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A Study on Using Queueing Theory to Reduce OPD Waiting Time in Hospital Operations

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Abstract:- Waiting is an inevitable part of the healthcare delivery system in India, and it presents a significant problem for practically every large hospital. The length of time you have to wait might be an indication of ineffectiveness of healthcare administration. When comparing wait times amongst hospital services, the outpatient department (OPD) consistently ranks worst. The focus of this research is a multifaceted examination of OPD. The outpatient department (OPD) of Fortis Escorts Hospital in Jaipur, India is operated in the same way as it is at many large hospitals in India: by experience and rule of thumb rather than by strategic research-based strategies like queuing theory. Longer waiting times for patients are a common occurrence at Jaipur's Fortis Escorts Hospital owing to the high volume of daily visitors. Fortis Escorts Hospital Jaipur (FEHJ) undertook a SWOT analysis of its outpatient department (OPD) to identify its strengths, weaknesses, opportunities, and threats in order to solve the issue of patient wait times and develop effective solutions. Measures to improve the delay spots and make the OPD more efficient were also proposed following an analytical examination of the issue and the use of queuing theory in order to achieve a high patient satisfaction rating.

Keywords:- *Queueing Theory, Outpatient Department, Wait Times, Hospital Operations, Strengths, Weaknesses, Opportunities, and Threats, and Patient Happiness are Some of the Terms We'll.*

I. GENERAL INFORMATION

For multi-specialty hospitals, the outpatient department, which is part of hospital services operations, is essential for delivering high-quality medical care (Carman, 1990). The outpatient department (OPD) may be a money-maker for hospitals, which can be used for things like upgrading infrastructure or reducing losses from inpatient care (Green, 2006).

Even while outpatient services are vital, hospitals often ignore patients' concerns about the excessive wait times they experience, which are mostly the consequence of visible lines (Kim et al., 2009). As a result, there is a great opportunity for hospitals in emerging countries like India to restructure their systems and adapt to the best practices and technologies with enhanced procedures in order to better meet the needs of their patients (Natarajan, 2006). (Nat chair et al., 1994).

Because the outpatient department (OPD) serves as a conduit between the hospital and the community, it is crucial that it be designed with efficiency and throughput in mind. According to (McQuarrie, 1983). The medical services and the support line service that meet OPD needs must work together effectively (Krishnaiah, 2012). OPD management and patient satisfaction are influenced by the medical staff's interpersonal skills, the availability of necessary medications, the quality of the hospital's physical facilities, and the accessibility of relevant medical data (Natarajan, 2006). Therefore, it is important for the health and happiness of patients to work toward minimizing waiting time in medical procedures.

Poor hospital service operations result in patients waiting long periods of time to get care (DeLaet et al., 2015; Lochlin et al., 2015). Hospital operations suffer and patient satisfaction drops when there are long wait times (Basta et al., 2016; Bring Edal, 2016; Bachmann and Barron, 1997). This is due to a lack of coordination, poor management, and inadequate resources. Waiting time is one of the most prevalent issues in hospital service operations, and it has to be reviewed because of its importance in boosting patient satisfaction with service quality (Benson et al., 2001; Bluestein et al., 2014).

While many sectors utilize queuing theory to analyze and model processes that entail waiting lines in order to optimize the supply of fixed resources under circumstances of fluctuating demand, the healthcare sector has a very different perspective (Krishnaiah, 2012). To boost operational performances and cut down on wait times, hospital operations managers should be up-to-date on the state of business processes (Hall et al., 2006). Several analytical methods exist to help us comprehend the intricacy of a system's operation,

Among them is the queuing theory, a framework for investigating systems that have queues and comprise various actors including customers, service providers, and queues (Kay et al., 1996; Van Wyck and Wallaba, 2014).

II. ABOUT THE COMPANY / INDUSTRY / SECTOR

- *Industry Profile*

The act of waiting in line, or queuing, is a regular part of daily life. When the number of people waiting for a service exceeds the number of people who can provide it, a queue

form. The length of time someone must wait in line depends on three variables: the total number of customers (or patients) waiting and the ratio of servers to clients. Due to dissatisfied customers, the healthcare provider experiences monetary losses. It's a waste of the customer's time to wait in line when he might have used that time more productively. Therefore, the purpose of queuing is to minimize the amount of time people have to wait.

We use queuing theory, the mathematical study of lines and queues, for this aim. The goal of queuing theory is to create a model that can accurately forecast queue length and wait periods. The study of queues and how they function falls under the umbrella of operation research. A. K. Erlang's studies on queueing theory have its origin in the study of telephone infrastructure.

