctors, nurses, lab assistant etc. Long waiting time to receive treatment at the outpatient department and thereby receiving short consultation period is a major complaint from many patients despite of hospitals having an appointment system. Inefficient appointment procedures and inconsistent service times have ultimately raised dissatisfaction among patients. Hence this simulation model is used to analyze patient flows especially patient waiting time at different stages of diagnosis process and thus will help these hospitals to identify best opportunities for improvement.

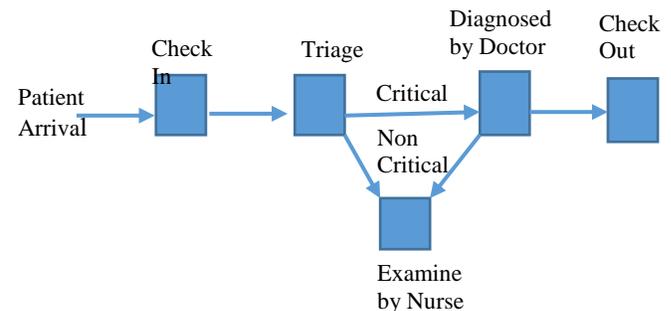
I. INTRODUCTION

The challenge of improving healthcare firms is getting stronger every day. In order to receive quality service the waiting time and consultation time are considered as high priority. Major reason for long waiting time is poor scheduling time put in place.

The process of delivering service is still inefficient where delays and cancellation of schedules occur regularly despite of technology and medical advances. Many hospitals try to mitigate this issue by adding more resources and ultimately couldn't succeed in this challenge grow further with every passing time. Moreover patient waiting time causes unnecessary burden to the hospital and further it is suffering to the staff to handle the delayed patients and additional cost as well as reduced efficiencies. Identifying bottlenecks and system failures by understanding the system as a whole as patients flow through the system will improve the healthcare process. One method of improving and understanding the causes of waiting time is through building a discrete event simulation model.

Utilization rates of doctors, nurses and examination rooms are often unknown. The absence of important operational measures such as throughput, utilization and patient waiting times makes it almost impossible for hospitals to make improvements in their outpatient department. Therefore proper way of understanding and using these measures will aid resource planning and allocation much easier. Hence this study is done in MediLand, a private SriLankan hospital which operates round the clock. This hospital is staffed by three receptionists at the reception office and five doctors on the premises, assisted by ten nurses. However additional one more

doctor is available on call at all time; this doctor is summoned when the number of patient arrival to outpatient department exceeds some threshold and is dismissed when the level comes to normal, possibly to be summoned later. Figure below demonstrate the patient sojourn in the outpatient department from their arrival to departure.



A. METHODOLOGY

Queuing concept is used in the simulation model since it is associated with time delays. Numerous studies have been done and shown that queuing theory is very useful in the medical field. Reference [1] has been made a study on the use of the queuing theory in obstetrics and Gynecology department in order to improve the patient waiting time for multiphase patient flow.

Data collected at the MediLand hospital which includes patient arrival time, waiting time at the triage, nurse's station and doctor's station, number of patients sent to the lab and the time it takes until the patient come back from the lab to the doctor queue. These data were analyzed using Arena input analyzer. And with results the relevant distribution are picked in developing the simulation model.

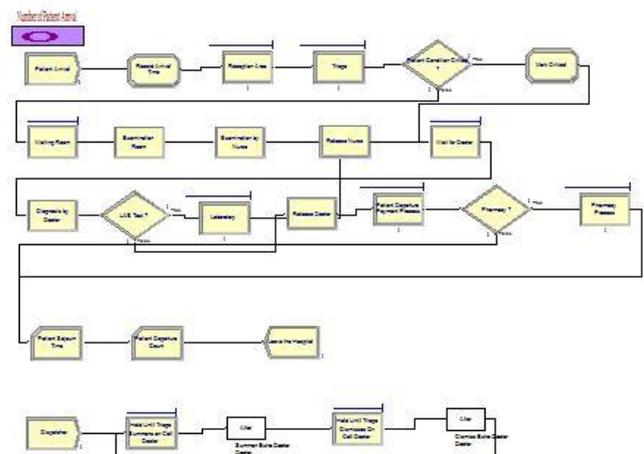


Fig: Simulation Model developed using Arena

II. FIGURES

Current Situation in the outpatient department of MediLand hospital.

Clinic hours	8 hours
Doctor's working hour	7 hours
Number of resources (doctors)	5
Number of resources (nurses)	10
Average patient sojourn time	1 hour
Doctor Utilization	

Summary of statistics obtained from the Arena input analyzer is given below in the table.

Statistics	Distribution/Parameter
Patient Arrival Rate	Exponential(Mean)
Service Time at the reception	Uniform(Min, Max)
Service Time at the Triage	Triangular(Min, Mode, Max)
Percentage of patients critical	0.4
Service Time at the nurse's station	Uniform(Min,Max)
Service Time at the doctor's station	Triangular(Min,Mode,Max)
Service Time at the Lab assistant's station	Triangular(Min,Mode,Max)
Percentage of patients needed Lab test	0.1
Percentage of patients needed Pharmacy	0.5

Hence the developed simulation model has been run to compare the output with the current process. The performance metrics of interest in this study are as follows,

- Utilization of the outpatient department staff by type (doctors, nurses, receptionists and pharmacists)
- Average waiting time of incoming patients for triage
- Average patient sojourn time in outpatient department.
- Average daily throughput (patients treated per period) in outpatient department.

