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APPLICATION OF MULTI-SERVER QUEUING MODEL TO ANALYZETHE QUEUING SYSTEM OF OPD DURING COVOD-19 PANDEMIC: A CASE STUDY

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Abstract

The purpose of this research paper was to suggest the optimum service level of queuing system of reception and the outpatient department during COVID-19 pandemic. The data was collected from the reception and OPD of the ABC public hospital of Hyderabad. Data included, the arrival times, service times of patients and number of doctors and receptionist at the workplace, their salaries and waiting cost of patients. Input analysis of patients` arrivals and service was conducted by in input analyzer of Rockwell Arena software. TORA optimization software was used for the calculation of performance measures. Various costs of queuing system were calculated in MS Excel and the required graphs were also plotted. After the in-depth analysis, it was revealed that one receptionist and one doctor should be increased to bring optimality in the queuing system and patients` flow. After this decision, waiting cost of patients decreased to greater extent.

Keywords: Covid-19, multi-server queuing model, hospital, outpatient department (OPD), pandemic.

Introduction

Worries have been raised for the unpreparedness of current health system in response to an infectious disease pandemic (COVID-19), even in developed countries (Jen et al., 2021).

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Nowadays, the biggest dilemma of healthcare facilities is the over density of people at the outpatient department (OPD), its corresponding receptions, emergency departments (EDs) and intensive care units. Waiting line is normal happening in our everyday lives (Agyei, Asare-darko, & Odilon, 2015; Kembe, Onah, & Iorkegh, 2012; Mwangi & Ombuni, 2015; Obamiro, 2010; Winston, 2004; Yusuff, 2015) for example at the health care facilities. When the number of physicians is less than that of customers after that this scenario, produces the starting point of queue or waiting line. EDs and OPDs are one of the most gone to departments at any medical care center. It is likewise the extremely initial meeting of the customers and also the personnel of the hospital when they go to consult with the physician (Wang, Guinet, Belaidi, & Besombes, 2009). One of the most dealt with concern that the individuals deal with at the healthcare facilities is long waiting lines. Also several of patients die while waiting to be seen by the physician. Outpatient as well as emergency department play considerable role in the health care delivery systems (HCDS). In the past years, anxiety is put on the EDs in the established countries in the context of over-crowding as well as its effect on the solution distribution; thus, capacity of hospital to fulfill the need was focused appropriately (Haghighinejad et al., 2016). As a result of non-rigid assimilation between the client service and also different operating departments at any healthcare facility, capacity preparation of the certain department can be made complex in regards to fulfillment of service demand (Uriarte, Zuniga, Moris, & Ng, 2015).In operations research, there are number of tools and techniques in order to solve the daily life problems (Kalwar, Khan, & Malik, 2020).The sensible technique or approach to solve these sort of problems, queuing theory is just one of the recognized techniques (Olorunsola, Adeleke, & Ogunlade, 2014).

Queuing theory was formulated by the famous Danish telephone designer Agner Krarup Erlang in 1913 (Bastani, 2009), (Kissani & Rifai, 2015), (Adaora .D., 2013; Green, 2011; Mustafa & Nisa, 2015; Varma, 2016). Erlang was the initial researcher who resolved the problem of over-crowding at the telephone exchange (Mwangi & Ombuni, 2015). The crucial aspects in the queuing concept include: variety of individuals obtaining served, their service mechanism at the medical facility, their waiting times in the queue as well as in the system at the numerous degrees of service (Fitzsimmons, Fitzsimmons, & Bordoli, 2008). When the patients are asked or expected to wait at the healthcare center, the specific amount of cost is associated with that waiting which expense is described as waiting cost/opportunity expense (Kembe et al., 2012). Therefore, the individuals at the hospitals or in any type of setting need to be served in a fashion so that the possibility cost must be optimum. In order to address these kinds of troubles, queuing concept is the best alternative. In queuing concept, the waiting times, solution times, maximum service degree are determined concurrently (Varma, 2016). This theory is recognized for specifying the waiting lines 'phenomenon by the calculation of performance measures i.e. ordinary length of queue, typical waiting time in the queue and also the system and also ordinary utilization factor (Adaora .D., 2013).

Queuing models are utilized to study queue systematically (Bastani, 2009; Kandemir-Cavas & Cavas, 2007). Because of handling the chock-full scenarios, queuing concept is likewise called the theory of congestion (Adaora .D., 2013). It is commonly utilized in service organizations for waiting lines to be assessed as well as their procedures to be modeled (Olorunsola et al., 2014). Over the last few years it has actually been the teething worry in

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healthcare solutions (Kalwar, Khaskheli, Khan, Siddiqui, & Gopang, 2018; Kalwar, Marri, Khan, & Khaskheli, 2021; Kalwar, Mari, Memon, Tanwari, & Siddiqui, 2020; Khaskheli, Marri, Nebhwani, Khan, & Ahmed, 2020). It is called for to boost the client satisfaction by decreasing the queue as well as making service distribution reliable (Fomundam & Herrmann, 2007). Delay is the distinction between solution demand as well as the offered capability to fulfill the demand (Green, 2011). Long waiting experience of the people in the queue usually have unfavorable influence on the endorsement of the person (Obamiro, 2010). As a result of the lengthy queues doctors are put to stress as well as they try to get the people cost-free without in depth assessment, which results in frustration of consumers (Obamiro, 2010),(Felix Albert, 2007; Puoza & Hoggar, 2014; Yusuff, 2015). Which sustains expense to organizations, which is described as price of customer frustration (Agyei et al., 2015; Kembe et al., 2012). Poor health services are serving as challenges versus the overall development of Pakistan (Saima Mustafa, 2015). Hereof, the objective of this research paper was to analyze the performance of current queuing system as well as recommend the method to its maximum solution degree.

