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Waiting Line System in Health Sector of Bangladesh: The Case of Dental Care Services in Dhaka City

Mohammad Anisur Rahman*
Mahbub Parvez**

Abstract: Waiting is inevitable in any service organization. Hence queues are formed. A long queue makes customer dissatisfied whereas increasing server to decrease the length of a queue requires costs. Waiting Line Theory provides a platform to that notion. The health sector of Bangladesh has been facing a bad experience for any citizen of Bangladesh. One of the reasons behind this is the queuing system prevailing in this sector. This paper presents an investigation into the prevailing queuing system in the private practices of Dhaka city. On the basis of investigation suggestions are put forward to improve the situation.

1. Introduction

Waiting or queuing is a common phenomenon in our day-to-day life. People wait at dental clinics, supermarkets, fuel stations, and tollbooths. The problem of managing waiting lines is complex as one has to take decision between two crucial phenomena; cost of providing services and customer satisfaction. Waiting Line Theory or Queuing Theory provides a better solution to this problem. However, research shows that 50% of the companies under study know about waiting line theory and 26.79% claim to use it (Ahsan & Ahmed, 2001).

This little percentage of users as referred above is creating problems in forms of customer dissatisfaction in service industries; particularly the health sector of Bangladesh is in worst condition. In the statistical language, 3500 people get a doctor only. As a result, in Bangladesh approximately 4, 50,000 people go abroad for better treatment which costs TK.125 million per Year (The Daily Prothom Alo, 2004). Queuing system in public & private hospitals is one of the problems that make people go abroad.

This study concentrates on exploring the prevailing queuing system in dental clinics in Dhaka City and tries to provide necessary suggestions. With this end in view first section gives a mental guide map on what to expect from this paper. Second section gives a literature review on waiting line theory. Third gives a detailed examination of prevailing waiting line system and suggests to improve the situation.

* Lecturer, Faculty of Business and Economics, Daffodil International University, Dhaka.
** Senior Lecturer, Faculty of Business and Economics, Daffodil International University, Dhaka.

2. Scope and Methodology

This study is based on analysis of prevailing waiting line system of different dental clinics in Dhaka City. These clinics serves customer on first-come, first-serve basis. Clinics that served on the prior appointment basis have been excluded from this study. For the purpose of the present study thirty private practitioners were interviewed using standard questionnaire (see **Appendix 1)**. In order to gauge the waiting room environment, observation method was used.
Data have also been collected from various published books, scholarly journal articles, and internet browsing. Mainly descriptive statistics i.e. frequency tables are used in determining the hourly customer arrival and service time. A simulation template of queuing system developed by David W. Ashely (1997) has been used in analyzing the queuing system.

3. Objectives of the study

The broad objective of this study is to analyze the prevailing waiting system in health sector in Dhaka city. This broad objective could be classified as the following specific ones:

- To give theoretical perspective on waiting line theory.
- To analyze prevailing waiting line system of different dental clinics in Dhaka City where patients are served on the basis of First Come First Serve.
- To suggest how to make their waiting line system more effective.

4. Theoretical Overview on Waiting Line or Queuing System

A Queuing System can be simply described as customers arriving for service, waiting for service if it is not immediate, and if having waited for service, leaving the system after being served (Gross & Harris, 1998). Queuing Theory or Waiting Line Theory was developed by Danish mathematician named A. K. Erlang, who, in 1909, published "***The Theory of Probabilities and Telephone Conversations"*** based on work he did for the Danish Telephone Company in Copenhagen, Denmark. The goal of Queuing Theory (Waiting Line Theory) is to find the trade-off point between the cost of improved service and the cost of making the customer wait.
Since its invention, it has been gaining wide acceptance in management. Now in management the queuing theory is used firstly to minimize the total cost of waiting and service and secondly to achieve a certain level of service that satisfy the customer. Now a day the application areas of queuing theory have broadened well beyond telephone systems (Gross and Harris, 1998). For example (Turban and Meredith, 1994): determining the capacity of an emergency room in a hospital, determining the number of runways at an airport, determining the number of traffic lights and their frequency of operations, determining the size of a restaurant, scheduling work in large computer system, and facility designs (banks, Post offices, amusement parks, fast food restaurant). Today we encounter a myriad of queues in our everyday life and Queuing Theory, as and when possible, help us navigate around these (Gross and Harris, 1998). To better gauge the Queuing Theory it is imperative to have a deep knowledge in Queuing System. A Queuing System has got five components, such as:

i. Arrival :

Arrival means how customers arrive at the business houses and service areas to take services. Different authors like Gross & Harris (1998), Turban & Meredith (1994), Edward (2003), Binkley, Kristofer, and Matthew (2004) have described different arrival rates in queuing theory. These are Internal, External, Finite, Infinite, Batch, Individual, Scheduled, and Nonscheduled. Waiting line formulae generally require an arrival rate, or the number of units per period (such as 10 units per hour). The time between arrivals is the interarrival time (such as an average of one every six minutes). Unscheduled arrival is more common than scheduled arrival rate. Usually, when dealing with waiting line problems, it is assumed that the time between arrivals is exponentially distributed and the number of arrivals per time unit is Poisson distributed.

ii . Waiting Line / Queue

A queue is a line (or buffer or inventory) feeding a number of servers (Edward, 2003). The characteristics of a queue depend on rules and regulations that are termed as Queue Discipline. The common queue disciplines are:

- A priority System
- Emergency (Preemptive Priority) System
- Last-Come, First-Served (LCFS)
- First-Come, First-Served (FCFS)
- Service-in-Random-Order
- Random
- Alphabetically

iii. Server:

The service is rendered by a *server*, which can be a person, group, machine, or a person-machine combination. The time that one particular server takes to complete a customer's service is termed as Service Time. Channels are the number of parallel servers, where phases denote the number of sequential servers. There is at least a server in each facility. On the basis of service facilities (single, multiple) the line structure can be divided into four. They are Single channel-Single phase, Single channel-Multiple phases, Multiple channels-Single phase, Multiple channels-Multiple phases.

iv. Exit:

The point through which the customers leave the system after getting service is called exit. Here the customers may be satisfied or dissatisfied reinforcing the next demand for the service. However, exit only makes an impact on the queue if the population is finite.

v. Cost:

Two types of cost involves in Queuing System; The Facility Cost and The Cost of Waiting Customer. The Facility cost includes cost of construction, operation, maintenance & repair, and other costs. For example, insurance, taxes, rental and other fixed costs are there. The cost of waiting Customer includes Loss of revenue, Will Cost, and Unquenchable Cost. There is yet another cost involved in the waiting system, which may be termed as Cost of Relationships.

5. Waiting Line Solution Approach

A queuing System could be of numerous types on the basis of the elements of the system. For example, a system with a Poisson arrival process; exponential service time distribution; two servers; first-come, first-served discipline; no queue size limit; and servicing a large (infinite) population would be labeled M/M/2 FCFS/∞/∞. The most common Queuing Systems with their model are listed below:

Table 1: Common Operating Characteristics in Waiting Line

Notation	**Operating Characteristics**
L	Average number of customers in the system
L_q	Average number of customers in the waiting line
W	Average time a customer spends in the system
W_q	Average time a customer spends waiting in line
P_0	Probability of no (zero) customers in the system
P_n	Probability of *n* customers in the system
	Utilization rate; the proportion of time the system is in use.

i. Single-Server Model (M/M/1 FCFS/∞/∞) :

Basic Assumption	**The symbols used**
- Poisson Arrival Rate - Exponential Service Times - First-come, first-serve queue discipline - Infinite queue length - Infinite calling population	λ (“lambda”) = mean arrival rate □ (“mu”) = mean service rate

6. Formula

- Probability that no customers are in queuing system, $P(0) = 1 - \frac{\lambda}{\mu}$
- Probability that exactly *n* customers are in the system, $P(n) = \rho^n \times P_0$
- Average number of customers in the system, $L = \frac{\lambda}{\mu - \lambda}$
- Average number of customers in the waiting line, $L_q = \frac{\lambda^2}{\mu(\mu - \lambda)}$
- Average time a customer spend in system, $W = \frac{1}{\mu - \lambda}$
- Average time a customer spends waiting in line to be served, $W_q = \frac{\lambda}{\mu(\mu - \lambda)}$
- Probability that the server is busy (utilization factor) , $\rho = \frac{\lambda}{\mu}$
- Probability that the server is idle and a customer can be served, $I = 1 - \rho$

i. Multi-Server Queuing Model (M/M/K FCFS/∞/∞)

