ORIGINAL RESEARCH ARTICLE
pISSN09763325 | eISSN22296816
Open Access Article (CC BY-SA)
www.njcmindia.com
DOI: 10.55489/njcm.130920222161

Queuing Dynamics and Beneficiary Satisfaction in The OPD of a Tertiary Care Centre in Bankura, West Bengal

Atanu Biswas[1], Tapas K Karmahapatra[2], Surya Prakash Dey[3]

[1]Bankura Sammilani Medical College, Bankura, West Bengal, India
[2]Bankura Sammilani Medical College, Bankura, West Bengal, India
[3]Bankura Sammilani Medical College, Bankura, West Bengal, India

ABSTRACT

Context/Background: Queuing, a major problem faced by beneficiaries availing services in public health care system, may also have influence on the level of satisfaction among beneficiaries. **Aims/Objectives:** To describe the queuing dynamics in the OPD, to explore different factors influencing the level of satisfaction among the beneficiaries and their perception regarding possible ways to improve the queuing situation.

Methodology: A hospital-based analytical study was conducted in an OPD of Bankura Sammilani Medical College and Hospital, West Bengal, among 202 beneficiaries. Data were collected from subjects, selected from random queue in total 30 shifts (30 minutes each) on different working days, using predesigned, pretested, questionnaire.

Results: Queuing dynamics revealed utilization factor of 75%, while 25% probability of the system being idle. Only 39.1% of the subjects were satisfied with the service in Paediatric OPD, in context of waiting in queue. MLR revealed subjects waiting in queue for a duration ≤ 1 hour and those with > 4 minutes consultation time were found to be more satisfied.

Conclusions: Considering variable consultation time, arrival and service rates at the OPDs and resources, a well-planned system can minimize the waiting time and thus improve the level of satisfaction among the beneficiaries.

Key-words: Queuing theory; Waiting time; Outpatient department; Patient satisfaction

INTRODUCTION

One of the most unpleasant experiences that majority of the patients/beneficiaries deal with, while availing health care services, is 'waiting' or 'queuing'. This includes waiting in line for attending a doctor, undergoing investigations, receiving treatment or therapy, or even procuring medicines. The delay in health care services is unpredictable and often occurs due to mismatch between the demand of services and the capacity available to address the demand.[1] Prolong waiting in queue not only causes wastage of precious time, but can also lead to frustration and displeasure among the patients and the people accompanying them. Patients who have to wait for a long time before consultation, often leave the healthcare facility without being consulted, and are very likely to never return to the same facility to avail any service.[2] This is very common in public health care system, especially in tertiary care centres like medical colleges and hospitals, which serve an enormous number of beneficiaries without any defined geographical boundary.

Queuing theory deals with problems that involve waiting or queuing. It is often described as the mathematical approach to analysis of waiting line (or queue) in a system.[3] In 1917, the concept and framework of queuing theory was first introduced by Agner Krarup Erlang, in his published article titled

How to cite this article: Biswas A, Karmahapatra TK, Dey SP. Queuing Dynamics and Beneficiary Satisfaction in The OPD of a Tertiary Care Centre in Bankura, West Bengal. Natl J Community Med 2022;13(9):612-618. DOI: 10.55489/njcm.130920222161

Financial Support: None declared | **Conflict of Interest:** None declared | **Date of Submission**: 10-06-2022 | **Date of Acceptance**: 03-08-2022 | **Date of Publication**: 30-09-2022

Correspondence: Dr. Atanu Biswas (Email: atanunbmc@gmail.com)

'Solution of Some Problems in the Theory of Probabilities of Significance in Automatic Telephone Exchanges'.[4] In queuing theory, customers (client, beneficiaries, patients etc.) arrive to the system (bank, office, hospital etc.) wait in queue to receive service from stations known as 'servers'. Based on the number of queues and servers, some of the common queuing models are: single server-single queue, multiple (parallel) servers-single queue, multiple (parallel) servers-multiple (parallel) queues, multiple servers in series etc.[5]

Bankura Sammilani Medical College and Hospital (BSMCH) is one of the oldest and busiest tertiary level health care centres in the state of West Bengal, India. It provides services not only to the population of Bankura district, but also to many coming from the neighbour districts. People of all socioeconomic status, especially those who are poor and deprived, attend the busy outpatient departments (OPDs) or the Emergency Room (ER) daily for the management of their ailments. It is the goal of the institute to provide smooth, uninterrupted, quality preventive, promotive, curative and rehabilitative services to each and every person attending the hospital. With this background, we had conducted our study with the objective to understand the queuing dynamics in the OPD of our hospital, to assess the level of satisfaction among the beneficiaries and their perception regarding possible the ways to improve the queuing situation.