The present research is comprised of seven Introduction, literature review, research gap, problem statement, research objectives, research methodology, results and discussions, conclusion, future implications, limitations, acknowledgement, conflict of interests and references.

Literature Review

Public health care system in Pakistan is big as well as spread and is given up accessibility to individuals with qualified physicians, officers and medications; however there was the problem of absence medicines as well as doctors (Kalwar et al., 2021).. It was concluded in the research that these both issues was because of organizational restraints not as a result of economic restrictions (Callen et al., 2013). An empirical study carried out to reveal the issues encountered by the individuals in public health treatment hospitals. Study showed that 36.4% customers were poor who paid a visit to the healthcare facility, 41.8% sick people reported that officers is irritated towards the sick people; moreover, 72.7% participants had typical viewpoint that poor subjects are not well treated, whereas, 96.4% of individuals reported concerning the preference of physicians to relatives and recognized subjects (Ahmad et al., 2013). One more research was conducted on public market hospitals of Pakistan, and it was revealed that primarily poor individuals paid a visit to the public healthcare facility for their health and wellness issues as well as they faced number of troubles there in terms of treatment as well as adeptness. The picture of public health care service delivery stands for an also distribution of resources between city and non-urban region. The poor in the backwoods are at apparent drawback in the context of main and tertiary public health care facilities as well as they likewise fail to benefit from immunization of their kids from the general public programs (Afzal & Yusuf, 2013). Because of poor health services subjects specifically youngsters as well as females are experiencing a great deal. It be seen in the table 1 that the health and wellness indications are improperly reducing; after the period of two decades, baby death is lowered from 95/1000 lives to 60/1000 lives. Very same case is with the

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maternal death rate, it has reduced from 490 -260 lives per 100,000 lives. Children mortality under 5 years is decreased from 122-74 in two decades.

It was suggested in the research study that the Government must concentrate on healthcare in regards to appropriate clinical equipment and infrastructure preserve check and equilibrium, by doing this the troubles can be lowered (Naz, Daraz, Khan, Khan, & Hussain, 2012). The personnel for medical care are gradually enhancing in Pakistan year by year. As reported by International Finance Corporation (IFC) in its article of 2011 that, 5000 medical grads are produced by various universities and also universities. The present ratio of physician to person is 1:1,183, which is rather below than the conventional advised by World Health Organization (WHO) i.e. 1:1000 (Bergman, 2011). The requirement of medical personnel i.e. physicians almost complete; it is quite near to the standard recommended by World Wellness Organization. Now, dynamic leadership and administration is needed desperately for designing and enforcing evidence-based plans, programs and also the way to look after the system (Kumar & Bano, 2017). Besides, above stated troubles the subjects in the general public field hospitals deal with too many troubles and also delay is among those significant trouble. Subjects wait as well long to get served in hospitals, it's a prospective danger to healthcare services and is observed to an enhancing level (Obulor & B.O, 2016). Healthcare industry is encountering the trouble of hold-ups. All of us await an appointment relating to wellness problem at medical facilities and also after arrival at the adeptness we are supposed to wait a lot more to see the medical professional. Hold-up is not unusual in healthcare facilities, we constantly discover might people awaiting at various phases in the healthcare facilities i.e. patients waiting on surgery, Diagnostic examinations, OPDs, Emergencies and so on. (Green, 2006) mentioned that the hospitals are called complex systems which are included with some societal advantages and also bulk sustained expenses. Those expenses are made to be incurred much more as a result of inefficacies of procedures which take place due to overcrowding and delays in the patients` treatment systems. Literary works indicates that forecast of degree of over-crowding and also needed capability is impossible to be determined without the help of queuing versions (Green, 2006). For that reason, in order to examine as well as enhance patients circulation, it appropriates to consider the facility with the lens queuing network (Armony et al., 2015). Queuing models are needed to be put in a little information and outcomes can be calculated by the aid of basic formulae in regards to efficiency measures; this is a less complicated way to identify the optimum solutions instead of estimating the efficiency of the system in the provided context (Green, 2006). Queuing theory was established by popular Danish telephone engineer Agner Krarup Erlang in 1913 in order to figure out the capacity demands of the Danish telephone system (Green, 2006)(Bastani, 2009), (Kissani & Rifai, 2015), (Adaora .D., 2013; Green, 2011; Mustafa & Nisa, 2015; Varma, 2016). He was the first scientist in 20th century who dealt with the crowdedness problem in the context of telephone exchange (Mwangi &Ombuni, 2015). Jen el al. (2021) indicated that during COVID-19 pandemic, in the capacity of hospitalization, the congestion of isolation beds has increased by the early of April, but started to relieve in mid-April 2020. The similar trend on the demands for ICU was notably observed as well. In other countries, the same situation was seen in France, Spain, Belgium, and New York State (USA) but not for South Korea and Japan (Jen et al., 2021).

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Problem Statement

This study is based on the analysis of the queuing system of out-patient department (OPD) of public sector hospital of Hyderabad during COVID-19 pandemic. Patients have to wait before getting served. Due to the greater workload, doctors may not be able to examine all the patients properly. Patients and doctors both are under stress due to waiting for long in the OPD waiting area and heavier workloads respectively. It is required to evaluate the current queuing system in the OPD. On the same time the responses of the patients/customers will be taken so that the impact of long waiting lines on the satisfaction of patients can be measured.