B. Simulation Output

Figure below displays statistics of patient sojourn time and patient flow through the Outpatient department. Here, the Tally section indicates that the tallied patient sojourn times,

from patient arrival to patient discharge, last on average some 20 minutes. However, the sojourn times have considerable variability as indicated by the minimal and maximal observed sojourn times.

8:03:22PM		User Specified		September 19, 2016	
Healthcare Appointment System					
Replications: 20					
Replication 1					
Start Time:	0.00	Stop Time:	720.00	Time Units:	Hours
Tally					
Interval	Average	Half Width	Minimum	Maximum	
Patient Sojourn Time	20.6653	(Insufficient)	0.8675	57.9527	
Counter					
Count	Value				
Patient Departure Count	10.0000				

Figure below displays utilization statistics of human resources in the emergency room, which consist of doctors, nurses, and receptionists. Recall that the numbers of nurses and receptionists at the emergency room are fixed throughout the simulation horizon, whereas the number of doctors is variable due to the periodic summoning and dismissal of the doctor on call.

8:24:43PM		Resources		September 19, 2016	
Healthcare Appointment System					
Replications: 20					
Replication 1					
Start Time:	0.00	Stop Time:	720.00	Time Units:	Hours
Resource Detail Summary					
Usage					
	Inst Util	Num Busy	Num Sched	Num Seized	Sched Util
Doctor	0.94	1.81	1.87	26.00	0.97
LAB Assistant	0.00	0.00	1.00	2.00	0.00
Nurse	0.00	0.00	1.00	9.00	0.00
Pharmacist	0.00	0.00	1.00	4.00	0.00
Receptionist	0.03	0.03	1.00	136.00	0.03

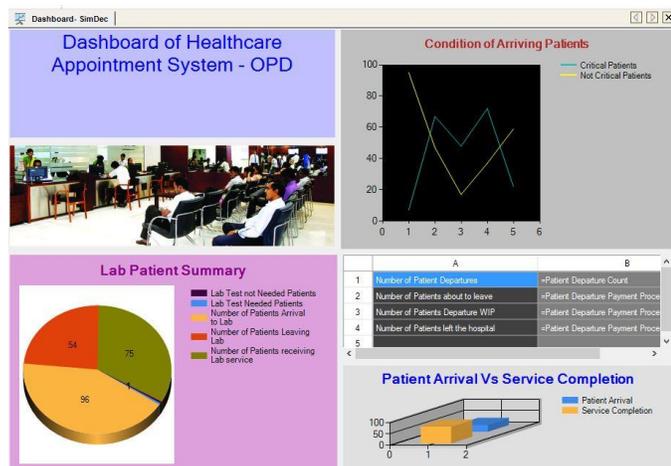
Resources segment displays utilization-related statistics of outpatient department (human) resources, taking into account the fact that the number of available resources (in this case doctors) may vary. The instantaneous utilization of doctors is very high (94%), and would have been even higher had an on-call doctor not been available.

Figure below displays waiting line statistics in the emergency room in terms of average waiting times and average number of patients in lines.

9:18:05PM		Queues		September 19, 2016	
Healthcare Appointment System					
Replications: 20					
Replication 1					
Start Time:	0.00	Stop Time:	720.00	Time Units:	Hours
Queue Detail Summary					
Time					
	Waiting Time				
Hold Until Triage Dismisses on Call Doctor.Queue	0.44				
Hold Until Triage Summons on Call Doctor.Queue	47.16				
Laboratory.Queue	0.00				
Patient Departure Payment Process.Queue	0.00				
Pharmacy Process.Queue	0.00				
Reception Area.Queue	0.00				
Triage.Queue	1.01				
Wait for Doctor.Queue	4.12				
Waiting Room.Queue	0.02				

Hence this result would help the staff to compare with current process and to alter the ways of allocating time and resources for each processes as to make it better. And also by changing/editing the arrival time and service time in each station staff could observe and analyze the utilization of the resources in the department and could study as how the waiting time is reduced in each cases.

Further for the staff to aid in decision making a dashboard also been created using Arena visual designer. Figure below shows the Arena visual designer.



III. CITING PREVIOUS WORK

The waiting problem is considered as one of the indicators of quality assurance for the health care system in several papers [2]. Reference [3] 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 than they should. In addition, because many physicians are late, patients' waiting time increase even more.

Reference [4] 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 [5] 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.

IV. CONCLUSION

In this study, we have considered the problem of designing a simulation model for outpatient department of MediLand Hospital. This is simulated using ARENA. From the result obtained in the figures above, it is clear that the proposed and designed model gives a result which is better than the current clinic situation that is mentioned in the collected data table above.

This shows that the proposed improvement 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.

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