iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** XI **Month of publication:** November 2022

DOI: https://doi.org/10.22214/ijraset.2022.47635

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

Management of Lines during Pandemics: Using Queuing Theory

Aarthi. R[1], Sumitha. R[2]
[1]M.sc Mathematics, Department of Mathematics, Dr. SNS Rajalakshmi college of arts and science, Coimbatore, Tamil nadu, India
[2]Assistant Professor, Department of Mathematics, Dr. SNS Rajalakshmi college of arts and science, Coimbatore, Tamil nadu, India

Abstract: In order to reduce the transmission of the viral disease in the coronavirus era, sustained social isolation measures have been required. To enforce social distance protocols, healthcare facilities are limiting the size of their working team and conducting their organisations on a shift-based schedule. The potential for creating waiting lines at service delivery sites is built into social distance protocol. Many countries' healthcare facilities are already overrun with patients seeking treatment for mild to serious illnesses on a regular basis. The already strained health systems are now under additional strain due to COVID-19. Despite an increase in visits, precautions for social distance must be taken. It is abbreviated to provide quick service, which is essential for patients visiting hospitals for treatment. Delivery, a vital requirement for patients visiting hospitals for medical care, is sped up. In most healthcare facilities, particularly in Ghana, waiting lines have become a typical occurrence and a barrier to providing healthcare. In addition to forfeiting financial gains, delays and subpar medical care may result in fatalities. In order to minimise the effects of COVID-19 and simultaneously cover capacity to fulfil the increased demands for health care delivery, units are tasked with managing staff schedules effectively. Therefore, making an effort to cut down on the amount of time needed to wait for medical attention is essential. Using query theory, we analyse the queue condition at a case Outpatient Department (OPD) in this work and provide suggestions for queue management. The research was carried out on May 2020. We also provide a method for calculating the ideal number of service windows needed to cut down on patient wait times. Additionally, a numerical analysis using pertinent equations from queuing theory is provided for the case department's queuing condition.
Keywords: COVID-19; pandemic; outpatient department; waiting line; queuing theory.

I. INTRODUCTION

The coronavirus pandemic has left the world dealing with a serious public health issue. The newly named coronavirus, COVID-19, belongs to the coronavirus family of viruses. The Severe Acute Respiratory Syndrome (SARS) is a novel strain of the Severe Acute Respiratory Syndrome (SARS) (SARS-CoV-2). The COVID-19 virus infects both people and animals' respiratory systems. Late December 2019 saw the pathogen's outbreak in Wuhan, China. Following a protracted period of hesitation, COVID-19 was officially declared to be pandemic in February 2020 by the World Health Organization (WHO). Most of the world has been affected by its expansion, including the entire continent of Africa. COVID-19 is spread when bodily contact between droplets from an infected person and vulnerable human body areas like the mouth, nose, and eyes occurs. At the time of writing, the virus has killed a number of people and infected well over 50,000,000 individuals worldwide. With the coronavirus pandemic present, health systems around the world are seriously under attack. Hospitals and temporary isolation facilities are employed as case management locations (CDC, 2020). The COVID-19 places even additional strain on the public health systems of nations around the world, especially developing nations like Ghana, given the prevalence of numerous other diseases and the sheer volume of patient visits to hospitals and other health facilities. Health care systems have run their course in many nations.

In this article, the mathematical idea of queuing theory is used to study queue management in healthcare facilities. In this era of the coronavirus pandemic, the primary goal is to bring a mathematical viewpoint to researching and understanding waiting lines at healthcare facilities in order to improve visitor safety and stem the spread of the infectious disease.

A. Background of Queuing Theory

The study of waiting in lines is known as queuing theory, and it has applications in operations research and mathematics. Agner Krarup Erlang's study, which involved developing models to represent the Copenhagen telephone exchange, is where the queuing theory concept first emerged [6].

In the years after they were first documented, Erlang's principles have found use in a variety of fields, including project management, computing, industrial engineering, and traffic engineering. The study of issues like queue behaviour, optimization, and statistical inference benefits greatly from the study of queuing theory. It is also helpful for assessing the effectiveness of customer service departments, healthcare systems, and computer systems that carry out software requests.