Research Objectives

The aim of the present research was to improve the queuing system of the selected OPD at the case hospital and this aim was achieved by following objectives.

- To assess the current performance of the queuing system
- To suggest the way to optimum service level of the queuing system

Research Methodology

1.1 Data Collection

The data was collected from the reception and OPD of the ABC public hospital of Hyderabad. Data included, the arrival times, service times of patients and number of doctors and receptionist at the workplace, their salaries and waiting cost of patients.

1.1.1 Service Cost

Salaries per hour of the various doctors working at the OPD were collected as presented in the form of graph in figure 1. And after the calculation, it was indicated that the average salary per hour at the OPD was Rs.1046.36. Furthermore, average salary of receptionist was calculated as Rs.166.67 per hour.

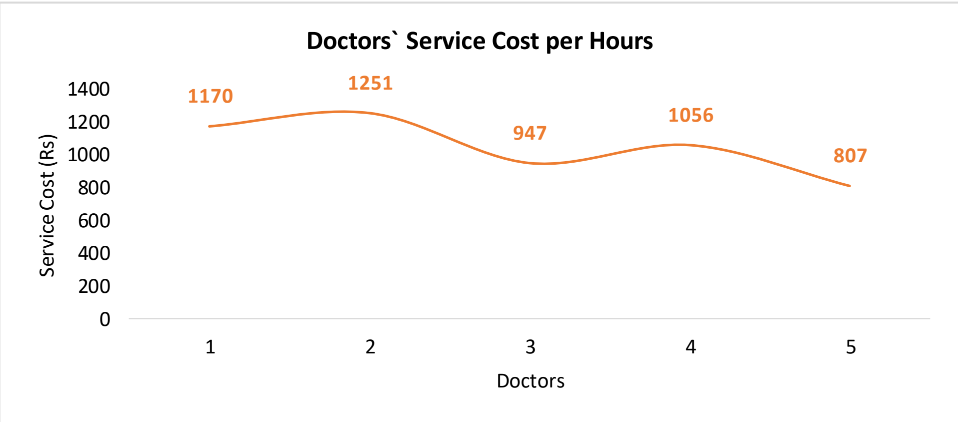

Figure 1. Doctors` service cost at the OPD of case hospital

1.1.2 Waiting Cost

The patients belong to 14 different occupations/professions. Their waiting cost was collected and calculated in MS Excel and it was plotted in bar chart as presented in figure 2. The average waiting cost of the arriving patients was computed as 227.98/hour.

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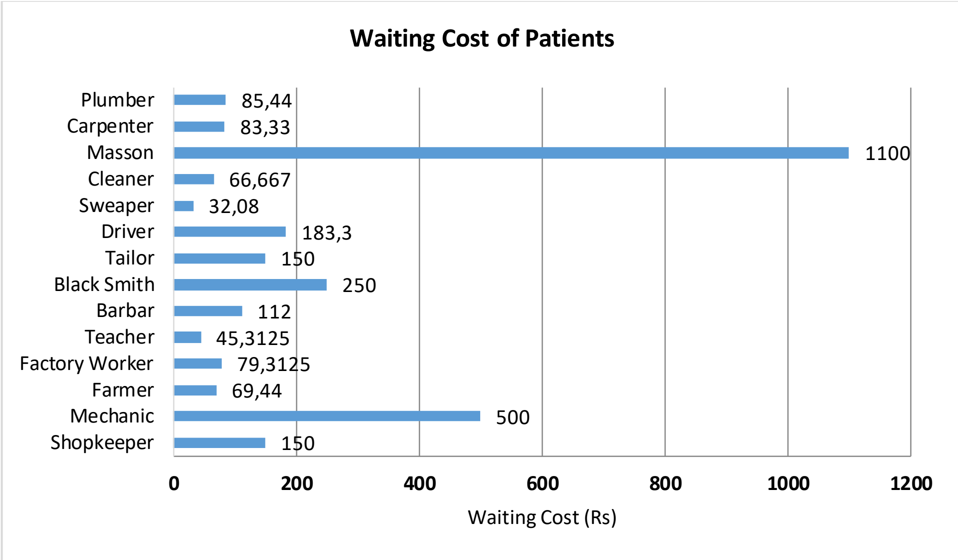

Figure 2. Waiting cost of patients arriving at civil hospital Hyderabad

1.2 Data Analysis

Input analysis of patients` arrivals and service was conducted by in input analyzer of Rockwell Arena software. TORA optimization software was used for the calculation of performance measures. Various costs of queuing system were calculated in MS Excel and the required graphs were also plotted.

1.2.1 Model Description and its Assumptions

When the number of patients exceeds the number of doctors then the queue is formed and multi-server queuing model is used in such situations to calculate the number of doctors to be appointed. Assumptions of multi-server queuing model are discussed below;

- The arrival of patients follows the poison distribution
- Patients` service follows the exponential distribution.
- All the doctors are assumed to work at the identical capacity

In the previously conducted research works, Agyei W., Asare-darko C. and Odilon F. 2015 also conducted the input analysis of the arrival and service distributions of patients. They also followed the same assumptions i.e. arrival and service of patients should be as per poison and exponential distribution respectively (Agyei et al., 2015). When Kabme et al. 2012 conducted their research at Riverside Hospital by applying the single phase multi-server queuing model, they also made sure of poison arrival and exponential service distributions (Kembe et al., 2012).

