Delays And Waiting - A Challenge For Hospitals' Analysis Of Outpatient Service Using Queuing Model

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INTRODUCTION

Health care providers are under much pressure to cut costs and improve quality of services. In recent years, given the greater emphasis on preventive medicine and shorter lengths of stay, outpatient service is becoming an essential component of health care. Hospitals that cannot make their outpatient services more efficient and cost effective find themselves in financially unviable positions in this fast-growing competitive industry.

Over the years, population has increased by several folds and demand and expectations of patients from hospitals is far more than perceived. As a result, it has become a constant rat race to make the current systems faster. This brings about questions such as how do we measure such improvements.

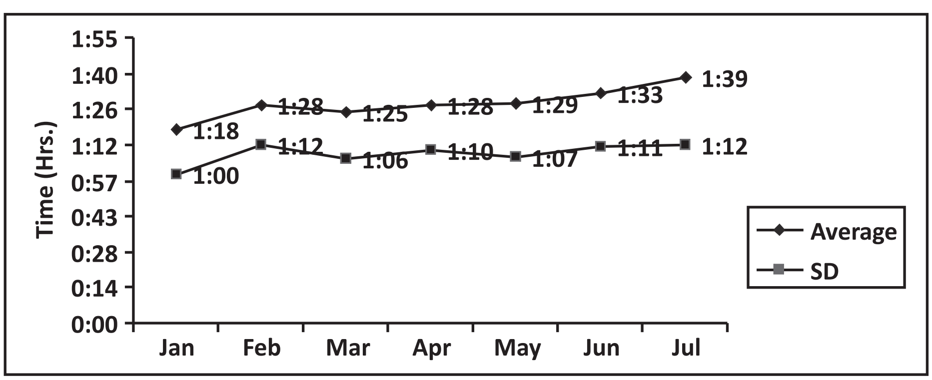
Waiting is a painful process and unnecessary waiting is much worse. Psychology of waiting suggests that such waiting adds pain to the physical ailment. An unwanted wait irritates and affects patient satisfaction. It is common for most of the hospitals to have complaints and suggestions on *"Waiting"*. Waiting also has implications on compromising the productive time which the patient had wastefully spent. Today, lot of research is taking place to make systems that provide critical life support to work faster. For example, the NHS has introduced performance specific targets such as treating 98 per cent of the patients who enter an accident and emergency service unit, within four hours (response time).

Now, the challenge is how to achieve such targets. The first option is increasing the number of doctors and paramedics and the speed of the equipments in Hospitals. This would be possible if one has unlimited resources but, since this is not feasible in most of the cases, we would have to look at alternatives. In essence, the hospital could vary their limited number of staffs at different departments according to the arrival rate and see what happens to the overall process time. However, this will prove to be time consuming and very expensive for the hospital and hence, is not feasible.

This motivated the researcher to find appropriate models that would help to simulate and predict the behaviour of an OPD.Various studies such as simulations, statistical modelling, etc. were conducted in this area with all of them broadly based on queuing theory. Since its inception by A.K Erlang in 1909, this has been the basis for modelling many different systems. If modeled accurately, such a model will not only give managers an insight into optimizing their resources, but will also show them which departments are bottlenecks.

Many hospitals have recognized the problem of waiting as one of their major challenges. This problem limits hospitals from serving the population who are mostly busy and want to spend their valuable time productively. This study was carried in an Eye Hospital, where it approximately takes about one hour and 30 minutes to serve a patient. (Refer Fig.1)

Figure 1: Process Time Of Patients From Jan- July 2006



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Poisson distribution is a discrete probability distribution. It expresses the probability of a number of events occurring in a fixed period of time if these events occur with a known average rate, and are independent of the time since the last event. The distribution was discovered by Siméon-Denis Poisson (17811840) and published, together with his probability theory, in 1838 in his work *"Research on the Probability of Judgments in Criminal and Civil Matters"*. The work focused on certain random variables *N* that count, among other things, a number of discrete occurrences (sometimes called *"arrivals"*) that take place during a time-interval of given length. The probability that there are exactly *k* occurrences (*k* being a non-negative integer, $k = 0, 1, 2, ...$) is

$$f(k; \lambda) = \frac{e^{-\lambda} \lambda^k}{k!^k},$$

Where

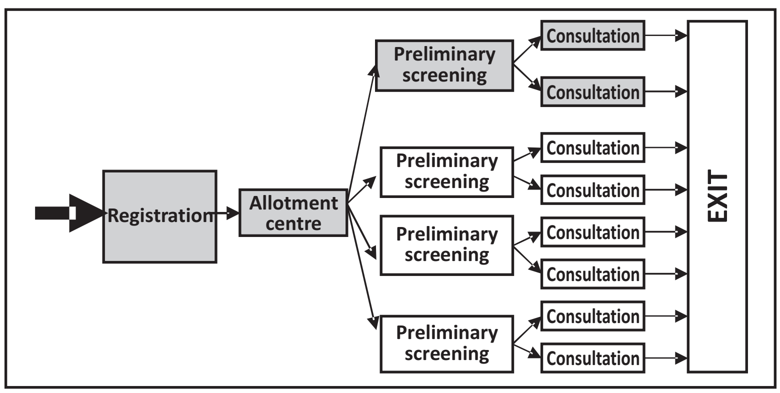
e is the base of the natural logarithm ($e = 2.71828...$),

λ is a positive real number, equal to the expected number of occurrences that occur during the given interval

METHOD

A study based on queueing principles was designed to know the arrival pattern of patients, the time took to provide the service (service rate), and the utilization of ophthalmologists, optometrists and other staff involved in the OPD. According to queuing principles, this OPD is a single channel- multiphase system with networks of such systems (Fig.2).