B. Queuing System

One or more service points known as servers that provide service to consumers as they arrive in some order are the usual characteristics of a queuing system. Such distribution sites receive customers from a limited or limitless population . Most people arrive at the centre in an unexpected, haphazard manner. These clients join either limited or unlimited capacity queues. The following criteria represent a typical queue system

1) Arrival rate (λ) — the average rate at which customers arrive.
2) Service time (s) — the average time required to service one customer.
3) Number waiting (L_q) — the average number of customerswaiting.
4) Number in the system (L_s) – the total number of customers in the system .

C. Queue Models

Kendall's provides a notation for specifying and representing a queuing system in the following form:

$$(a/b/c): (d/e) \qquad (1)$$

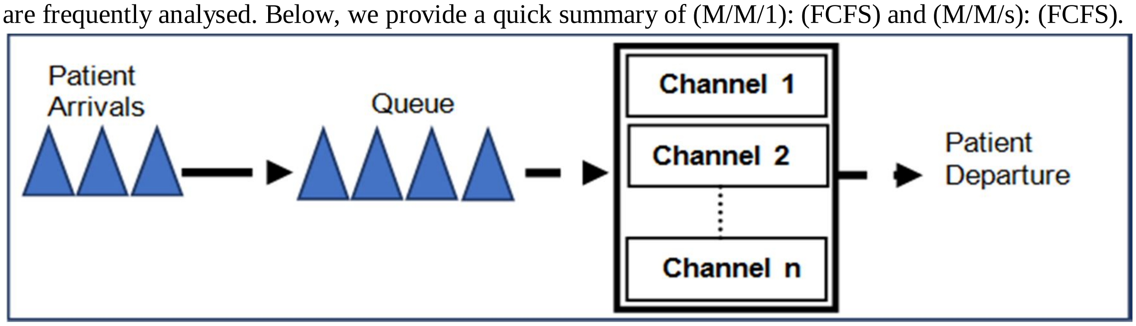
Where

1) a is the distribution of the inter-arrival times
2) b is the distribution of the service times
3) c is the number of servers (channels or service stations)
4) d is the capacity of the system, themaximum number of customers in the system including the one being serviced
5) e is the service discipline.

Equation (1) above denoted as $a/b/c$ to describe the queueing systems.

General, Exponential, and Deterministic distribution types are also known as G, M, and D. When both the arrival rate and the service rate are random, a queue model is said to be probabilistic; deterministic when both the arrival rate and the service rate are fixed; or mixed when just one of the two rates is constant while the other varies.

As a result of the aforementioned, there are numerous models that may be used to forecast how well service systems will operate under variable arrival and service times. Models like (M/M/1): (K/FCFS), (M/M/S): (K/FCFS), (M/M/1): (/SIRO), and (M/G/1): (/GD), where FCFS, SIRO, and GD stand for First-In-First-Out, Service-In-Random-Order, and General (GD) service disciplines, respectively, are frequently analysed. Below, we provide a quick summary of (M/M/1): (FCFS) and (M/M/s): (FCFS).



A FIFO queue system

D. Model for single server queues is the M/M/1: (/FCFS) queue

One of the most popular queuing models for analysing server-specific queuing issues is the M/M/1 model. A system with Poisson arrivals occurring at a rate, exponentially distributed service times, and a single server providing services to clients in a first-come, first-served manner is specifically represented by this model. Service begins the moment a customer enters an empty system.

The customer however joins the line if the system is not empty. If there are any remaining customers in the line, they enter the service window after the service is finished . Performance The following metrics are relevant to the M/M/1 Queue Model .

Utilization factor (ρ) =λ/μ
Probability of an idle system (P_0) = 1 -ρ
Probability of n customers in the system
(P_n) = $P_0\rho^n$ = (1 -ρ)ρ^n
Number of customers in the system (L) =ρ/(1-ρ)= λ/μ-λ
Number of customers in the queue(Lq)= L_s ×ρ= ρ2/1-ρ= ρλ/μ-λ
Waiting time for a customer in the queue (wq)= ρ/μ-λ
Waiting time for a customer in the system (ws)=1/ μ-λ

II. METHODOLOGY

The first-hand collecting of consumer queue characteristics, such as average wait duration, is necessary for the research of waiting lines. The case study design is suggested to highlight the research circumstance. The case study approach gives researchers the chance to examine important aspects of the queuing problem in-depth in a constrained amount of time. Additionally, it permits the coverage of contextual and non-queue conditions pertinent to the operations and procedures of the health delivery point.