1.2.2 Arrival Distribution

According to the assumptions of the multi-server queuing model that arrival of patients should follow the poison distribution; in this regard, the input analysis of arrival of patients was conducted and it was indicated that arrival of patients followed the poison distribution (POIS (1.73)) as indicated by figure 3 and 4 respectively.

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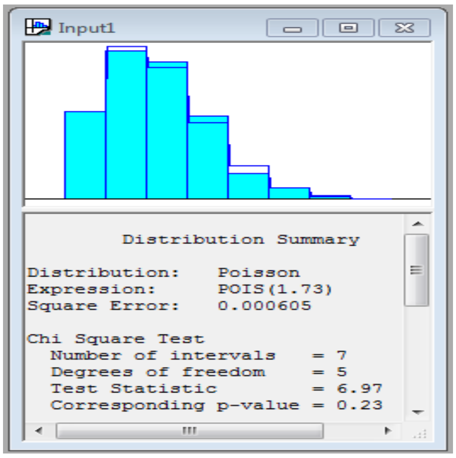
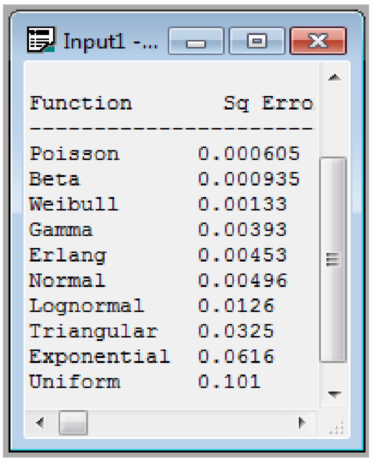


Figure 3. Distribution fit for the arrival of patient



Function	Sq Erro
Poisson	0.000605
Beta	0.000935
Weibull	0.00133
Gamma	0.00393
Erlang	0.00453
Normal	0.00496
Lognormal	0.0126
Triangular	0.0325
Exponential	0.0616
Uniform	0.101

Figure 4. Summaries of square error of various Applied distribution functions

1.2.3 Queue Discipline

First come first served (FCFS) was the followed queuing discipline at the queuing system.

1.2.4 Service Distribution

Patients were being served at two stages i.e. when the patients were getting themselves registered at the reception and when they go to see the doctor. The data for both stages was collected and its input analysis was also conducted.

1.2.4.1 Reception

Input analysis of the service of patients at the reception was conducted and it was revealed that it followed exponential distribution (EXPO (0.41)) as indicated by the figure 5 and 6.

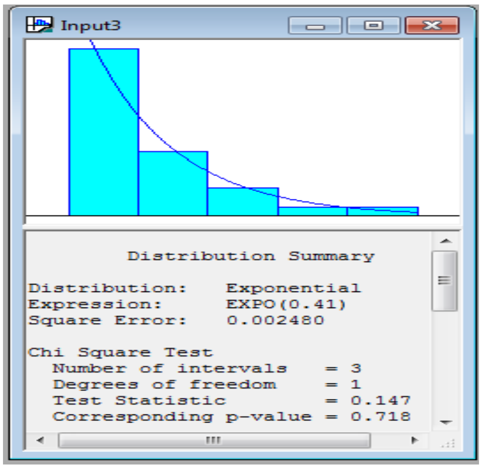
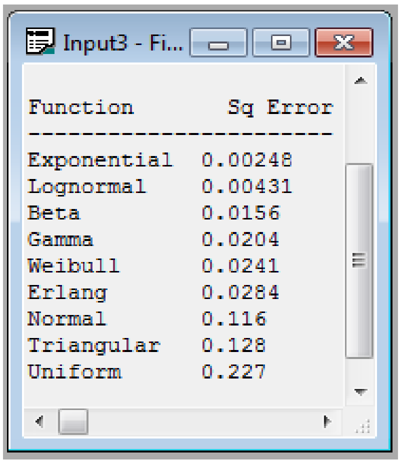


Figure 5. Distribution fit for the service of patients by the doctors



Function	Sq Error
Exponential	0.00248
Lognormal	0.00431
Beta	0.0156
Gamma	0.0204
Weibull	0.0241
Erlang	0.0284
Normal	0.116
Triangular	0.128
Uniform	0.227

Figure 6. Summaries of square error of various Applied distribution functions

1.2.4.2 Service Distribution of Doctors

Input analysis of the service of patients at the OPD was conducted and it was revealed that it followed exponential distribution (0.999+EXPO (3.01)) as indicated by the figure 7 and 8.

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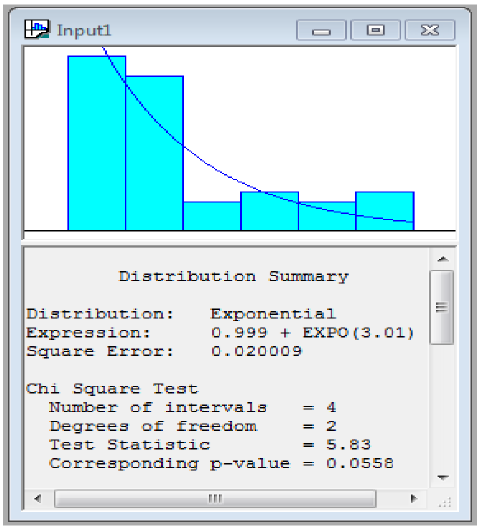