METHODOLOGY

A hospital-based observational, analytical study (cross-sectional in design) was conducted in the outpatient department (OPD) of Paediatric, Bankura Sammilani Medical College and Hospital, Bankura, West Bengal. The Paediatric OPD was chosen based on random selection, as the site of our study. Each child attending the OPD, along with his/her attendant, was considered as a single unit of study subject. Subjects attending the Paediatric OPD during the data collection period were included as study population, while those, who were unwilling to take part in the study were excluded from the interview. A predesigned, pretested, structured interviewer administered questionnaire was used for data collection.

After getting clearance from the Institutional Ethics Committee, Bankura Sammilani Medical College and Hospital, Bankura, the Paediatric OPD was visited on scheduled working days and time in the OPD period for consecutive weeks between last week of July and third week of August, 2021. Data were collected on eleven different days (one Monday, two Tuesdays, two Wednesdays, four Thursdays, one Friday and one Saturday). Every day, data were collected on three different shifts (1st shift = 10.00 am – 10.30 am, 2nd shift = 11.30 am – 12.00 pm, 3rd shift = 1.00 pm – 1.30 pm) except one 2nd Shift was missed on one Thursday and two 3rd shifts were missed on two Thursdays. So, a total of thirty shifts were attended (eleven 1st shifts, ten 2nd shifts, nine 3rd shifts) for data collection. A random queue in a random Paediatric OPD room was selected every day on each shift for data collection.

Patients were asked to give a score from 1 to 5 (1 being very dissatisfied and 5 being very satisfied) on how much satisfied they wre with the service provided in the respective OPD, in context of waiting in line. The median of the responses wes taken as the cut-off value. The level of satisfaction was converted in to a dichotomous categorical variable for the purpose of analysis: 'satisfactory' for the subjects with score above the median value and 'unsatisfactory' for the subjects with score of median value or lower.

Data were entered in Microsoft Excel Spreadsheet and were checked for completion, duplication or validity. Quantitative data were expressed in mean, standard deviation (SD), while categorical data were expressed in frequency and percentage. Binary logistic regression and multiple logistic regression were used to assess the association of different sociodemographic and service-related factors with level of satisfaction among the subjects.

The following parameters were estimated for exploring the queuing dynamics of the Paediatric OPD[6,7]:

a) *Arrival rate (λ) = Average number of subjects arriving per unit of time*
b) *Service rate (μ) = Average number of subjects being served per unit of time*
c) *Utilization factor (ρ) = λ/μ = Traffic intensity*
d) *Average queue length (L_q) = $\lambda^2/\mu(\mu-\lambda)$ = Average number of customers waiting in the queue*
e) *Average number of customers in system (L_s) = $\lambda/(\mu-\lambda)$ = Average number of subjects waiting in the system (both in queue and in the service)*
f) *Average waiting time of a customer in queue (W_q) = $\lambda/\mu(\mu-\lambda)$ = Expected waiting time in the queue*
g) *Average waiting time of a customer in system (W_s) = $1/(\mu-\lambda)$ = Expected waiting time in the system (both in queue and in service)*
h) *Average waiting time of a customer in queue (W_q) = $\lambda/\mu(\mu-\lambda)$ = Expected waiting time in the queue*

In terms of arrival rate and service rate, the status of queue can be interpreted as follows:

$\lambda / \mu > 1$, the queue is growing without end
$\lambda / \mu < 1$, length of queue is decreasing
$\lambda / \mu = 1$, queue length remains constant

For application of Queueing theory, service rate should be more than arrival rate (i.e. $\mu > \lambda$)

RESULTS

In Table 1. the number of subjects arriving and getting served in different shifts across the six days of the weeks have been shown. Shift-wise breakdown

of the table shows that queuing theory is applicable for shift 3 only.