A. Data Collection

Each patient arriving at a health care point is associated with the following time measurement

1) The arrival times
2) The service start time
3) The service completion time
4) The wait times
5) The service times
6) The wait time of in system

For a week, daily computations of the above time data were made. On a daily basis, averages are taken for the service and inter-arrival times. The daily averages are then further averaged to provide a picture of the queue behaviour throughout the course of the study.

The suitable distribution for the arrival and inter-arrival times must be decided, which is a crucial step in modelling a case delivery point as a queuing system. The inter-arrival and service times are fitted using a method known as a "goodness of fit test." The Chi square test was used to analyse the inter-arrival times and service times at the case study points at a 0.05 significant level.

B. Computing Arrival rate (λ) and Service Rate (μ)

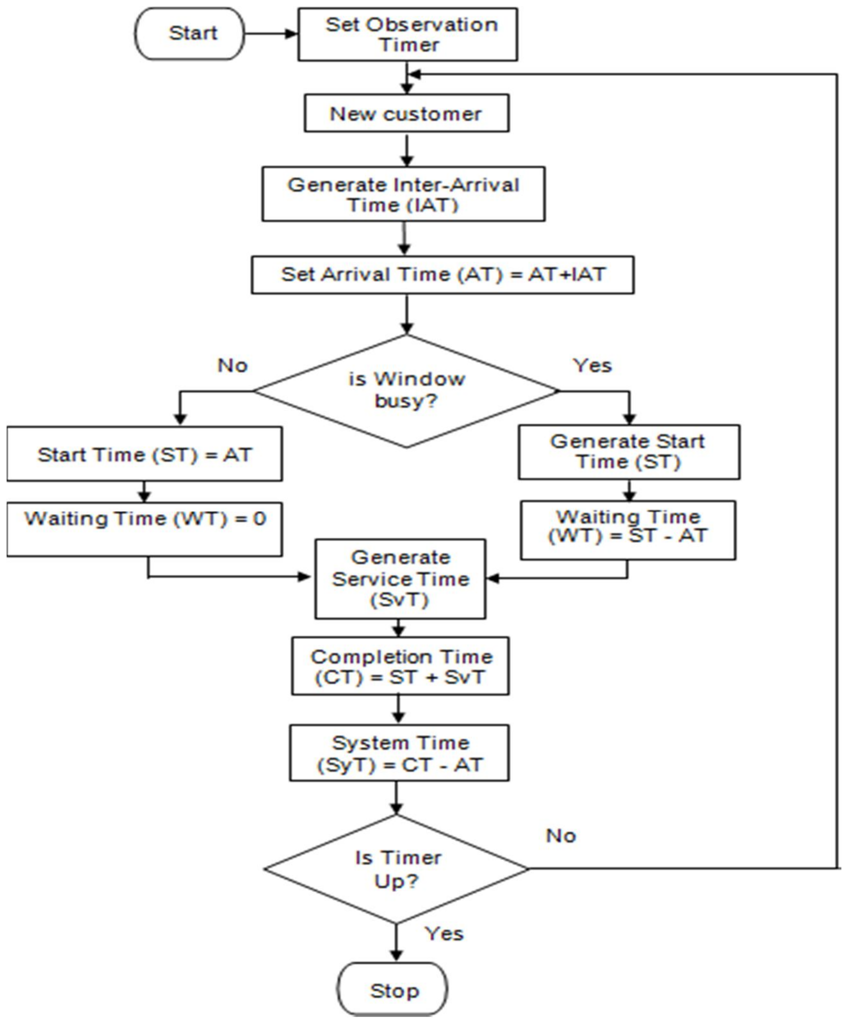
The patient arrival rate and service rate are the first two fundamental characteristics that we compute. The average number of patients who visit the outpatient department over a given time period is represented by parameter. If this is unavailable, an arithmetic mean (tint) indicating the typical gap between the arrivals of two consecutive patients is computed. The value of tint is equal to one and is the inverse of the patient arrival rate.

λ= 1 t_{int}

We may calculate the service rate denoted as using the same matching as in. The service rate at the outpatient department is the typical number of patients who can be attended to in a given period of time.

