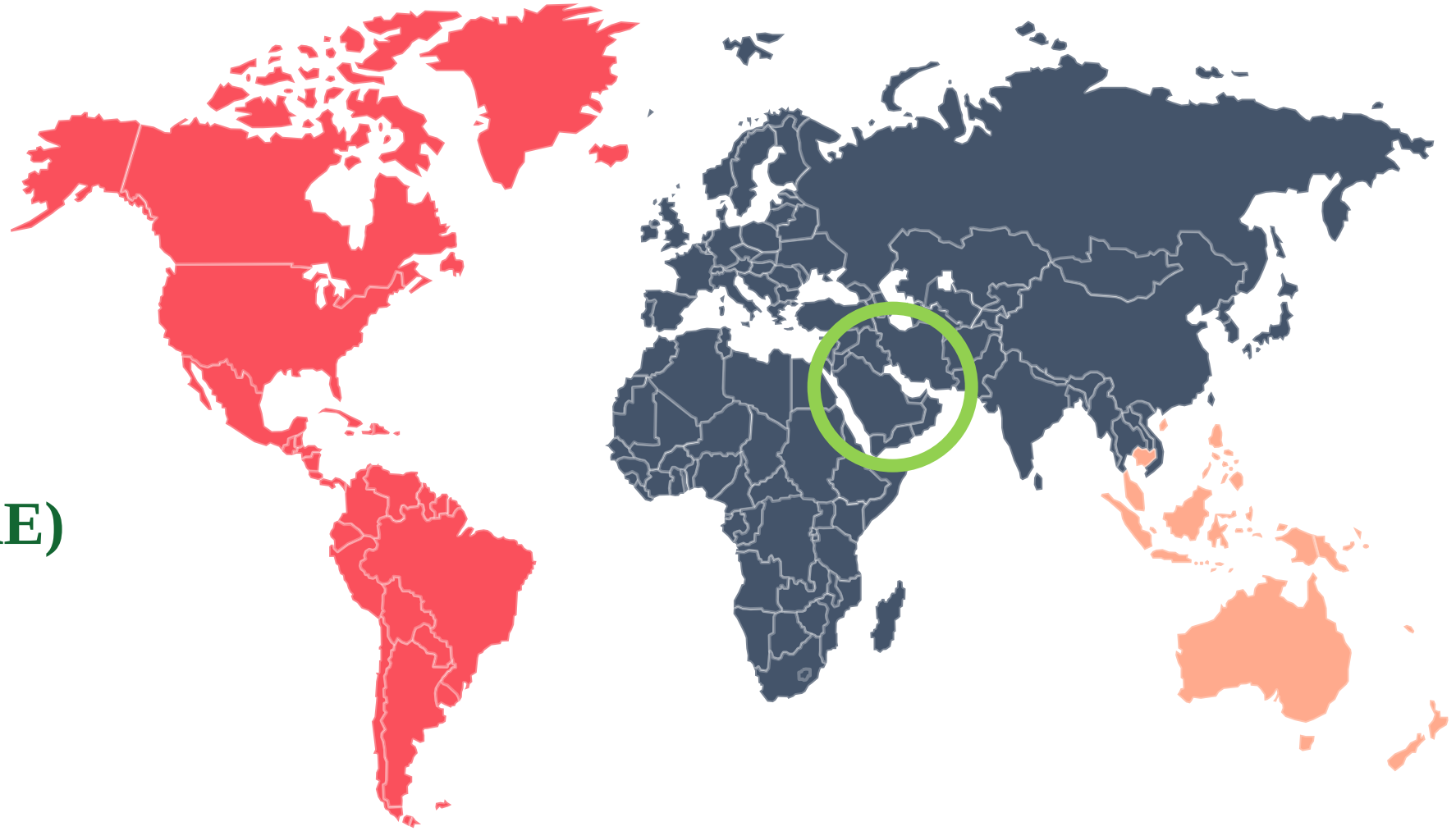
To gauge the performance of Queuing system using Multi-server queuing model (M/M/S) in a private hospital outpatient department

Presented by :
Dr. Payal Mittal
BDS,MDS
MBA Health and Hospital Management (2018-20)

LOCATION :
ABU DHABI (UAE)



INTRODUCTION

Queues or waiting lines are experienced commonly in day to day life whereby array of business providers require their customers to wait in line, such as for telephone services, Healthcare etc.

The methods of studying these line formations and different ways to manage them is termed as Queuing theory. Basically, it is a mathematical way of analysing the system, which renders service to random demands and deals with one of the common & irksome experience, waiting.

Considering the fact that in this competitive world there is high pressure to make correct management decision at all time which include one of waiting time management decision.

First phase of study : current queuing pattern and waiting lines in department and root and cause analysis for long waiting time.

Second phase of study: application of queuing model to find the optimal server required to reduce the fraction of patient due to long waiting time and improve the performance in out-patient department.