For 1st shift (10.00 A.M. - 10.30 A.M.): Total patients served = 73, Total patients in queue = 105; service rate < arrival rate, so queuing theory not applicable.

For 2nd shift (11.30 A.M. - 12.00 P.M.): Total patients served = 70, Total patients in queue = 84; service rate < arrival rate, so queuing theory not applicable.

For 3rd shift (1.00 P.M. - 1.30 P.M.): Total patients served = 59, Total patients in queue = 44; arrival rate < service rate, so queuing theory is applicable.

But, overall, queuing theory is not applicable as total patients arrived (233) in the queue within the specified time period of data collection was more than the patients served (202) during that period (service rate is < arrival rate).

Table 1: Day and shift wise distribution of subjects arriving at or receiving service from the Paediatric OPD*

Day of visit	Shift 1 (10.00 am – 10.30 am)		Shift 2 (11.30 am – 12.00 pm)		Shift 3 (1.00 pm – 1.30 pm)	
	Arrived	Served	Arrived	Served	Arrived	Served
Monday	10	8	10	10	6	9
Tuesday	20	12	20	14	13	15
Wednesday	16	13	16	14	10	11
Thursday	38	26	16	18	5	11
Friday	10	6	10	6	4	6
Saturday	11	8	12	8	6	7
Total	105	73	84	70	44	59

*Frequencies in the cells denote all the subjects arriving to join the queue and being served

Table 2: Queuing dynamics in 3rd shift (1.00 pm – 1.30 pm)

Parameters	Estimate
Arrival rate (λ)	9.78 patients/hour
Service rate (μ)	13.11 patients/hour
Utilization factor or traffic intensity (ρ)	0.75 = 75% (approx.)
Average queue length (L_q)	2.19 patients
Average number of customers in system (L_s)	2.93 patients
Average waiting time of a customer in queue (W_q)	3 minutes (approx.)
Average waiting time of a customer in system (W_s)	4 minutes (approx.)
Probability that the queuing system is idle (P_0)	0.25 = 25% (approx.)

Table 3: Sociodemographic profile of the study subjects (N=202)

Variables	Subjects (%)
Age of the children/beneficiaries	
< 5 years	174 (86.1)
≥5 years	28 (13.9)
Gender of the children	
Male	122 (60.4)
Female	89 (39.6)
Relationship of the accompanying person	
Mother	149 (73.8)
Father	51 (25.2)
Grand mother	2 (1)
Religion of the children	
Hindu	163 (80.7)
Muslim	39 (19.3)
Caste of the children	
General	53 (26.2)
Scheduled Caste (SC)	58 (28.7)
Scheduled Tribe (ST)	66 (32.7)
Other backward class (OBC)	25 (12.4)
Education of the accompanying person	
Illiterate	33 (16.3)
Class I – X	116 (57.4)
Class XI – XII	30 (14.9)
Graduation or above	23 (11.4)
Socioeconomic status (B G Prasad SES scale)	
I	3 (1.5)
II	8 (4)
III	5 (2.5)
IV	78 (38.6)
V	108 (53.5)

Table 4: Distribution of subjects according to factor related to services (N=202)

Variables	Subjects (%)
Distance travelled to avail service	
≤20 Km	72 (35.6)
> 20 Km.	130 (64.4)
Waiting time in queue to avail service	
≤ 1 hour	91 (45)
> 1 hour	111 (55)
Time spent with doctor while availing service	
≤ 4 minutes	105 (52)
> 4 minutes	97 (48)
Day of availing service	
Monday	27 (13.4)
Tuesday	41 (20.3)
Wednesday	38 (18.8)
Thursday	45 (22.3)
Friday	28 (13.9)
Saturday	23 (11.4)
Time of availing service	
Shift 1 (10.00 – 10.30 am)	73 (36.1)
Shift 2 (11.30 am – 12.00 pm)	70 (34.7)
Shift 3 (1.00 – 1.30 pm)	59 (29.2)

It is to be mentioned that the highest number of subjects queuing on Thursday, despite missing three different shifts, can probably be explained by the fact that a total of four Thursdays were considered for data collection.