The average service time per patient (ts) is represented by the arithmetic mean if only the length of service time per patient is known, as is the case with the arrival rate. This time is equal to the inverse of the service rate, which is provided as;

μ=1/ ts



Proposed data collection approach

III. NUMERICAL RESULT

A. Problem

The patients arrive at the hospital at rate of 0.10 and the patients service at the hospital in rate of 0.26 .find the following ,

1) Utilization factor .
2) Waiting time for a patient in the queue.
3) Waiting time for a patient in the system.
4) Number of patient in the system .
5) Number of patirnt in the queue .

a) Utilization Factor

$$P = \lambda/\mu$$

$$= \frac{0.10}{0.26}$$

$$= 0.38$$

b) Waiting Time for a Patient in the Queue

$$(wq) = \frac{\rho}{\mu-\lambda}$$

$$= \frac{0.38}{0.26-0.10}$$

$$= \frac{0.38}{0.16}$$

$$= 2.37$$

c) Waiting Time for a Patient in the System

$$(Ws) = \frac{1}{\mu-\lambda}$$

$$= \frac{1}{0.16}$$

$$= 6.25$$

d) Number of Patients in the System

$$(Ls) = \frac{\rho}{1-\rho}$$

$$= \frac{0.38}{1-0.38}$$

$$= 0.61$$

e) Number of Patients in the Queue

$$(Lq) = \mathbf{Ls\times\rho}$$

$$\mathbf{= 0.62\times0.10}$$

$$\mathbf{= 0.062}$$

IV. CONCLUSION

The ongoing coronavirus pandemic is severely threatening health systems throughout the world. Most health facilities have outpatient departments that serve as common sites of contact and service. The emergence of COVID-19 has increased the workload for outpatient departments and numerous other crucial care facilities. The delivery of rapid, high-quality healthcare is impeded by the growing and widespread presence of patient waiting lines. The ideal number of service windows must be determined in order to reduce patient waiting times and benefit from the associated improvements in health care delivery. This will help outpatient departments operate more efficiently and expedite service delivery during epidemics like the corona virus. In this study, we show how queueing theory can be used to control patient wait times at outpatient services.

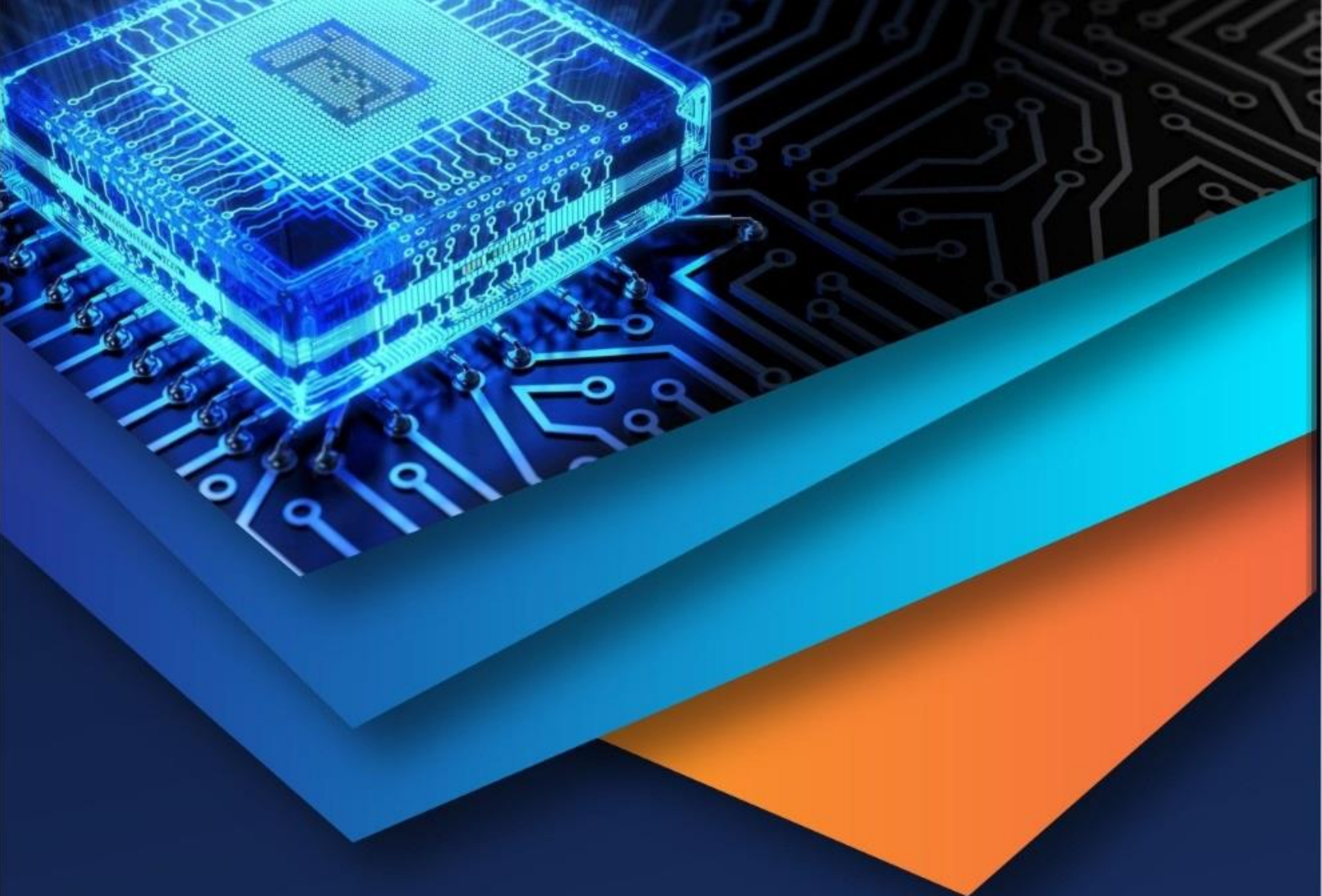
The outpatient case department uses an M/M/1 queuing system as its paradigm. In a one-week period, the patient arrival rate and service rate were assessed. The performance of the case outpatient department was evaluated computationally using formulas from queueing theory, including measures of system usage, anticipated patient volume, patient wait times, and more.