To analyse health care process ; Three methodologies

- **Simulation modelling**
- **Flowcharting tools**
- **Queuing models**

Significance of study

- OPD considered as shopping window of any hospital
- First service encounter of patient and the provider which often influences the patient's perception towards the hospital
- Hospitals have much succeeded in providing advancement in medical and technical area for rendering more effective treatments, but they are still struggling with delays and inefficiencies
- Current competitive business scenario, there is always a growing demand to take correct management decisions every times
- It is often seen that patients make choices of either leaving the hospital without being treated or switch to other hospitals due to long waiting queue
- Considering all the above factors, the project was undertaken to formulate a queuing model for optimal utilization of the current system and improving the performance of the department.

Characteristic of queuing model

Waiting line model was originated by Erlang in 1917 the time when he first published telephone traffic theory

Two basic approaches to the queuing problems ; analytical methods using either single server model (M/M/1) or the multi-server model (M/M/s) and the simulation method

Queuing theory has been applied to simulation models to help in deciding the numbers of hospital servers, proper resource utilization and to curtail waiting time.

TYPES OF QUEUING SYSTEMS

Single-server, single-phase system	• Single queue of customers are to be served by a single service facility (server) one after the other
Single-server, multiple-phases system	• Single queue but customers receive more than one kind of service before departing the queuing system
Multiple-servers, single-phase system	• More than one service facility (servers) providing identical service but drawn on a single waiting line
Multiple servers, multiple-phases system	• Patient first form the queue for registration, and then he/she is triage for assessment, then for consultation and finally exits from the system

AIM AND OBJECTIVES

- To study the process flow of the out patients department
- To study the existing queuing model in department
- To undergo root and cause analysis for long waiting time
- To identify the ideal number of server required to reduce the waiting time
- To study the arrival and service rate in out-patient department
- To study the system utilization rate
- To identify the average time patient wait in the system and queue
- To identify the average number of patients in the system and queue

RESEARCH METHODOLOGY

1

Descriptive-analytical study was carried out in out-patients department located at Burjeel Hospital Abu Dhabi (UAE)

2

A total of 8677 samples were included in study using the purposive sampling method

3

The per hour arrival data that was observed was matched with the data extracted by the hospital system (SAP) and the extracted data were used to map the arrival pattern of patients in department

4

A Fishbone analysis was carried out to show cause and effect relationship that give rise to certain problems

1

Data were analyzed using queuing software {QM} tool of operational research and the result obtained were rounded to nearest absolute values

Research Methodology…..

INCLUSION CRITERIA

1. The department with highest flow of patients ; Family Medicine, Internal Medicine, Endocrinology and Pulmonology

2. Patients who waited in queue on arrival

3. Patients followed first come first basis protocol based on the token number taken through token vending machine

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EXCLUSION CRITERIA

1. Patients who abandon the queue
2. Any patients who did not adhere the protocol of first come and first serve protocol
3. Patients who didn't take token from vending machine
4. Data of patient flow for Weekend (Friday)

LIMITATION OF STUDY

- Service and waiting cost could not be included in study due to the financial data privacy

SAMPLING DURATION

- 15th February 2020 to 15th March 2020

RESULT

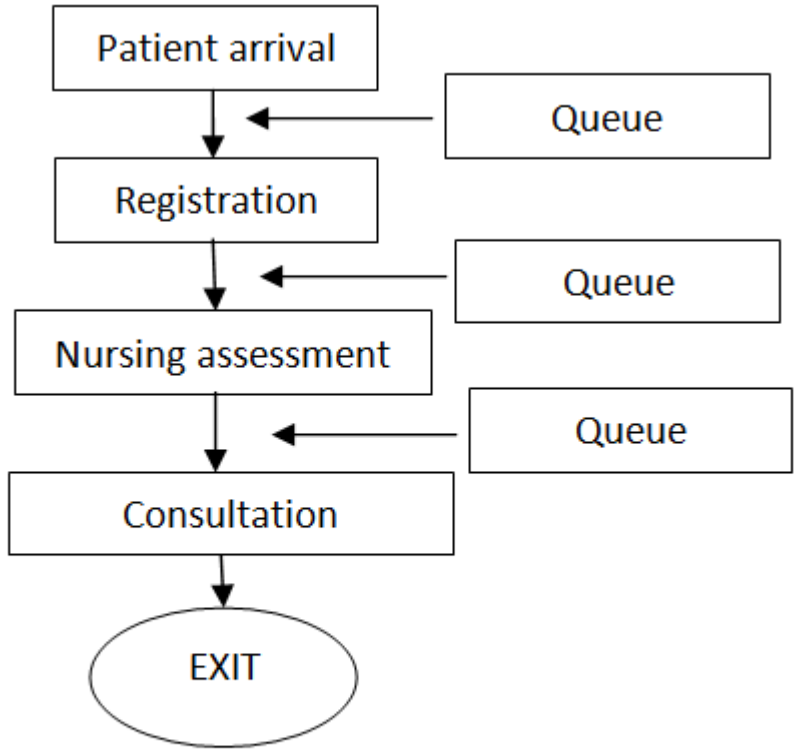


Figure1.1. Patient flow in the out-patient department

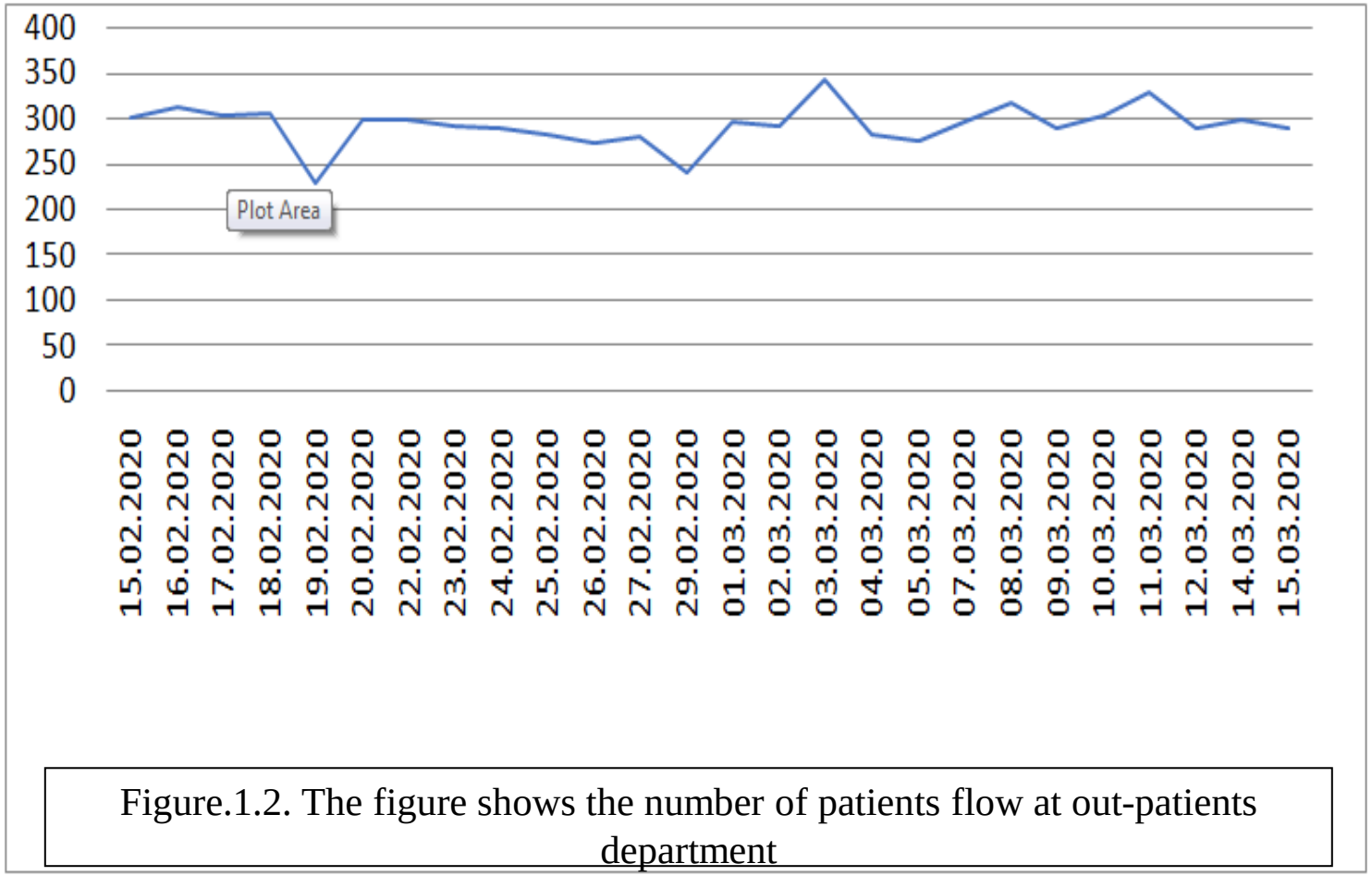


Figure.1.2. The figure shows the number of patients flow at out-patients department