Basic Assumption:	**The symbols used**
- Poisson Arrival Rate - Exponential Service Times - First-come, first-serve queue discipline - Infinite queue length - Infinite calling population	λ (“lambda”) = mean arrival rate (“mu”) = mean service rate **k** = number of servers

ii. Probability that no customer is in queuing system,

P (0) = "Table-P (0) for the Multi-Server Queue" [1]

- Probability that exactly n customers are in the system,

$$P(n) = \left(\frac{1}{k!k^{n-k}}\right) \times \left(\frac{\lambda}{\mu}\right)^n \times P(0) \qquad \text{for n > k}$$

$$P(n) = \left(\frac{1}{n!}\right) \times \left(\frac{\lambda}{\mu}\right)^n \times P(0) \qquad \text{for n < k}$$

- Average number of customers in the system, $L_q = \dfrac{P(0)\rho^k \bar{\rho}}{k!(1-\bar{\rho})^2}$

- Average number of customers in the waiting line, $L = L_q + \rho$

- Average time a customer spends in system, $W = \dfrac{L}{\lambda} = W_q + \dfrac{1}{\mu}$

- Average time a customer spends waiting in line to be served, $W_q = \dfrac{L_q}{\lambda} = W - \dfrac{1}{\mu}$

- Probability that the server is busy (utilization factor), $\bar{\rho} = \dfrac{\lambda}{k\mu}$ □

- Utilization factor of each facility $\rho = \dfrac{\lambda}{\mu}$ (single facility)

- Probability that the server is idle and a customer can be served, $I = 1 - \rho$

iii. Finite **Source Queuing System (M/M/1 FCFS/∞/n)**

The symbols used are:

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[1] See **Appendix-2**

λ (“lambda”) = mean arrival rate

(“mu”) = mean service rate

M =the finite number of customer in the source

i = summation index

iv : Probability that no customer is in queuing system, $P(0) = \dfrac{1}{\sum_{i=0}^{M}\left[\dfrac{M!}{(M-i)!}(\rho)^{i}\right]}$

- Probability that exactly n customers are in the system, $P(n) = P(0)\rho^{n}\left(\dfrac{M!}{M-N)!}\right)$

- Average number of customers in the system, $L = L_q + (1 - P(0))$

- Average number of customers in the waiting line, $L_q = M - \dfrac{\lambda + \mu}{\lambda}(1 - P(0))$

- Average time a customer spends in system, $W = W_q + \dfrac{1}{\mu}$

- Average time a customer spends waiting in line to be served, $W_q = \dfrac{L_q}{\mu(1 - P(0))}$

- Probability that the server is busy (utilization factor) , $\rho = \dfrac{\lambda}{\mu}$

- Probability that the server is idle and a customer can be served, $I = 1 - \rho$

v. Serial (Multiphase) Queues:

In certain service situations, a customer receives services at a number of stations. The customer (product) moves from one to another station and possibly from one to another queue. This is known as serial or multiphase queue.

Assumption	The symbols used
- Poisson Arrival Rate - Exponential Service Times - First-come, first-serve queue discipline - Infinite queue length - Infinite calling population	λ (“lambda”) = mean arrival rate □ (“mu”) = mean service rate **k** = number of servers

vi . The total waiting line for the service, $W_q = \sum_{i=1}^{k} W_{qi}$

6. Cost Analysis of Queuing System

Queuing System can be compared on the basis of their Total Cost (TC), which is composed of two components: the Facility Cost (C_F) and the total Cost of Waiting customers (C_W).

$$TC = C_F + C_W$$

Cost of Waiting (C_W): $C_W = W\lambda C = LC$

where, C is the cost of one customer waiting one unit of time and W is the average time in the system per customer (W_q could be used if the cost is directly proportional to the time in the queue) and λ is the average arrival rate per unit of time.