Since 1952, researchers have examined how queueing theory applies to the healthcare industry. However, most healthcare systems throughout the globe only make limited use of this important instrument. Services in a wide variety of healthcare settings are benefiting from the use of queuing theory and modeling. In hospitals, it has been used to cut down on wasteful spending. The inefficiency of hospital services has been shown by the length of waiting times. This is unfortunately common in many Indian hospitals. Decisions on the hospital's capacity are made on the basis of past experience rather than strategic research models.

The Arogya hospital in Rajkot sees a lot of patients every day, which means that wait periods for treatment are sometimes rather lengthy. To address this issue, this study examines Arogya Hospital's outpatient department's queueing system and proposes a methodology for shortening patients' wait times. Most hospitals and clinics use an appointment system, with patients being seen either in order of arrival or by treatment priority. According to McQuarrie's analysis (183), waiting times may be reduced by providing preference to patients who need less time for care. Patient flow is a critical component in maximizing the effectiveness of healthcare delivery. Patients wait less when the flow of patients is high, and they wait longer when the flow is low. Thus, current technologies like as queuing theory and modeling might be helpful in deciding issues involving capacity and resources.

In India, waiting is an accepted part of receiving medical attention, and long lines are a serious problem at many of the country's larger hospitals. A hospital's inefficiency may be reflected in a patient's wait time. When compared to other areas of hospital administration, the outpatient department (OPD) consistently experiences the longest wait times. In-depth examinations of OPD from a variety of angles are included in this research.

The outpatient department (OPD) of Fortis Escorts Hospital in Jaipur, India, is controlled more by experience and rule of thumb than by strategic research-based strategies like queuing theory, as is common in many large hospitals in India. Patients at Jaipur's Fortis Escorts Hospital may expect to wait longer than usual owing to the high volume of daily visitors. In order to address this issue, a SWOT analysis was performed on the Outpatient Department (OPD) at Fortis Escorts Hospital Jaipur (FEHJ). This allowed us to identify the root causes of the waiting room congestion and devise effective ways to alleviate them. Moreover, solutions were proposed to enhance the delay points and make the OPD more efficient following an analytical examination of the situation and the use of queuing theory.

- *Overview of World Market*

Medical care is severely constrained by the lack of available health resources. The challenge of how to most effectively and sensibly distribute healthcare resources has recently emerged as a pressing issue for hospital administrators. In-hospital emergency integration relies on a number of resources, one of which being beds. Although we can't be sure, we'll presume that factors like personnel levels and bed availability likewise have no effect on our chosen metrics. Adding more beds to a hospital means more money spent on idle resources; reducing the number of beds leads to longer wait times and worse patient satisfaction. As the scope of healthcare reform expands, so does the rivalry between healthcare facilities. In order to optimize service quality, profits, and market share while also considering societal advantages, hospital administrators must find a middle ground between the two.

As healthcare reform moves forward and is implemented, the average length of a hospital stay will be shortened scientifically and appropriately, making optimizing bed usage a fundamental problem that hospital management is paying particular attention to. Refined management, target management, clinical route management, day wards, medical prepayment systems, and pay-by-case systems are just a few of the management models that large domestic hospitals are investigating as they adapt to the contemporary medical climate. Researchers in the field have analyzed how people use their beds, with a focus on prospective cohort studies.

The findings demonstrate that bed usage may be efficiently increased by maintaining consistent and continuous patient consultations, physician transfers, and discharges of physician consultations from Monday through Sunday. The study's authors delved at three facets of the appointment system: patient waiting times, system architecture, and service use analyses [9]. They compiled the findings of several experts who have studied the application of queuing theory to the healthcare system and then used those findings in the context of individual clinics, hospitals, and even whole regions. Scholars who are relevant to this discussion use a hospital as an example to divide patients into those who are seriously sick, those who are not, and those who do not have appointments. In order to examine the hospital's unique circumstance, they used a simulation of patient flow in the emergency department informed by understanding of queuing theory. U.S. hospital bed use was analyzed using a simulation model developed in Subscript 11.5 that considers a number of factors, including patient diagnosis, admission categorization, duration of stay, bed type, and patient gender. It is the hospital's or nation's policies that have the most impact on bed usage on a macro level.

They include the minute details of the hospital, such as where and how patients are put in their beds and how new patients are admitted. Utilization efficiency of hospital beds in a specific Canadian region has been the subject of research and evaluation by academics. Out of the overall study population of 2007, 14.2% did not match the admission requirements, and the average duration of hospital stay was 14.194 days (22.8 of which were excessive). The research looked at the causes of hospital stays that were too long and found that doctors were responsible for 49.2% of those [18]. In spite of a regional drop from 5.9 to 5.39 days, 10.5% of hospitals still have average lengths of stay that are too long relative to the rest of the country. This research demonstrates that inefficient hospital operations and decreased alternative services might result from inappropriate bed use. According to some research [22, 23], the hospital bed capacity may have a nonlinear structure, with management evaluation being influenced by environmental uncertainty. Bed size is currently determined using a straightforward modeling-based calculation approach.