RESULT……

Timing	Total no of patients	No of servers	Av. Arrival rate per hour	Av. service rate per hour	System Utilization rate	Waiting time in queue {minutes}
7-8am	217	1	8	10	0.8	**37**
8-9am	466	2	33	17	0.97	**114**
9-10am	593	2	42	22	0.95	**51**
10-11am	659	3	48	19	0.84	**34.8**
11-12am	727	4	52	38	0.34	10
12-13pm	723	4	51	18	0.94	**29**
13-14pm	679	4	48	41	0.29	15
14-15pm	712	3	50	25	0.67	10
15-16pm	636	3	45	21	0.71	20
16-17pm	648	2	48	26	0.92	**26.5**
17-18pm	595	3	43	24	0.6	13
18-19pm	553	3	39	22	0.59	10
19-20pm	455	2	32	17	0.94	**54**
20-21pm	441	2	32	18	0.89	**27**
21-22pm	342	1	24	25	0.96	24
22-23pm	160	1	11	12	0.92	24
23-00pm	69	1	5	11	0.45	22
00-1.00pm	2	1	1	9	0.11	19

Table.1.1 The current queuing characteristic for registration at out-patients

RESULT……

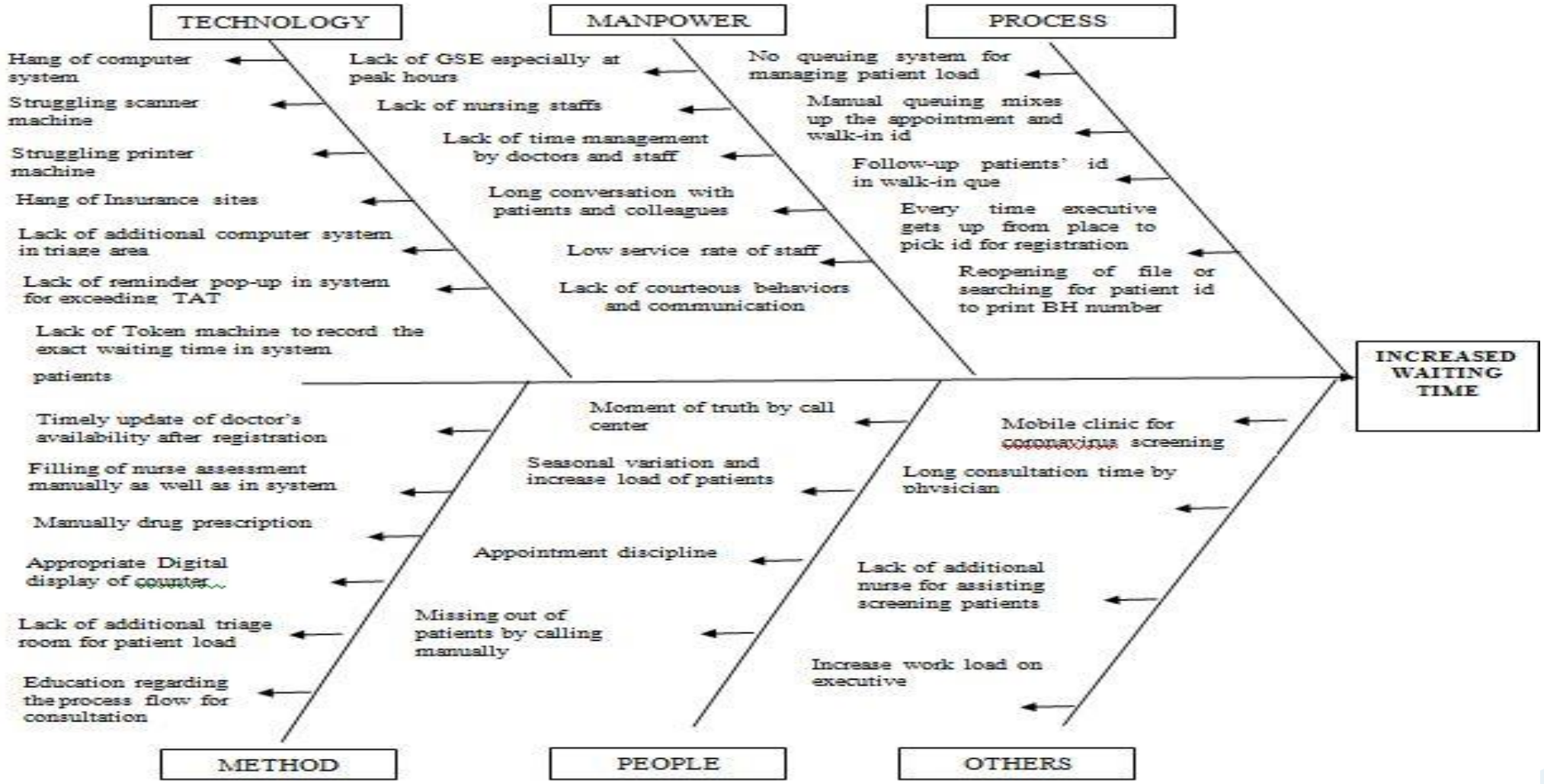
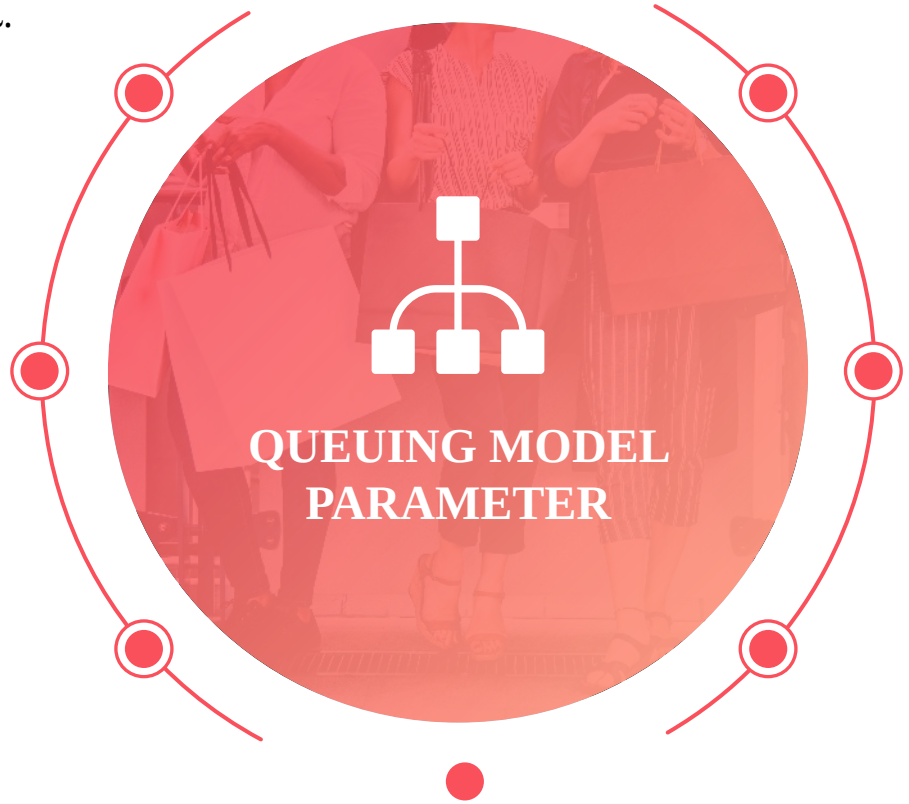