Cost of Facility (C_F):

The cost incurred by providing the service, C_F, is typically composed of both fixed and variable costs. The annual fixed cost (amortization, insurance, taxes) and the variable (hourly) cost must both be converted into the same time units so that the cost components can be added together.

8. Findings:

The Waiting Line System that is prevailing in the dental clinics is given in average value. It is assumed that the time between arrivals is exponentially distributed and the number of arrivals per time unit is Poisson distributed.

Table 2.1: Average Scenario of Dental Clinics under Study

Business Time (minutes)	Server	No. of Patients	Average Service Time (in minutes)	Service Charge (per patient)	Establishment Cost (TK.)[2]	Monthly Variable Costs(TK.)	Waiting Room Facilities
240	2	13	25	314	1,299,600	23,517	Sitting Arrangement, Magazines, Newspapers
Hourly Calculation							
4	2	3	0.42 (app. 5 customer per hrs)	314	15.00	131.00	

From the scenario we could see that there is more than one server with a system with the Poisson arrival process; exponential service time distribution; two servers; first-come, first-served discipline; no queue size limit; and servicing a large (infinite) population would be labeled M/M/2 FCFS/∞/∞. Thus the model of Multi-Server Queuing Model (M/M/K FCFS/∞/∞) is used here. Using the model the following results have been found.

[10] Assuming 10 years of life time of fixed assets.

Table 2.2: Operating Characteristics of the Dental Clinics

L	Average number of customers in the system	0.6593
L_q	Average number of customers in the waiting line	0.0593
W	Average time a customer spends in the system	13.20 minutes
W_q	Average time a customer spends waiting in line	1.20 minutes
P_0	Probability of no (zero) customers in the system	53.80%
	Utilization rate; the proportion of time the system is in use.	30.00%
C_W	Cost of waiting[3]	TK. 2.00
C_F	Cost of Facility	TK. 146.00
TC	Total Cost	TK. 148.00

The average time a customer spent in the clinic to get service is 12 minutes. If we consider hundred customers then only 5 customers seem to wait in the queue for only one and a half minute whereas 65 patients can be found in the clinic. Therefore, the utilization rate of each facility (dental clinic) is only 30 percent meaning that 70 percent of capacity remains idle. The main cause behind this is: for 53.80 percent time (2.15 hour) the facility remains without customers. This idle state costs those dental clinics is TK. 318.20 per day.

9. Recommendations

From the simulation of the prevailing waiting lines of the clinics under study gives the following options to improve the current situation:

- Dental clinics, where the patients are served on first-come, first-serve basis, can increase their marketing efforts to attract more customers so that the arrival rate equates the service rate. Here, the customers have to wait for only 4 minutes in the queue and 16 minutes in the clinic to get the service. Form the customer point of view it is quite acceptable. The utilization rate will be only 50%, where the total cost of idle capacity would be TK.195.00 per day.
- Dental clinics can decrease the number of servers, i.e., one doctor instead of two with constant service rate. Here the customers have to wait for only 18 minutes in the queue and 30 minutes in the clinic to get the service. Form the customer point of view it is moderately acceptable. The utilization rate will be only 60%, where the total cost of idle capacity would be TK.236.00 per day.

[11] Computed by taking per capita income of country i.e. $380 ($1 = TK. 70)

However if the service rate is decreased to four instead of five, the patients may have to wait 45 minutes in the queue and 15 minutes in the clinic to get the service. This would drastically shun the customer satisfaction level, although the idle cost will shrink to TK. 148.

From the psychological aspect of waiting line and customer relationship management, the first option should be adopted. The prudent marketing will cost the firm but it will increase the customer base as well. If customers are satisfied by the service they will be loyal and will become the repeated customer. Even though the second option offers less cost, it dramatically decreases the customer satisfaction level. Hence these dental clinics should adopt the first option with 10 percent level of less utilization from that of second option.

10. Conclusion

In any service waiting is inevitable. Thus queues are formed. In managing queues, the management has to take decision considering two crucial factors: cost of rendering service and customer satisfaction. Management has to trade-off between these two aspects. The queuing models help the management to take better and informed decisions here.

The prevailing health sector in Bangladesh is in vulnerable state due to shortage of doctors, facilities, mobility of doctors etc. However, the study of some dental clinics of different locations in Dhaka reveals a different scenario where only 30% of the capacity is utilized due to low penetration of patients. Location concentration of these dental clinics has made such a situation.

Increasing the number of patients to these clinics could help to better off the situation. Efficient and strategic marketing could play a vital role here. An advanced study could be done to gauge the prevailing waiting line system of the whole health sector of Bangladesh. This could play a vital role in improving the health sector of the country.

References

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4. Turban, E., and Meredith R.(1994). *Fundamentals of Management Science,* 6th Edition. Irwin / McGraw-Hill, USA.

Appendix
Questionnaire

This survey is to find out the Queuing System prevailing in the Dental Care Services in Bangladesh. It is solely for research purpose. No individual information is going to be disclosed in public.

For Enquiry contact with

- Mr. Mahbub Parvez
  Head,
  Department of Business Administration
  Faculty of Business & Economics
  Daffodil International University
  Cell: 0171278887
- Mr. Mohammad Anisur Rahman
  Lecturer
  Faculty of Business & Economics
  Daffodil International University
  Cell: 0189133780

Please answer the following questions:

1. Organization's Name?____
2. What is your business hour?____
3. How many doctors work to serve the patients?______________________________
4. How many patients come daily?____
5. What is the service time per patient?____________________________________
6. What is the service charge?____
7. What is the establishment cost?____
8. What is the monthly average cost of running this clinic?_______________________
9. What are the facilities in the waiting room (should be filled by the interviewer) ?

____
Respondent

Appendix-2

	2	3	4	5	6	7	8	9	10	15
0.02	0.96079	0.94177	0.92312	0.90484	0.88692	0.86936	0.85215	0.83527	0.81873	0.74082
0.04	0.92308	0.88692	0.85215	0.81873	0.78663	0.75578	0.72615	0.69768	0.67032	0.54881
0.06	0.88679	0.83526	0.78663	0.74082	0.69768	0.65705	0.61878	0.58275	0.54881	0.40657
0.08	0.85185	0.78659	0.72615	0.67032	0.61878	0.57121	0.52729	0.48675	0.44983	0.30119
0.1	0.81818	0.74074	0.67031	0.60653	0.54881	0.49659	0.44933	0.40657	0.36788	0.22313
0.12	0.78571	0.69753	0.61876	0.54881	0.48679	0.43171	0.38289	0.3396	0.30119	0.1653
0.14	0.75439	0.65679	0.57116	0.49657	0.43171	0.37531	0.72628	0.28356	0.2466	0.12246
0.16	0.72414	0.61838	0.5272	0.44931	0.38289	0.32628	0.27804	0.23693	0.2019	0.09072
0.18	0.69492	0.58214	0.4866	0.40653	0.33959	0.28365	0.23693	0.1979	0.1653	0.06721
0.2	0.66667	0.54795	0.4491	0.36782	0.30118	0.24659	0.20189	0.1653	0.13534	0.04979
0.22	0.63934	0.51567	0.41445	0.33277	0.26711	0.21437	0.17204	0.13807	0.1108	0.03688
0.24	0.6129	0.48519	0.38224	0.30105	0.23688	0.18636	0.1466	0.11532	0.09072	0.02732
0.26	0.5873	0.4564	0.35284	0.27233	0.21007	0.162	0.12492	0.09632	0.07427	0.02024
0.28	0.5625	0.42918	0.32548	0.24633	0.18628	0.14082	0.10065	0.08045	0.06081	0.015
0.3	0.53846	0.40346	0.30017	0.2227	0.16517	0.12241	0.0907	0.0672	0.04978	0.01111
0.32	0.51515	0.37913	0.27676	0.20144	0.14644	0.10639	0.07728	0.05612	0.04076	0.00823
0.34	0.49254	0.3561	0.2551	0.18211	0.12981	0.09247	0.06584	0.04687	0.00334	0.0061
0.36	0.47059	0.33431	0.23505	0.1646	0.11505	0.08035	0.05609	0.00392	0.02732	0.00452
0.38	0.44928	0.31367	0.21649	0.14872	0.10195	0.06981	0.04778	0.03269	0.02236	0.00335
0.4	0.42857	0.29412	0.19929	0.13433	0.09032	0.06065	0.04069	0.02729	0.0183	0.00248
0.42	0.40845	0.27559	0.18336	0.12128	0.07998	0.05627	0.03465	0.02279	0.01498	0.00184
0.44	0.38889	0.25802	0.1686	0.10944	0.0708	0.04573	0.0295	0.01902	0.01225	0.00136
0.46	0.36986	0.24135	0.15491	0.0987	0.0265	0.03968	0.02511	0.01587	0.01003	0.00101
0.48	0.35135	0.22554	0.14221	0.18895	0.0554	0.03442	0.02136	0.01324	0.00826	0.00075
0.5	0.3333	0.21053	0.13043	0.0801	0.04896	0.02984	0.01816	0.01104	0.00671	0.00055
0.52	0.31597	0.19627	0.00951	0.07207	0.04323	0.02586	0.01544	0.0092	0.00548	0.00041
0.54	0.2987	0.18273	0.10936	0.06477	0.03814	0.02239	0.01313	0.00767	0.00448	0.0003
0.56	0.28205	0.16986	0.09994	0.05814	0.03362	0.01936	0.01113	0.00638	0	0.00022
0.58	0.26582	0.15762	0.09119	0.05212	0.02959	0.03679	0.00943	0.00531	0.00298	0.00017
0.6	0.25	0.14559	0.08306	0.04665	0.02601	0.01443	0.00799	0.00441	0.00243	0.00012
0.62	0.23457	0.13491	0.0755	0.04167	0.02282	0.01243	0.00675	0.00366	0.00198	0.00009
0.64	0.21951	0.12438	0.06847	0.03715	0.01999	0.01069	0.0057	0.00303	0.00161	0.00007
0.66	0.20482	0.11435	0.06194	0.03304	0.01746	0.00918	0.0048	0.00251	0.00131	0.00005
0.68	0.19048	0.10479	0.05587	0.0293	0.01522	0.00786	0.00404	0.00207	0.00106	0.00004
0.7	0.17647	0.09569	0.05021	0.0259	0.01322	0.0067	0.00338	0.0017	0.00085	0.00003
0.72	0.16279	0.08702	0.04495	0.0228	0.00144	0.0057	0.00283	0.0014	0	0.00002
0.74	0.14943	0.07875	0.04006	0.01999	0.00986	0.00483	0.00235	0.00114	0.00055	0.00001
0.76	0.13636	0.07087	0.0355	0.01743	0.00847	0.00407	0.00195	0.00093	0.00044	0.00001
0.78	0.1236	0.06335	0.03125	0.0151	0.00721	0.00341	0.0016	0.00075	0.00035	0.00001
0.8	0.11111	0.05618	0.0273	0.01299	0.0061	0.00284	0.00131	0.0006	0.00028	0.00001
0.82	0.0989	0.04933	0.02362	0.01106	0.00511	0.00234	0.00106	0.00048	0.00022	0
0.84	0.08696	0.0428	0.02019	0.00931	0.00423	0.0019	0.00085	0.00038	0.00017	0
0.86	0.07527	0.03656	0.017	0.00772	0.00345	0.00153	0.00067	0.00029	0.00013	0
0.88	0.06383	0.0306	0.01403	0.00627	0.00276	0.00012	0.00052	0.00022	0.0001	0
0.9	0.05263	0.02491	0.01126	0.00496	0.00215	0.00092	0.00039	0.00017	0.00007	0
0.92	0.04167	0.01947	0.00867	0.00377	0.00161	0.00068	0.00028	0.00012	0.00005	0
0.94	0.03093	0.01427	0.00627	0.00268	0.00113	0.00047	0.00019	0.00008	0.00003	0
0.96	0.02041	0.0093	0.00403	0.0017	0.0007	0.00029	0.00012	0.00005	0.00002	0
0.98	0.0101	0.00454	0.00194	0.00081	0.00033	0.00013	0.00005	0.00002	0.00001	0