Figure 7. Distribution fit for the service of patients by the doctors

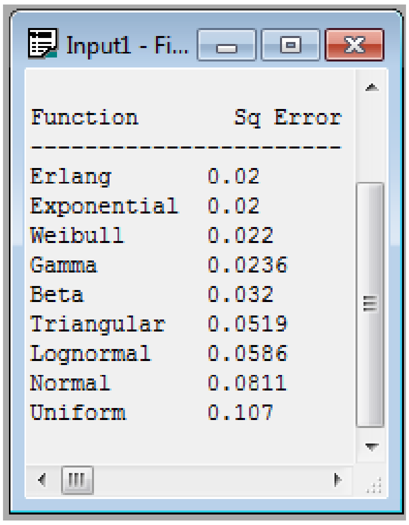

Figure 8. Summaries of square error for each Distribution fuction

1.2.5 Software

Three software applications were used in the present research paper at three different stages of the analysis. At the very first, MS excel was used for the data entry and calculation of average arrival and service rate. The entered data was then put into Rockwell Arena software for the input analysis of the data (arrival and service) so that the distribution of data could be revealed. In third step the data was then put into the TORA optimization software for the calculation of performance measures of multi-server queuing model. The performance measures were then put into MS Excel for the plotting the graphs and cost calculations as per formulae presented in 6.3.

1.3 Formulae and Equations

$$\text{Estimated Service Cost} = \textit{Number of Doctors} \times \text{Average } \textit{Salary of Doctors} \quad (1)$$

Estimated Waiting cost= (Number of Patients x Waiting Time) x Average Waiting cost of Patients (2)

Total System Cost = Estimated Waiting Cost + Estimated Service Cost (3)

1.4 Performance Measures of the Queuing System

Performance measures of the queuing system are presented in table 1 as adopted from Khaskheli S.A, 2018.

Table 1. Description of the performance measures of the queuing system as adopted from Khaskheli S.A. (Khaskheli, 2018) (p. 13)

Symbol	Definition
μ	**Service rate:** Number of patients served per unit time
λ	**Arrival rate:** Rate at which the patients are served at the facility

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S	**Number of servers**: Number of available service channels e.g. receptionists, nurses and doctors
n	Number of patients
P_o	**Probability of the system to remain idle:** This performance measure calculates the probability of the system that it gets free from the customers at the particular time period.
Lq	**Number of patients in the queue:** This performance measure calculates the number of awaiting patients customers/patients in the queues following doctors
Ls	**Number of the patients in the system:** This performance measure calculates the 'number of patients in the queue + number patients currently served by the doctor'
Wq	**Time spent by patient in the queue:** This performance measure calculates the amount of time the patient wait in the queue in order to see the doctor
Ws	**Time spent by the patients in the system:** This performance measure is the sum of 'waiting time of patients in the queue + service time of patients by the server'

Table 2. Description of the performance measures of the queuing system as adopted from Khaskheli S.A. (Khaskheli, 2018) (p. 13)

Symbol	Definition
μ	**Service rate:** Number of patients served per unit time
λ	**Arrival rate:** Rate at which the patients are served at the facility
S	**Number of servers**: Number of available service channels e.g. receptionists, nurses and doctors
n	Number of patients
P_o	**Probability of the system to remain idle:** This performance measure calculates the probability of the system that it gets free from the customers at the particular time period.
Lq	**Number of patients in the queue:** This performance measure calculates the number of awaiting patients customers/patients in the queues following doctors
Ls	**Number of the patients in the system:** This performance measure calculates

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	the 'number of patients in the queue + number patients currently served by the doctor'
Wq	**Time spent by patient in the queue:** This performance measure calculates the amount of time the patient wait in the queue in order to see the doctor
Ws	**Time spent by the patients in the system:** This performance measure is the sum of 'waiting time of patients in the queue + service time of patients by the server'

Result and Discussions

Result was presented in two sections i.e. performance measures of queuing systems of reception and OPD. Moreover, the costs of the queuing system i.e. service cost, waiting cost and total system cost. In last the costs, utilization factor and probability of 0 patients in the system were plotted in line charts.

1.5 Performance measures of the queuing system of Reception

Good health of the people is essential in order to develop and improve the economic state of country (Kalwar et al., 2021). The top most objective of healthcare services is to improve the health of population (Latha Lavanya & Ahmed, 2015). Health care delivery system (HCDS) is the response of society to those activities and practices which determine health (Kalwar et al., 2021). HCDS is the integration of people, agencies, organizations and numerous resources by the help of which it renders its services to the public (Kumar & Bano, 2017), (Musgrove et al., 2000). Number of frameworks are available which are used for the analysis of patients flow at the emergency departments; they are also used for the calculation of variables i.e. patients waiting times and service times; moreover, they also provide numerous other tools to analyze the factors having influence on the mentioned variables (Connelly & Bair, 2004). Among those frameworks, queuing theory is a famous concept to deal with solution of waiting line problems. Small piece of data is needed to be entered in queuing models and they gives their output in the form of performance measures and in the calculated result one optimal solution exist (Green, 2006). It was estimated the process of patient flow from the confirmation of COVID-19 to the discharge from hospitals or death, and further developed two indices for the congestion of isolation wards and ICU beds in hospitals in response to the surge of patients in critical condition due to COVID-19 (Jen et al., 2021).
After putting the average arrival rate (lambda), service rate (Mu) and number of receptionists (c), performance measures as shown in figure 9 were calculated by TORA optimization software. The performance measures were calculated in five different scenarios. In existing scenario, the probability of reception to have zero patients (p0) was calculated to be 0.0471(4.71%); there were 20.20 patients at the reception (Ls); 19.24 patients were in the reception queue (Lq); total was time taken by a patient in the system (Ws) and in the queue (Wq) were calculated to be 0.20 hours and 0.19 hours respectively as indicated by the figure 9.