Figure 1.3. Fish Bone analysis diagram

QUEUING MODEL PARAMETER ANALYZED USING QM SOFTWARE

- Mean customers arrival count: λ.
- Mean service rate: μ
- Utilisation factor{ρ}= λ/ μ.



- Av. no. of customers in the system: Ls = λ/ λ- μ
- Av. no. of customers in the queue: Lq= Ls – λ/ μ
- Av. time patients spent in the system, Ws= 1/ μ- λ
- Av. time patients spent in the queue, Wq= p/ μ- λ

RESULTS

BEFORE

		Results		Minutes	Total {minutes}
		Av. server utilization	0.8		
Time	7-8am	Av. No. of customers in queue $\{L_q\}$	3.2		
Arrival rate $\{\lambda\}$	8	Av. No. of customers in the system$\{L\}$	4		
Service rate $\{\mu\}$	10	Av. waiting duration in the queue$\{W_q\}$	0.4	13	37
Number of servers$\{s\}$	1	Av. duration in the system$\{W\}$	0.5	30	60
		Probability of system is empty $\{P_0\}$	0.2		

		Results		Minutes	Total {minutes}
Timing	8-9am	Av. server utilization	0.97		
Arrival rate $\{\lambda\}$	33	Av. No of customers in the queue$\{L_q\}$	31.55		
Service rate $\{\mu\}$	17	Av. No of customers in the system$\{L\}$	33.49		
Number of servers$\{s\}$	2	Av. waiting period for the queue$\{W_q\}$	0.96	57.37	114
		Av. time period in the system$\{W\}$	1.01	60.9	120
		Probability of system is empty $\{P_0\}$	0.01		

		Results		Minutes	Total (minutes)
Timing	9-10am	Average server utilization(ρ)	0.95		
Arrival rate (λ)	42	Average number of customers in the queue(L_q)	19.58		
Service rate (μ)	22	Average number of customers in the system(L)	21.49		
Number of servers(s)	2	Average waiting time in the queue(W_q)	0.47	27	51
		Average time in the system(W)	0.51	30	60
		Probability (% of time) system is empty (P_0)	0.02		

		Results		Minutes	Total {Minutes}
Timing	10-11am	Av. server utilization	0.84		
Arrival rate $\{\lambda\}$	48	Av. No. of customers in the queue$\{L_q\}$	3.82		
Service rate $\{\mu\}$	19	Av. No. of customers in the system$\{L\}$	6.35		
Number of servers$\{s\}$	3	Av. waiting duration in the queue$\{W_q\}$	0.08	30	34.8
		Av. time period in the system$\{W\}$	0.13	40	47.8
		Probability {% of time} system is empty $\{P_0\}$	0.04		