REFERENCES

[1] Fosu GO. Flattening the exponential growth curve of COVID-19 in Ghana and other developing countries. Divine Intervention Is A Necessity; 2020. Available:https://ssrn.com/abstract=3565147

[2] Centers for Disease Control and Prevention.COVID-19 Overview and InfectionPrevention and Control Priorities in non-USHealthcare Settings.

[3] Accessed 12 August 2020 Available:https://www.cdc.gov/coronavirus/2019-ncov/hcp/non-us- settings/overview/index.html
[4] Ghana Health Service. COVID-19, Ghana'soutbreak response management updates. Accessed 15 May 2020 Available:https://ghanahealthservice.org/covid19/archive.php.
[5] World Health Organization. Coronavirusdisease (COVID-19).
[6] Accessed 03 June 2020 Available:https://www.who.int/docs/defaultso urce/coronaviruse/situation- reports/20200306-sitrep-46-covid19.pdf?sfvrsn=96b04adf 4
[7] Jorenby J. Queuing Theory andApplication; 2003.
[8] Sundarapandian V. Probability, statistics and queueing theory. PHI Learning PrivateLtd., New Delhi. 2009;686-709
[9] Xiao H, Zhang G. The queuing theory application in bank service optimization. International Conference on Logistics Systems and Intelligent Management. Harbin. 2010;2:1097-1100
[10] Copper RB. Introduction of queuing theory.2nd ed. Elsevier North Holland, Inc., New York; 1981
[11] Dhar SK, Rahman T. Case study for bank atm queuing model. IOSR Journal of mathematics. 2013;7(1):01-05.
[12] Nawusu YAW, Najim U. An application of queuing theory to ATM service optimization:A case study. IISTE - Journal of Mathematical Theory and Modelling. 2014;4(6).
[13] Adnan I, Resing J, Queueing J. Systems, Eindhoven University of Technology Department of Mathematics and ComputingScience; 2015.
[14] Bhat UN. Elements of applied stochastic processes, 2nd ed., Wiley, New York;1984.
[15] Nain P. Lecture notes on basic elements of queueing theory — Application to the modelling of computer system. University of Massachusetts, Abreast, MA; 1998.
[16] Lariviere M, Van Mieghem J. Strategically seeking service: How competition can generate Poisson arrivals. Manufacturing & Service Operations Management. 2004; 6:23-40.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY