Simulation of Dental Clinic Patient

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***Abstract*—Patient queues are typical at dental clinics, and wait times are one sign of how easily patients may receive care. We propose a queueing theory example, a tool for analysis that has provided service providers with a wealth of helpful data for managing and developing new service systems. For five days, we gathered data from a dental clinic, and then we used the data to create a simulation to compare it against. According to the findings, there is no discernible difference between the simulated data and the actual data.**

I. Introduction

In the Dental Clinics, patient lines are common, and wait times are one indicator of patient access to care. We give an example of queueing theory, an analytical tool that has given service providers a lot of useful information for managing and creating new service systems. This well-known theory aids in quantifying the necessary service capacity to satisfy patient demand while balancing system use and the length of time patients must wait. Average patient demand, average service rate, and the fluctuation in both are taken into account as the four main variables that influence the patient's wait time. It can be difficult for dental clinic managers to streamline and organize their procedures. As both the need for healthcare and its costs are continually rising, pressure on healthcare administrators is mounting. There are numerous approaches to studying the vast field of dental care.

The areas of health care now supported by queueing models were identified through a survey of the literature. We searched for articles that discussed queueing models and their subjects, or keywords, associated with population health or dental care. While keeping in mind that the resultant bibliography should not be regarded as the definitive one, the purpose of this study is to outline the key trends in the use of queueing models that are available to decision-makers in the health care industry. Numerous new articles in scholarly publications as well as fresh instances of applications are waiting to be added to the list in this quickly evolving topic.

The remainder of the essay is organized as follows: The background of the case study is covered in the following part. A simulation strategy built on Excel is presented in Section III. Results from comparative simulations are presented in Section IV. Section V brings the paper to a close.

Case Study Background

The chosen case study's ISCAG Dental Clinic shift hours are from 0900 to 1800. The five primary services offered by the dental clinic are extraction, cleaning, pasta, check-ups, and dentures. However, according to clinic data, cleaning accounts for almost 41% of all patients seen in the dental clinic; as a result, it is the service that is most in demand. While patients who need dental cleaning have the longest waits, this could result in dissatisfied customers. In the clinic, cleaning and extraction are the most popular services.

Prior to joining the line, patients entering the clinic must complete registration. There are currently five lines waiting for extraction, cleaning, pasta, checkups, and dentures. On a first-in, first-out (FIFO) basis, five dentists who specialize in each service give care for these patients. Because there are no breaks, lines do not form during the tea and lunch breaks.

II. Related Literature

A.H. Nor Aziati (2018) created a viable model for this investigation, descriptive analytical and simulation methods were used. The outpatient counter's patient arrival and service rates were used to calculate the waiting time for this investigation. Microsoft Excel was used to generate and evaluate the data. ARENA software was used to model and recreate the patient's present queue system based on the data analysis. According to the simulation model's output, the average wait time for patients in the queue is 54.295 minutes, and the average number of people leaving the queue at once is 327. Thus, 13.481 minutes are spent on average each service. This study demonstrated that the clinic met the goal of having patients wait no more than 60 minutes to see a doctor, which was adopted by the Ministry of Health patient charter. The study also addressed a few issues that were noticed during observation, and relevant solutions, such as scheduling resource changes, were developed to reduce waiting times and increase utilization rates. The Ministry of Health can make better public health clinic services and more informed resource plans using the study's findings. [1]

M. Babes and G.V. Sarma (2017) research shows that in some areas of the Ibn-Rochd health center, long lines and lengthy wait times were caused by an arbitrary policy of fixing the number of outpatient appointments and specifying the dates of appointments, while other areas experienced significant downtime for consulting doctors. Numerous factors, including a finite source size, a random sample of initial patients, group arrivals, a non-exponential service time distribution, a late start-up of the servicing unit, and many others, made it difficult to apply the theoretical results that were already known to exist and rendered the conclusions drawn from the use of roughly equivalent theoretical models unreliable in comparison to those obtained in real-world situations. It is demonstrated that simulation could be used in certain circumstances more profitably.[2]