RESULTS

BEFORE

		Results		Minutes	Total {Minutes}
Timing	11-12pm	Av. server utilization	0.34		
Arrival rate {λ}	52	Av. No. of customers in the queue{L_q}	0.03		
Service rate {μ}	38	Av. No. of customers in the system{L}	1.40		
Number of servers{s}	4	Av. waiting duration in the queue{W_q}	0.05	5	8
		Av. Time period in the system{W}	0.08	8	12.8
		Probability {% of time} system is empty {P_0}	0.25		

		Results		Minutes	Total (minutes)
Timing	12-13pm	Average server utilization(ρ)	0.94		
Arrival rate (λ)	51	Average number of customers in the queue(L_q)	15.25		
Service rate (μ)	18	Average number of customers in the system(L)	18.08		
Number of servers(s)	3	Average waiting time in the queue(W_q)	0.30	17	29
		Average time in the system(W)	0.35	21	39
		Probability (% of time) system is empty (P_0)	0.01		

		Results		Minutes	Total {Minutes}
Timing	13-14pm	Av. server utilization	0.29		
Arrival rate {λ}	48	Av. No. of customers in the queue{L_q}	0.01		
Service rate {μ}	41	Av. No. of customers in the system{L}	1.18		
Number of servers{s}	4	Av. waiting duration in the queue{W_q}	0.00	0.02	0.02
		Av. time period in the system{W}	0.02	1.48	3
		Probability {% of time} system is empty {P_0}	0.31		

		Results		Minutes	Total {Minutes}
Timing	14-15pm	Av. server utilization	0.67		
Arrival rate {λ}	50	Av. No. of customers in the queue{L_q}	0.89		
Service rate {μ}	25	Av. No. of customers in the system{L}	2.89		
Number of servers{s}	3	Av. waiting duration in the queue{W_q}	0.02	1.07	2.27
		Av. time period in the system{W}	0.06	3.47	6.5
		Probability {% of time} system is empty {P_0}	0.11		

RESULTS

BEFORE

		Results		Minutes	Total {Minutes}
Timing	15-16pm	Av. server utilization	0.71		
Arrival rate {λ}	45	Av. No. of customers in the queue{L_q}	1.28		
Service rate {μ}	21	Av. No. of customers in the server{L}	3.43		
Number of servers{s}	3	Av. waiting duration in the queue{W_q}	0.03	1.7	3
		Av. time period in the system{W}	0.08	4.57	9
		Probability {% of time} system is empty {P_0}	0.09		

		Results		Minutes	Total {Minutes}
Timing	16-17pm	Av. server utilization	0.92		
Arrival rate {λ}	48	Av. No. of customers in the queue{L_q}	10.63		
Service rate {μ}	26	Av. No. of customers in the system{L}	12.48		
Number of servers{s}	2	Av. waiting duration in the queue{W_q}	0.22	13.29	**26.5**
		Av. time period in the system{W}	0.26	15.6	**31**
		Probability {% of time} system is empty {P_0}	0.04		

		Results		Minutes	Total {Minutes}
Timing	17-18pm	Av. server utilization	0.60		
Arrival rate {λ}	43	Av. No. of customers in the queue{L_q}	0.52		
Service rate {μ}	24	Av. No. of customers in the system{L}	2.31		
Number of servers{s}	3	Av. waiting duration in the queue{W_q}	0.01	0.73	1.5
		Av. time period in the system{W}	0.05	3.23	6.5
		Probability {% of time} system is empty {P_0}	0.15		

		Results		Minutes	Total {Minutes}
Timing	18-19 pm	Av. server utilization	0.59		
Arrival rate {λ}	39	Av. No. of customers in the queue{L_q}	0.50		
Service rate {μ}	22	Av. no. of customers in the system{L}	2.27		
Number of servers{s}	3	Av. waiting duration in the queue{W_q}	0.01	0.76	1.5
		Av. time period in the system{W}	0.06	3.49	7
		Probability {% of time} system is empty {P_0}	0.15		

RESULTS

BEFORE

		Results		Minutes	Total (Minutes)
Timing	19-20pm	Average server utilization(ρ)	0.94		
Arrival rate (λ)	32	Average number of customers in the queue(L_q)	14.60		
Service rate (μ)	17	Average number of customers in the system(L)	16.48		
Number of servers(s)	2	Average waiting time in the queue(W_q)	0.46	27.38	54
		Average time in the system(W)	0.52	30.91	60
		Probability (% of time) system is empty (P_0)	0.03		

		Results		Minutes	Total {Minutes}
Timing	20-21 pm	Av. server utilization	0.89		
Arrival rate {λ}	32	Av. No. of customers in the queue{L_q}	6.69		
Service rate {μ}	18	Av. No. of customers in the system{L}	8.47		
Number of servers{s}	2	Av. waiting duration in the queue{W_q}	0.45	0.1	**27.1**
		Av. time period in the system{W}	0.30	20	**38**
		Probability {% of time} system is empty {P_0}	0.06		

		Results		Minutes	Total {Minutes}
Timing	21-22 pm	Av. server utilization	0.96		
Arrival rate {λ}	24	Av. No. of customers in the queue{L_q}	23.04		
Service rate {μ}	25	Av. No. of customers in the system{L}	24		
Number of servers{s}	1	Av. Waiting duration in the queue{W_q}	0.21	12.5	24
		Av. time in the server{W}	0.26	15.8	28
		Probability {% of time} system is empty {P_0}	0.04		

RESULTS

BEFORE

		Results		Minutes	Total (Minutes)
Timing	22-23 pm	Average server utilization(ρ)	0.92		
Arrival rate (λ)	11	Average number of customers in the queue(L_q)	10.08		
Service rate (μ)	12	Average number of customers in the system(L)	11.00		
Number of servers(s)	1	Average waiting time in the queue(W_q)	0.40	0.02	24.02
		Average time in the system(W)	1.00	0	60
		Probability (% of time) system is empty (P_0)	0.08		

		Results		Minutes	Total {Minutes}
Timing	23-00 pm	Av. server utilization	0.45		
Arrival rate {λ}	5	Av. No. of customers in the queue{L_q}	0.38		
Service rate {μ}	11	Av. No. of customers in the system{L}	0.83		
Number of servers{s}	1	Av. Waiting duration in the queue{W_q}	0.08	4.55	11
		Av. time period in the server{W}	0.17	10	22
		Probability {% of time} system is empty {P_0}	0.55		

RESULTS

BEFORE

AFTER

Timing	Queuing characteristics		No of servers				
		1	2	3	4	5	6
7-8am	Av. server utilization{ρ}	0.8	0.4				
	Av.No. of customers in the queue{L_q}	3.2	0.15				
	Av.No. of customers in the system{L}	4	0.95	INEFFICIENT			
	Av. waiting time in the queue{W_q}	**37 minutes**	**3 minutes**				
	Av. time in the system{W}	**60 minutes**	**14 minutes**				
	Probability {% of time} system is empty {P_0}	0.2	0.1				

Timing	Queuing characteristics		No of servers				
		1	2	3	4	5	6
8-9am							
	Av. server utilization{ρ}		0.97	0.65			
	Av.No. of customers in the queue{L_q}		31.55	0.76			
	Av.No. of customers in the system{L}	INEFFICIENT	33.49	2.71			
	Av. waiting time in the queue{W_q}		**114 minutes**	**5 minutes**	INEFFICIENT		
	Av. time in the system{W}		**120 minutes**	**10 minutes**			
	Probability {% of time} system is empty {P_0}		0.01	0.12			

RESULTS

BEFORE

AFTER

Timing	Queuing characteristics		No of servers				
		1	2	3	4	5	6
9-10am							
	Average server utilization(ρ)		0.95	0.67			
	Average number of customers in the queue(L_q)	Inefficient	19.58	0.89	Inefficient		
	Average number of customers in the system(L)		21.49	2.89			
	Average waiting time in the queue(W_q)		51 minutes	5 minutes			
	Average time in the system(W)		60 minutes	8 minutes			
	Probability (% of time) system is empty (P_0)		0.02	0.11			

Timing	Queuing characteristics		No of servers				
		1	2	3	4	5	6
10-11am							
	Av. server utilization{ρ}			0.84	0.63		
	Av.No. of customers in the queue{L_q}	INEFFICIENT		3.82	0.56	INEFFICIENT	
	Av.No. of customers in the system{L}			6.35	3.09		
	Av. waiting time in the queue{W_q}			**34.8 minutes**	**2.5 minutes**		
	Av. time in the system{W}			**47.8 minutes**	**7 minutes**		
	Probability {% of time} system is empty {P_0}			0.04	0.07		

RESULTS

BEFORE

AFTER

Timing	Queuing characteristics	No of servers					
		1	2	3	4	5	6
12-13pm							
	Av. server utilization{ρ}			0.94	0.71		
	Av.No. of customers in the queue{L_q}			15.25	1.07		
	Av.No. of customers in the system{L}	INEFFICIENT		18.08	3.91	INEFFICIENT	
	Av. waiting time in the queue{W_q}			**29 minutes**	**2.5 minutes**		
	Av. time in the system{W}			**39 minutes**	**9.4 minutes**		
	Probability {% of time} system is empty {P_0}			0.01	0.05		

Timing	Queuing characteristics	No of servers					
		1	2	3	4	5	6
16-17pm							
	Average server utilization(ρ)		0.92	0.62			
	Average number of customers in the queue(L_q)	Inefficient	10.63	0.60	Inefficient		
	Average number of customers in the system(L)		12.48	2.45			
	Average waiting time in the queue(W_q)		26.5 minutes	1.35 minutes			
	Average time in the system(W)		31 minutes	6 minutes			
	Probability (% of time) system is empty (P_0)		0.04	0.14			