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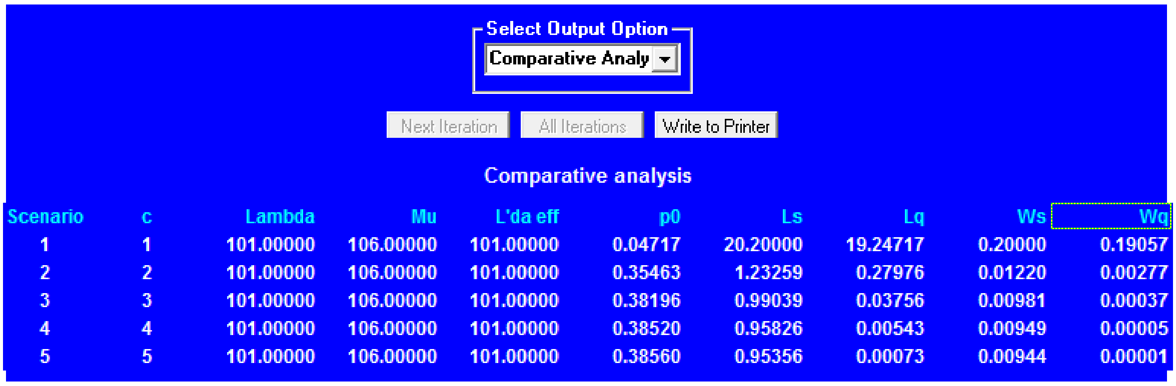

Scenario	c	Lambda	Mu	L'da eff	p0	Ls	Lq	Ws	Wq
1	1	101.00000	106.00000	101.00000	0.04717	20.20000	19.24717	0.20000	0.19057
2	2	101.00000	106.00000	101.00000	0.35463	1.23259	0.27976	0.01220	0.00277
3	3	101.00000	106.00000	101.00000	0.38196	0.99039	0.03756	0.00981	0.00037
4	4	101.00000	106.00000	101.00000	0.38520	0.95826	0.00543	0.00949	0.00005
5	5	101.00000	106.00000	101.00000	0.38560	0.95356	0.00073	0.00944	0.00001

Figure 9. calculation of performance measures of the reception of OPD of case hospital

In the second scenario, after addition of one receptionist at the workplace, the probability of the reception to have zero patients was 34.4% (see figure 9 and 10); utilization factor came down from 95% to 48% as indicated by figure 10; number of patients at the reception queue and overall reception were computed as 0.27 and 1.29 patients respectively.

Delay is the difference between available capacity and the service demand (Green, 2011). At any hospital, after waiting too long, the patients get dissatisfied with the healthcare service provider (Obamiro, 2010). In this regard, it should be ensured by the hospital management for patients not be waiting too long at the waiting areas or OPDs (Latha Lavanya & Ahmed, 2015).

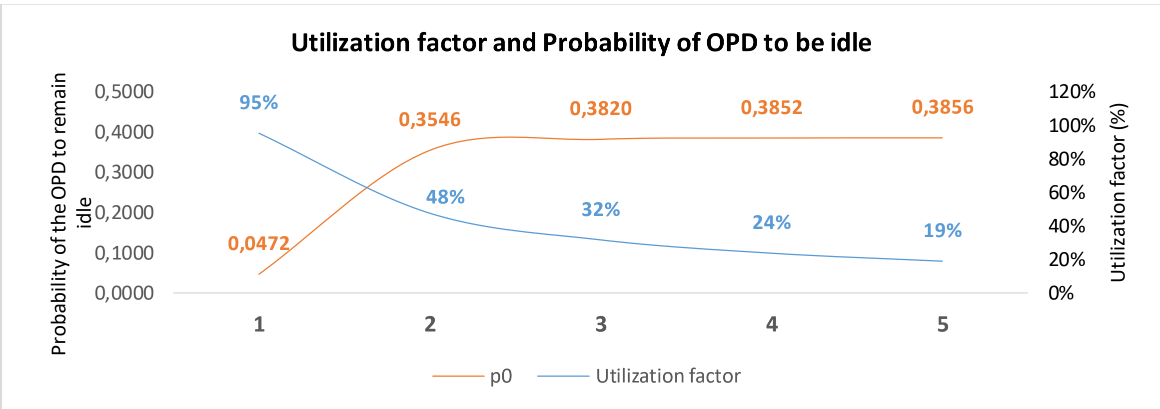

Figure 10. Utilization factor and the probability of the reception to remain idle

Moreover, time spent by the patients in the queue of reception and overall reception procedure was calculated to be 0.012 hours and 0.0027 hours respectively as shown in the figure 9.