M. Brahimi and D.J. Worthington (2017) study stated that the challenge of creating a suitable appointment system for the outpatient department of the Royal Lancaster Infirmary is successfully addressed via research on queueing models. However, it is stated that the model used here could be a useful tool in local research even though it is accepted that improving appointment systems is not merely a modeling problem.[3]

K. and R. K. Palvannan L. Teow (2012) By balancing system utilisation and patient wait times, this established theory enables us to calculate the necessary service capacity to fulfill patient demand. Average patient demand, average service rate, and the fluctuation in both are taken into account as the four main variables that influence the patient's wait time. We present four fundamental observations that managers and physicians who oversee healthcare delivery systems at the hospital or department level might apply. In two examples from nearby hospitals, we demonstrate how to estimate service capacity using queueing models and examine the effects of capacity configurations while taking into account the inherent variability in healthcare.[4]

M. Czech, M. Witkowski, and E. J. Williams (2007) research paper, they describe a simulation study conducted to dentistry clinic customer service. Analyzing simulation data proven novel techniques for reducing patient wait times and increasing patient throughput at no additional cost. The institution gave the study publicity (as is customary for many "senior projects" or "capstone initiatives") has attracted positive local consideration of simulation's capacity (and, implicitly, further analytical techniques used in the field of industrial engineering) to support the struggling health care sector rise to the dual pressures of cost containment and rising standards for service quality. [5]

III. Methods

- **Study Population**

Based on the principles of motion time studies, the dental clinic was watched for more than 5 days, for a sample of 104 total clients throughout the course of 5 days. The processing times for each service were calculated in the same way. A simulation was run utilizing the clinic's data to study the number of clients in line and service times for comparison's sake. 104 clients in all were tracked for five days. The goal was to determine whether the simulation differed from these measurements and investigations on the clinic.

services	patients	%
extraction	29	27.88462
cleaning	43	41.34615
pasta	14	13.46154
check up	5	4.807692
denture	13	12.5
total	104	100

Table 1: Patient Data

The data reveals that 104 individuals were seen over the course of 5 days, 29 of whom required extractions, accounting for 27.88% of the total number of patients, followed by 43 cleaning patients (41.34%), 14 pasta patients (13.46%), 5 checkup patients (4.8%), and 13 denture patients (12.5 percent).

- **Simulation Model**

The simulation procedure is depicted in the following figure:

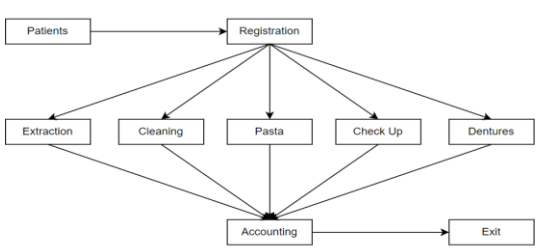

Fig 1: Simulation Process

The figure demonstrates that the patient must first register at registration before moving on to the required treatment. If there is already a patient in the service the patient needs, they must wait during the service period for every treatment. Using the software SIMIO, the simulation needs some data to be made properly.

Service Time

We list the patient service times and use the mean of the gathered data to determine the average time for the services. According to the data, an extraction typically takes 30 minutes, plus an additional 15 minutes for a check-up, 60 minutes for dentures, 45 minutes for cleaning, and 45 minutes for pasta.

Source

Since there are 5 services that are being observed, there are also 5 sources which are the extraction patient, cleaning patient, pasta patient, check up patient, and denture patients. Patients arriving at the clinic must register before getting in line. There are currently five queues waiting for dentures, extractions, cleanings, and pasta. according to the FIFO principle.

Inter-arrival Time

The time elapsed between each patient's arrival and the next is known as the inter-arrival time. The average patient per source was determined and divided over the clinic's total operating hours, which is 9 hours from 0900 to 1800, in order to determine the inter-arrival time.

The calculated inter-arrival time for every sources was 93 minutes for extraction patients, 62 minutes for cleaning patients, 192 minutes for pasta patients, 540 minutes for check up patients, and 204 minutes for denture patients.

IV. Result

Simulation Result

It's time to gather the simulation's data findings after everything has been calculated and put into action. A sampling of the simulation's data is shown in the image below.