RESULTS

BEFORE

AFTER

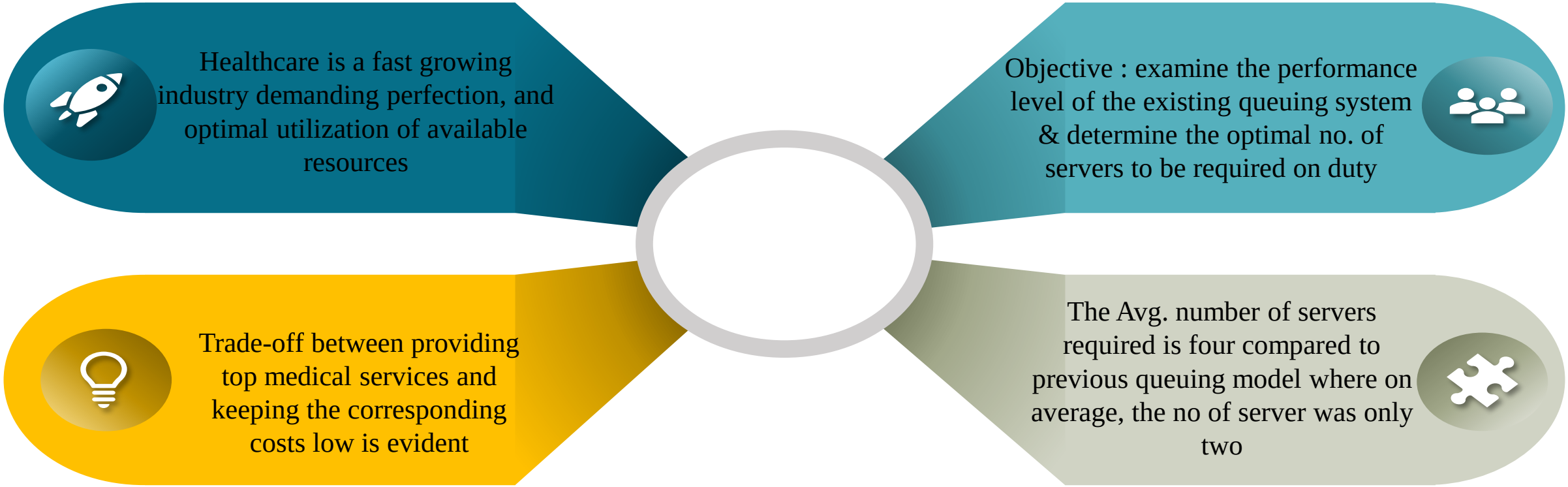
Timing	Queuing characteristics		No of servers				
		1	2	3	4	5	6
19-20pm							
	Av. server utilization{ρ}		0.94	0.63			
	Av.No. of customers in the queue{L_q}		14.60	0.66			
	Av.No. of customers in the system{L}		16.48	2.54	INEFFICIENT		
	Av. waiting time in the queue{W_q}	INEFFICIENT	**54 minutes**	**2.96 minutes**			
	Av. time in the system{W}		**60 minutes**	**9.5 minutes**			
	Probability {% of time} system is empty {P_0}		0.03	0.13			

Timing	Queuing characteristics		No of servers				
		1	2	3	4	5	6
20-21pm							
	Av. server utilization{ρ}		0.89	0.59			
	Av.No. of customers in the queue{L_q}		6.69	0.50			
	Av.No. of customers in the system{L}		8.47	2.28	INEFFICIENT		
	Av. waiting time in the queue{W_q}	INEFFICIENT	**27.1 minutes**	**2.5 minutes**			
	Av. time in the system{W}		**38 minutes**	**8 minutes**			
	Probability {% of time} system is empty {P_0}		0.06	0.15			

Timing	Total no of patients	No of ideal server required
7-8am	217	**2**
8-9am	466	**3**
9-10am	593	**3**
10-11am	659	**4**
11-12am	727	4
12-13pm	723	4
13-14pm	679	**4/3**
14-15pm	712	3
15-16pm	636	3
16-17pm	648	**3**
17-18pm	595	3
18-19pm	553	3
19-20pm	455	**3**
20-21pm	441	**3**
21-22pm	342	1
22-23pm	160	1
23-00pm	69	1
00-1.00pm	2	1

Table 1.4. The number of servers required for registration

CONCLUSION


Healthcare is a fast growing industry demanding perfection, and optimal utilization of available resources
Objective : examine the performance level of the existing queuing system & determine the optimal no. of servers to be required on duty
Trade-off between providing top medical services and keeping the corresponding costs low is evident
The Avg. number of servers required is four compared to previous queuing model where on average, the no of server was only two

THANKYOU