Table 5: Association between sociodemographic factors and levels of satisfaction among respondents (N=202)

Sociodemographic factors	Level of satisfaction		Unadjusted OR	95% CI		P value
	Unsatisfactory	Satisfactory		Lower	Upper	
Age group of children						
< 5 years	105 (60.3%)	69 (39.7%)	REF			
≥5 years	18 (64.3%)	10 (35.7%)	0.845	0.368	1.94	0.692
Gender of children						
Male	73 (59.8%)	49 (40.2%)	1.119	0.627	1.997	0.704
Female	50 (62.5%)	30 (37.5%)	REF			
Religion						
Hindu	96 (58.9%)	67 (41.1%)	REF			
Muslim	27 (69.2%)	12 (30.8%)	0.637	0.301	1.346	0.237
Age of the accompanying person						
< 25 years	59 (56.7%)	45 (43.3%)	REF			
≥ 25 years	64 (65.3%)	34 (34.7%)	0.697	0.394	1.23	0.213
Gender of the accompanying person						
Male	30 (58.8%)	21 (41.2%)	REF			
Female	93 (61.6%)	58 (38.4%)	0.891	0.467	1.701	0.726
Level of education of the accompanying person						
Up to class XII	105 (58.7%)	74 (41.3%)	2.537	0.902	7.139	0.078
Graduation and above	18 (78.3%)	5 (21.7%)	REF			
Socioeconomic status						
Class I – IV	52 (55.3%)	42 (44.7%)	REF			
Class V	71 (65.7%)	37 (34.3%)	0.645	0.365	1.139	0.131

Table 6: Association between service-related factors and levels of satisfaction among respondents (N=202)

Service-related factors	Level of satisfaction		Unadjusted OR	95% CI		P value
	Unsatisfactory	Satisfactory		Lower	Upper	
Day of OPD visit						
Mon – Thurs	97 (64.2%)	54 (35.8%)	REF			
Fri – Sat	26 (51.0%)	25 (49.0%)	1.727	0.909	3.282	0.095
Shift						
1	43 (58.9%)	30 (41.1%)	1.262	0.622	2.563	0.519
2	42 (60.0%)	28 (40.0%)	1.206	0.59	2.469	0.608
3	38 (64.4%)	21 (35.6%)	REF			
Distance travelled to avail service						
≤ 20 Km.	38 (52.8%)	34 (47.2%)	1.69	0.94	3.04	0.08
> 20 Km.	85 (65.4%)	45 (34.6%)	REF			
Waiting time in queue						
≤ 1 hour	37 (40.7%)	54 (59.3%)	5.021			
> 1 hour	86 (77.5%)	25 (22.5%)	REF	2.725	9.249	<0.001*
Duration of service availed						
≤ 4 minutes	78 (74.3%)	27 (25.7%)	REF			
> 4 minutes	45 (46.4%)	52 (53.6%)	3.338	1.846	6.036	<0.001*

* Statistically significant

Table 7: Multiple logistic regression showing association between different factors and levels of satisfaction among respondents (N=202)

Service-related factors	Adjusted OR	95% CI		P value
		Lower	Upper	
Level of education of the accompanying person				
Up to class XII	2.572	0.843	7.845	0.097
Graduation and above	REF			
Day of OPD visit				
Mon – Thurs	1.307	0.638	2.679	0.465
Fri – Sat	REF			
Distance travelled to avail service				
≤ 20 Km.	1.106	0.571	2.145	0.765
> 20 Km.	REF			
Waiting time in queue				
≤ 1 hour	3.239	1.587	6.611	0.001*
> 1 hour	REF			
Duration of service availed				
≤ 4 minutes	REF			
> 4 minutes	2.086	1.041	4.18	0.038*

* Statistically significant

Table 8: Distribution of respondents according to their suggestion (most suitable) to fasten service (N=202)

Suggestions	Frequency (%)
More doctors to be placed at OPD	52 (25.8)
Service to be started on time	12 (5.9)
To follow 'first come first serve' basis for providing service	58 (28.7)
No change needed	80 (39.6)

The queuing dynamics in 3rd shift, as given in Table 2, reveals arrival rate of 9.78 patients/hour, service rate of 13.11 patients/hour. Utilization factor was about 75%, while the probability of the system being idle being about 25%. Average queue length was 2.19 patients, average number of customers in system (considering both in queue and in service) was 2.93 patients. Average waiting time of a customer in queue was approximately 3 minutes, and average waiting time of a customer in system (in queue or in service) was approximately 4 minutes.

The sociodemographic profile of the subjects in Table 3 shows majority (86.1%) of the patients were under-5 years of age. About 60% were male children. Almost 73.8% of the subjects were accompanied by their mothers. More than 80% of the subjects were Hindu by religion. More than half (57.4%) of the person accompanying the children had education level between class I and X. About 53.5% of subjects belong to class V (lower class) of Modified BG Prasad socioeconomic scale, 2021.

The age of the under-5 children ranged from 1-48 completed months; mean age 8.01 ± 9.085 months. Age does not follow normal distribution.

The age of the children above 5 years ranged from 5-11 completed years; mean age 7.5 ± 1.915 years. Age does not follow normal distribution.

The accompanying persons' age ranged from 18-50 years; mean age 25.63 ± 5.883 years. Age does not follow normal distribution.

Table 4 shows 64.4% subjects had to travel more than 20 Km to avail services, 55% subjects had to wait more than one hour in queue. Only 48% of them spent more than 4 minutes with the doctor in OPD for consultation. Majority of them (61.4%) availed the services in the middle of the week, i.e. Tuesday, Wednesday and Thursday. Most number of subject availed services in 1st shift (36.1%), followed by 2nd shift (34.7%) and 3rd shift (29.2%).

For the purpose of analysis, level of satisfaction was categorized into two groups: satisfactory (those with score above the median value) and unsatisfactory (those with score of median value or lower) which were 39.1% and 60.9% respectively.

Binary logistic regression in Table 5 does not show any association between the sociodemographic factors (age, gender, religion of the subjects or the age, gender, level of education and socioeconomic status of their accompanying person) and level of satisfaction that is statistically significant.

In Table 6, binary logistic regression between factors related to service and level of satisfaction shows statistically significant association of waiting time in queue and duration of service availed (i.e. time spent with doctor in OPD for consultation) with level of satisfaction. Subjects who had to wait in queue for a duration of less than one hour (unadjusted OR: 5.021, 95% CI: 2.725 – 9.249, P < 0001) and the subjects who spent more than 4 minutes with the doctor for consultation (unadjusted OR: 3.338, 95% CI: 1.846 – 6.036, P < 0001) were found to be more satisfied.

All the factors having P value of < 0.1 in binary logistic regression, as found in Table 5 and 6, were considered for multiple logistic regression, as shown in Table 7. Subjects who had to wait in queue for a duration of one hour or less (adjusted OR: 3.239, 95% CI: 1.587 – 6.611, P = 0001) and the subjects who spent more than 4 minutes with the doctor for consultation (adjusted OR: 2.086, 95% CI: 1.041 – 4.180, P = 0.038) were found to be more satisfied.

When the people accompanying the children were asked about how the service can be quickened and the waiting time can be shortened, 25.8% of them thought placement of more doctors in OPD would be helpful, 28.7% mentioned service should be provided on 'first come first serve' basis, so as to discourage anyone cutting the line or skipping the queue (FIFO model), only 5.9% said the services should be started on time without delay, and 39.6% perceived that no change is needed (as depicted in Table 8).

DISCUSSION

The biggest advantage that queuing theory offers is that it breaks complex queuing situation into simplified mathematical equations that help the administration with optimal solution for reducing the long waiting time. But its limitations lie in the fact that a lot of hypothetical assumptions are to be made before we can apply queuing theory.[8]

Our study had revealed the arrival rate was more than the service rate in shift 1 and 2, i.e. during early and mid-hours of OPD services; while the scenario reverses in shift 3, i.e. during the late OPD hours. This is probably because of the fact that most of the patients/beneficiaries attend the OPD during early hours, and as the day progresses, number of arrivals gradually decreases. Majority of the person accompanying the children were females, and almost all of them were the mothers of the children, owing to the fact that majority of the earning members of the family were probably male and were unavailable to accompany the children to the hospital. The mean age of the accompanying persons was 25.63 ± 5.883 years. All these findings are explained by the fact that most of the children were under-5 years of age and were accompanied by their mothers. A study by Sri-

ram S and Noochpoung R revealed how the hospital waiting time can be determined by the demographic characteristics, hospital ownership (government, private etc.) and ambulance arrival.[9] On the other hand, our study was conducted in a tertiary level government hospital, among subjects with different socio-demographic profile, while most of them availed public transport to reach the hospital for availing services.

When asked about the subjects' view on waiting situation, our study revealed that almost 60.9% subjects were unsatisfied. Afrane S, Appah A, in their study in a hospital in Ghana, showed that out of 143 respondents, 898% had negative experience with queuing at the said hospital. Out of this number, 43% felt frustrated with the service, 38% felt tired from waiting, 15% were anxious about their health, while 4% had no desire to return to the facility to avail services again. Also, as much as 93% respondents blamed insufficient staff as the main reason behind delay.[10]

When we explored the factors determining the level of satisfaction among the beneficiaries or the persons accompanying them, it was found that they were satisfied with the service when they had to wait in queue for less than an hour or they spent more than 4 minutes with the doctors providing the services. So, shorter waiting time and longer consultation time increase the satisfaction among the patients or their caregivers while attending OPD services. A similar study by Kumar MVK and Pillai JSK revealed about 63.3% patients had seen a waiting time of more than one hour for consultation with doctors and most of the patients were not satisfied with this waiting time in OPD process.[11] Another study by Ahmed F, Yasir I, Hameedi K, Ahmed S, Ahmed W, Maroof et al. conducted in Pakistan shows about 61.2% subjects were satisfied with the consultation time, and 41.1% subjects had to wait up to 30 minutes in queue before consulting the doctor.[12] Joshi S and Joshi MK, in their study addressed important factors like waiting time to get treatment, waiting time to get OPD appointment, working condition and environment at OPD in context of patient satisfaction regarding OPD services.[13] A study conducted in Karnataka, by Hunasikatti R, revealed about 50% of the subjects were satisfied in context of waiting time, while 58.33% subjects were satisfied with the consultation time.[14] Our study also showed that people who had to travel less than 20 kilometre to reach the hospital were 1.69 times more likely to be satisfied compared to those who had to travel more than 20 kilometres, although the finding was not statistically significant. Another study conducted by Geberu DM, Biks GA, Gebremedhin T and Mekonnen TH in Ethiopia, showed that factors like male gender, prolong waiting time etc. were associated with lower level of satisfaction, although the finding were significant in binary logistic regression, not in the multivariate logistic analysis.[15] Time taken to reach consultant in OPD was found unsatisfactory by 80% of subjects, as found in a study by Kulkarni SK.[16] In a study by Mahale P and Deshmukh BB, one of the various methods adopted by the hospitals to tackle waiting lines was to keep assistant doctors to the senior doctors for attending patients. It also showed unpredicted delays from doctors due to association with other hospitals or personal reasons.[17] These finding is in accordance to our study where the subjects suggested for posting of more doctors and starting of service on time, so as to avoid long queuing time.

CONCLUSION

It is of utmost importance to acknowledge the problem of prolong waiting time, by the patients or people accompanying them, for availing different services in any busy hospital, including registration, consultation, investigation, procurement of reports, documents and medicines etc. Application of queuing models can help us identify the queuing dynamics of different service stations in a hospital. It is to be considered that every patient has unique health issue, requiring unique management, and hence the consultation time may vary during OPD services. Considering the circumstances, along with the arrival and service rates at the OPDs, resources including manpower and infrastructure, a well-planned system can minimize the waiting time and thus improve the level of satisfaction among the beneficiaries.

ACKNOWLEDGEMENT

We are thankful to all the study participants for their co-operation. We are also thankful to the faculties of the Dept. of Community Medicine, Bankura Sammilani Medical College, for their motivation and valuable feedback.