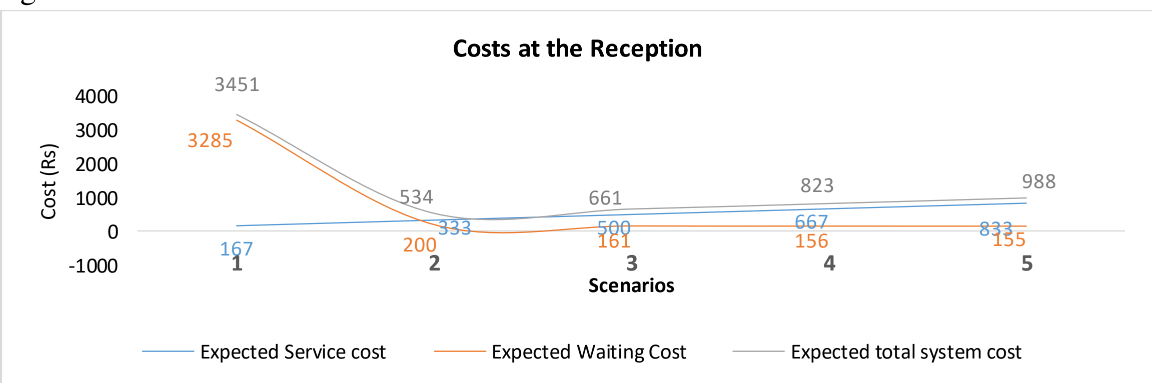

Figure 11. Costs of the queuing system of the reception

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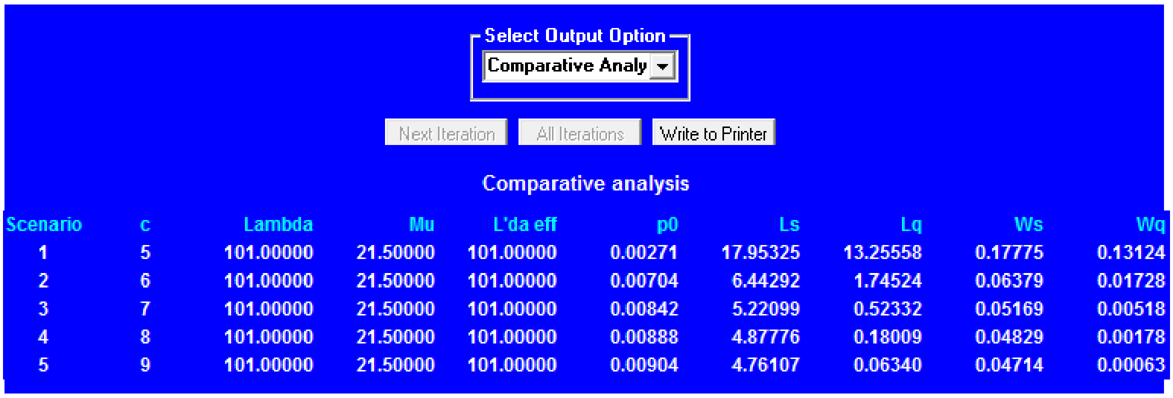
Figure 11 presents the costs (service cost, waiting cost and total system cost) in the various scenarios of analysis. In first scenario, the expected service cost, waiting cost and total system cost were calculated as Rs.167, Rs.3285 and Rs.3451 respectively (see figure 11). In the second scenario, the service cost increases and waiting cost and total system cost decrease and in third scenario, service cost increases with waiting cost and total system cost. In this case, the point where total cost increases after decrease was considered as the point of decision to hire one more receptionist.

The same model was used by Kembe et al., 2012 at the Riverside hospital; when they conducted their research, there were 10 doctors; they collected data and calculated performance measures of the targeted queuing system by using TORA optimization software. After the detailed evaluation, it was suggested to increase doctors from 10 to 12; by this the very suggestion, utilization factor of the system was reduced from 86.6% to 72.2%, patients waiting time in the system and queue also significantly decreased from 0.238 hours to 0.178 hours; moreover, the probability of the system to have zero customers was increased from 1.2% to 1.6% (Kembe et al., 2012).

1.6 Performance measures of the queuing system of OPD

When average arrival rate (lambda), service rate (Mu) and number of doctors (c) were put in TORA optimization software, performance measures as shown in figure 12 were calculated. The performance measures were calculated in five different scenarios. In existing scenario, the probability of OPD to have zero patients (p0) was calculated to be 0.0271(2.71%); there were 17.95 patients at the OPD (Ls); 13.25 patients were in the OPD queue (Lq); total was time taken by a patient in the system (Ws) and in the queue (Wq) were calculated to be 0.177 hours and 0.131 hours respectively as indicated by the figure 12.



Scenario	c	Lambda	Mu	L'da eff	p0	Ls	Lq	Ws	Wq
1	5	101.00000	21.50000	101.00000	0.00271	17.95325	13.25558	0.17775	0.13124
2	6	101.00000	21.50000	101.00000	0.00704	6.44292	1.74524	0.06379	0.01728
3	7	101.00000	21.50000	101.00000	0.00842	5.22099	0.52332	0.05169	0.00518
4	8	101.00000	21.50000	101.00000	0.00888	4.87776	0.18009	0.04829	0.00178
5	9	101.00000	21.50000	101.00000	0.00904	4.76107	0.06340	0.04714	0.00063

Figure 12. calculation of performance measures of the OPD of case hospital

In the second scenario, after addition of one receptionist at the workplace, the probability of the OPD to have zero patients was 34.4% (see figure 12 and 13); utilization factor came down from 94% to 78% as indicated by figure 13; number of patients at the OPD queue and overall OPD were computed as 1.745 and 6.44 patients respectively.