Sink	Exit	[DestroyedEntities]	FlowTime	TimeInSystem	Average (Hou...	0.9851
					Maximum (Ho...	2.0476
					Minimum (Hou...	0.3608
					Observations	23.0000
		InputBuffer	Throughput	NumberEntered	Total	23.0000
				NumberExited	Total	23.0000

Fig 2: Sample Data From the Simulation

Based on this figure, which was derived from simulation data using replication number 1 as its randomization, 23 patients visited the clinic. The simulation's data were collected with replications 1, 2, 3, 4, and 5.

Comparison

We utilized t-testing to compare the real data with the simulated data, and we also performed a two-tailed test to solve for the p-value. These are the steps in calculation the t-test.

1. **Get the Mean**

Clinic Data	X_1^2	Simulation Data	X_2^2
30	900	23	529
18	324	27	729
21	441	29	841
16	256	16	256
19	361	18	324
104 total patient	$\sum x_1^2 = 2282$	113 total patient	$\sum x_1^2 = 2679$
Mean = 20.8		Mean = 22.6	

Table 2: Actual Data and Simulation Data

The simulation-generated data and the real data are displayed in the table. Getting the necessary means in place is the first step.

2. **Compute the Variance**

$$s_1^2 = \frac{\Sigma x_1^2}{N_1} - M_1 \qquad s_2^2 = \frac{\Sigma x_2^2}{N_2} - M_2 Z$$

$$= \frac{2282}{5} - 20.8^2 \qquad = \frac{2679}{5} - 22.6^2$$

$$= 456.4 - 432.64 \qquad = 535.8 - 510.76$$

$$= 23.76 \qquad = 25.04$$

Fig 3: Variance Computation

The computed variance of the two data is depicted in the image. The variance of the simulation data was 25.04 whereas the variance of the actual data was 23.76.

3. **Compute the Standard Error of Difference**

$$sM_1 - M_2 = \sqrt{\left(\frac{N_1 s_1^2 + N_2 S_2^2}{N_1 + N_2 - 2}\right)\left(\frac{N_1 + N_2}{N_1 N_2}\right)}$$

$$= \sqrt{\left(\frac{5(23.76) + 5(25.04)}{5+5-2}\right)\left(\frac{5+5}{5*5}\right)}$$

$$= \sqrt{\left(\frac{118.8 + 125.2}{8}\right)\left(\frac{10}{25}\right)}$$

$$= \sqrt{\left(\frac{244}{8}\right)(.04)}$$

$$= \sqrt{(30.5)(.04)}$$

$$= \sqrt{12.2}$$

$$= 3.49285$$

Fig 4: Standard Error of Difference Computation

The standard error of difference from the data gathered was 3.49285. It is going to be important for computing the t-value

4. **Compute the T-Value and P-Value**

$$t = \frac{M_1 - M_2}{sM_1 - M_2}$$

$$= \frac{20.8 - 22.6}{3.49285}$$

$$= \frac{-1.8}{3.49285}$$

$$t = 0.52 \quad p\ value = 0.620251$$

Fig 5: T-value and P-value Computation

Once we have our t-value and p-value, it is time to draw a conclusion based on the results of the t-test.

V. Conclusion

Based on data acquired over the course of 5 days from 104 patients in a real dental clinic, of whom 29 underwent extractions, 43 underwent cleanings, 14 underwent pasta, 5 underwent checkups, and 13 underwent dentures. Using SIMIO, these data were utilized to simulate dental clinic patients, and the resulting data were compared with the original data using a t-test.

Our t-value, which is 0.52, is smaller than the table value at the 0.05 level of alpha, which is 1.860, according to the t-test. Also take note that the p-value of 0.620251 greater than the alpha level of 0.05. Therefore, we can conclude that the real data collected and the simulated data are identical. which hints at the success of the simulation.

Reference

[1] A.H. Nor Aziati "Application Of Queuing Theory Model And Simulation To Patient Flow At The Outpatient Department" January 2018 https://www.researchgate.net/publication/337672536_Application_Of_Queuing_Theory_Model_And_Simulation_To_Patient_Flow_At_The_Outpatient_Department

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