REFERENCES

1. Green, L. (2006). Queueing Analysis in Healthcare. In: Hall, R.W. (eds) Patient Flow: Reducing Delay in Healthcare Delivery. International Series in Operations Research & Management Science, vol 91. Springer, Boston, MA. DOI: https://doi.org/10.1007/978-0-387-33636-7_10
2. Bindman AB, Grumbach K, Keane D, Rauch L, Luce JM. Consequences of Queuing for Care at a Public Hospital Emergency Department. JAMA; 1991 Aug; 266(8): 1091-6.
3. Mehandiratta R. Application of queuing theory in health care. International Journal of Computing and Business Research. 2011 May; 2(2).
4. Erlang AK. Solution of Some Problems in the Theory of Probabilities of Significance in Automatic Telephone Exchanges. Elektroteknikeren. 1917; 13:5.
5. Prasad SV, Badshah VH, Koka TA. Mathematical analysis of a single queue multi server and multi queue multi server queuing models: comparison study. Global Journal of Mathematical Analysis. 2015; 3(3): 97-104.
6. Yaduvanshi D, Sharma A, More PV. Application of Queuing Theory to Optimize Waiting Time in Hospital Operations. Operations and Supply Chain Management. 2019; 12(3): 165-74. DOI: http://doi.org/10.31387/oscm0380240

7. Paul BC, Kumar N, Kumar A, Singh IB, Neogy SK. Queuing-Model to Optimize Patient waiting time in Out Patient Department (OPD) of a Super-speciality public hospital in India. Journal of Emerging Technologies and Innovative Research. 2021 November; 8(11): 676-86.
8. Chandra D. reducing waiting time of outdoor patients in hospitals using different types of models: a systematic survey. International Journal of Business and Management Review. 2017 July; 4(1): 79-91.
9. Sriram S, Noochpoung R. Determinants of hospital waiting time for outpatient care in India: how demographic characteristics, hospital ownership, and ambulance arrival affect waiting time. International Journal of Community Medicine and Public Health. 2018 July; 5(7): 2692-8. DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20182601
10. Afrane S, Appah A. Queuing Theory and the Management of Waiting-time in Hospitals: The Case of Anglo Gold Ashanti Hospital in Ghana. International Journal of Academic Research in Business and Social Sciences. 2014; 4(2): 34-44. DOI: http://dx.doi.org/10.6007/IJARBSS/v4-i2/590
11. Kumar MVK, Pillai JSK. A study of patient satisfaction on OPD services using standard indicators in a Tertiary Care Teaching Hospital, AIIMS, Bhubaneswar. International Journal of Scientific Research. 2020 January; 9(1): 32-5.
12. Ahmed F, Yasir I, Hameedi K, Ahmed S, Ahmed W, Maroof et al. Assessment of OPD Patient's Satisfaction with Health Care Services at Al-Nafees Medical Hospital. ISRA medical Journal. 2015 September; 7(3): 154-9.
13. Joshi S, Joshi MK. A Study on Patient Satisfaction in Outpatient Department of Secondary Care Hospital of Bhopal. Int J Community Med Public Health. 2017 April; 4(4): 1141-7. DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20171339
14. Hunasikatti R. A Study on Patient Satisfaction in OPD at District Hospital at Navanagar, Bagalkot, Karnataka. International Journal of Evidence Based Nursing. 2021; 4(1): 25-34.
15. Geberu DM, Biks GA, Gebremedhin T, Mekonnen TH. Factors of patient satisfaction in adult outpatient departments of private wing and regular services in public hospitals of Addis Ababa, Ethiopia: a comparative cross-sectional study. BMC Health Services Research. 2019 November [cited 2022, April]. DOI: https://doi.org/10.1186/s12913-019-4685-x
16. Kulkarni SK. A study of patient satisfaction level in Outpatient Department (OPD) in a tertiary care hospital in Maharashtra. IOSR Journal of Dental and Medical Sciences. 2019 March; 17(3): 31-9. DOI: 10.9790/0853-1703073139
17. Mahale P, Deshmukh BB. Analysis of delays due to waiting lines in health care delivery for sustainability. SAMVAD: SIBM Pune Research Journal. 2016 December; XII: 66-71.