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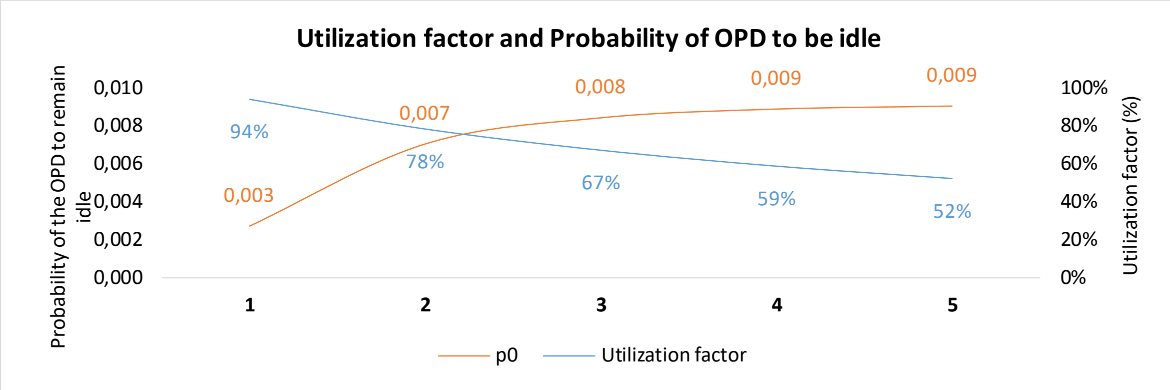

Figure 13. Utilization factor and the probability of the OPD to remain idle

Moreover, time spent by the patients in the queue of OPD and overall OPD procedure was calculated to be 0.017 hours and 0.063 hours respectively as shown in the figure 12.

Kyoung W. C. et al. 2017 analyzed the variation in waiting times of patients prior and after the implementation of electronic medical record (EMR) system. They used queuing theory concepts for the calculation of patients` waiting times. After the implementation of EMR, they found that the patients` waiting times at the targeted public hospitals decrease within the range of 44%-78% (Cho, Kim, Chae, & Song, 2017).

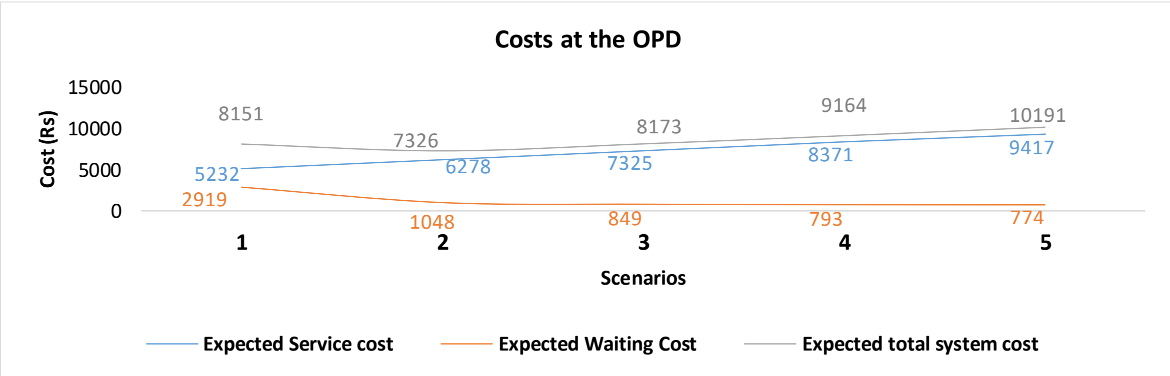

Figure 14. Costs of the queuing system of the OPD

Figure 14 presents the costs (service cost, waiting cost and total system cost) in the various scenarios of analysis. In first scenario, the expected service cost, waiting cost and total system cost were calculated as Rs.5232, Rs.2919 and Rs.8151 respectively (see figure 14). In the second scenario, the service cost increases and waiting cost and total system cost decrease and in third scenario, service cost increases with waiting cost and total system cost. In this case, the point where total cost increases after decreasing was considered as point of decision to hire one more doctor at the OPD.

In the way, Agyei W., Asare-darko C. and Odilon F. 2015 also applied multi-server queuing model to improve the queuing system of Ghana commercial bank, Kumasi. After the necessary calculations and analysis, they came to the conclusion that 5 teller points should be installed at the facility to minimize the congestion at the study area. The customers` waiting time after the implementation of suggested point, was reduced by 98.78% in the queue and by 87.85% in the system. Moreover, the total cost also decreased from GH¢1010.90 to GH¢631.69 (Agyei et al., 2015). Kembe et al. 2012 also applied the same queuing model and after the suggested implementation the total cost decreased from N14,509.08 to N13,174.84 (Kembe et al., 2012).

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Conclusion

Pakistani public health care system assisted in with the numerous facilities and sources which are absolutely not enough and the readily available centers and resources go to the point of mismanagement. This is the factor people arriving at public field health centers encounter a lot of troubles. Delay is just one of the major troubles, a few of the people pass away waiting for their turn of service. Solution is delayed when the service demand is greater than the available capacity. When there is low capacity in comparison to the demand after that the queue will certainly form in the system. For the analysis and research study of queues, queuing theory is used. It is the mathematical tool to resolve the troubles of queuing systems. The maximum options are found out by the aid of queuing theory in the form of performance measures. In the present research, after the analysis of the performance measures of the reception as well as OPD, it was disclosed that a person assistant and one doctor must be enhanced to bring optimality in the queuing system as well as people 'flow. After this decision, waiting cost of people lowered to greater level.

Future Implications

It was suggested that this research can be extended by adding the time spent by the patients in the way to hospital so that the time cost can be measured in all means. This research was only conducted on the medical OPD; it can also be conducted in all the OPDs of hospital in order to bring the improvement in public sector hospitals. The seasonal analysis of queuing system of the corresponding OPD can also be conducted.

Limitations

The scope of the present research was limited to only one OPD due to shortage of time, this research can be conducted in broader scope.

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Conflict Of Interest

There was no conflict of interest among the authors of the present research paper.

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