Figure 2: Process Model



We examined 1413 samples during this study. The response time was calculated from finding the difference between the entry and exit time. *"QM for Windows"* was used for data analysis.

BOTTLENECK ANALYSIS

A bottleneck is the node(s) in the queueing network that has the highest utilization. In other words, it is a place where patients' queue length builds-up. Hence, when performing a bottleneck analysis for the different activities (nodes), we are trying to find the utilization values for each node and ensure that this value never exceeds its capacity. If it does, then we will have to look at varying the parameters of this node, namely the service rate and the number of servers (staffs) and see the effect that this change has on the overall response time of the system.

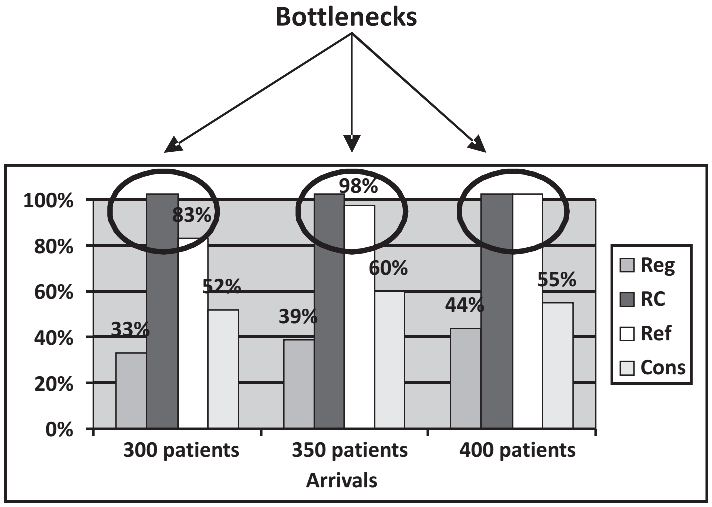
In this study, the bottleneck analysis reveals, where the system fails in ensuring quicker service. Figure 4 reveals that if more than 300 patients arrive to JEH OPD, queue starts building at the reception centre. In the refraction system, when the arrivals are 350 to 400, the system exceeds the service capabilities and the queue builds up.

Reception centre is the primary bottleneck, and Refraction closely follows that. This strengthens the argument that the congestion developed at these two areas affects the performance of subsequent systems and the system as a whole as well.

SOLUTION FOR BOTTLENECKS

A mathematical simulation allows us to plan the service point requirements without any trial and error methods.

Figure 3 : Server Utilization Values For Different Arrival Rates



(Reg-Registration, RC-Preliminary check-up, Ref- Refraction, Cons-Consultation)

Table 1 depicts that the reception centre system that was violating the steady state (beyond capacity) with one server was working at 50 per cent utlization level and with less waiting with two servers. Which means adding up more staff could solve the Reception centre bottleneck.

Table 1: Reception Centre With One And Two Servers

Parameter	Present system 1 staff	Proposed system 2 staff
	Value	Value
Average server utilization		50 %
Average number in the queue(Lq)	Steady	0.333
Average number in the system(Ls)	State	1.333
Average time in the queue(Wq)	Violation	0.333
Average time in the system(Ws)		1.333

Having a centralized preliminary screening area with pooled technicians is another practical solution, which increases the staff utilization with even less number of technicians.

Table 2: Centralized Preliminary Screening Area As A Solution

	1		2		3	
	Present System (Technicians at different places)		One common refraction (with same No. of technicians)		One common refraction (with reduced No. of technicians)	
No. of technicians	8		8		6	
Parameter	**Value**	**Minutes**	**Value**	**Minutes**	**Value**	**Minutes**
Average refraction server utilization	44%		48%		63%	
Average number of patients in the queue(Lq)	0.55		0.04		0.41	
Average patient in the Refraction chamber(Ls)	1.08		3.84		4.21	
Average time in the queue for refraction(Wq)	4.75	285	0.05	3	0.54	32
Average time in the Refraction chamber(Ws)	9.75	585	5.05	303	5.54	332

Table 2 explains how patients need to wait for lesser time comparing to the present system. Even with a reduced number of six technicians, a higher utilization of 63 per cent is achieved with reduced waiting time.

(Contd. On Page 30)

developing Neighborhood search heuristics to solve large size problems.

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DISCUSSIONS

☸ Since Reception centre is the primary bottleneck, increasing another server (personnel) would make it to work in a steady state.
☸ The possibility of clubbing functioning of the Reception centre with the registration centre may also be explored since this could cut down one additional node and a total process time of 10 minutes approximately would be required for each patient.
☸ However, it was evidently proved through the simulations that having a single refraction chamber with eight or even six technicians, the hospital could reduce waiting time up to 25 percent, as well as better utilize the resources.

CONCLUSION

Applying queuing models to healthcare processes helps to study variety of parameters like arrival rate, queue length, server utilization and so on. Each parameter could be individually altered to make the system produce high efficiency. Advanced simulations using simulators would help the administrators to see what happens when we change the resources in the system. Modelling can be applied in healthcare, in the areas wherever queue is involved such as rationing, scheduling, bed allocation, laboratory design, and so on.

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