➢ *Overview of Indian Market*

The healthcare system is plagued by long wait times. Almost all of us have experienced the frustration of waiting days or weeks for a doctor's appointment or scheduling a treatment, only to arrive and wait some more before being seen. The waiting rooms at hospitals are often full with people looking for beds, and patients often have to wait for their surgeries or diagnostic tests to be performed.

When there is a disconnect between service demand and supply, delays occur. Typically, this discrepancy is only transient and results from the inherent wiggle room in both demand and service delivery times. A basic example would be a healthcare \clinic where individuals come in without appointments in an unpredictable \fashion and seek anything from a flu vaccine to the setting of a broken limb.

This unpredictability and the interplay between the arrival and service processes make the dynamics of service systems exceedingly complicated. Thus, without the aid of a queueing model, it is difficult to foresee degrees of congestion or establish how much capacity is required to reach any desired level of performance.

When trying to calculate the capacity needs of the Danish telephone system in 1904 (see Brookmeyer et al., 1948), A.K. Erlang created the notion of queueing. It has since found widespread use in a variety of service-oriented industries, such as banking, aviation, and telecommunications (see, for example, Brewton 1989, Stern and Hersh 1980, Halloran and Byrne 1986, Bruscia et al. 1995, and Brigand et al. 1994), as well as emergency services (see, for example, Larson 1972, Kloser et al. 1975, Chest and Balich 1981, Green As this chapter progresses, we will also cover its use in a variety of medical contexts. Decisions concerning resource allocation and the development of new services, as well as the determination of staffing, equipment, and bed requirements, may all benefit greatly from queueing models.

➢ *Growth of the Company / Industry / Sector*

The steady-state performance of a system is the primary focus of queueing theory.

For the most part, queueing models assume that the system has been running with the same arrival, service time, and other characteristics for a long enough time that the probability distribution for the queue length and customer delay is independent of time. Clearly, time of day, day of the week, or seasonality influences many service systems, including health care systems. Starting with the assumption that systems are in steady state, the next few sections will cover how to handle systems with time-varying properties.

- *Time Lags, Resource Consumption, and Overall System Scale*

Utilization, in queueing theory, is the proportion of active servers to the total number of servers multiplied by 100. From a management point of view, a high utilization rate is perceived as an indicator of efficiency, making it an attractive goal to strive towards. Occupancy level is the measure of use in hospital bed planning, and traditionally, a minimum occupancy level of 85% has been used by states to make a conclusion under Certificate of Need (CON) laws that extra beds could be required (see Becher and Spezia 1995). There is a common belief among medical professionals that there are too many hospital beds despite the fact that the real average occupancy rate for nonprofit hospitals is now around 66%. This misconception is largely responsible for the almost 25% drop in hospital beds that has occurred during the last two decades.

However, if bed availability is calculated based on current patient counts, it may take a very long time for people to be admitted (Green 2003). Regardless of the kind of queueing mechanism, wait times will always increase as average use rises. However, keep in mind that this is a nonlinear connection. See Figure 1 for an illustration of this principal link between wait times and utilization in a queueing system. It's possible to draw three important conclusions from this graph. To start, average delays tend to rise steadily in tandem with average usage (or occupancy rate). Second, the average delay rises more substantially following an "elbow" in the curve, even while the utilization increases by only a modest amount. In the end, when usage equals one, the average delay becomes infinite. (It should be stressed that this is predicated on the infinite length of the wait and the persistence of consumers in it.)

➢ *About Major Companies in the Industry*

When it comes to patient care, many hospital resources are limited in both time and quantity. beds, operating rooms, imaging devices, etc. are examples of such "things" rather than people. However, queueing models aren't necessarily the best approach to look at these kinds of resources. In particular, there is little to no chance of congestion if patients for a resource are scheduled into regular time slots, unless people habitually appear late or the time slots are not big enough to accommodate most patients. This is the case, for instance, with an MRI machine that is only utilized on prearranged occasion.

Managing several healthcare facilities is challenging since patient needs are unpredictable and hence treatment must be delivered quickly. The majority of a hospital's departments fall into this category since they focus on treating patients who were admitted unexpectedly. Queueing models are very useful in these situations for forecasting future capacity requirements.

- *Incorporating the M/M/s Model*

Take the obstetrics department as an example to see how a queueing model might be used to assess available resources. The number of postpartum beds, for example, may be planned for without worrying about affecting other areas of the hospital's capacity. It's also one that benefits greatly from the use of the usual M/M/s queueing approach. Studies of unplanned hospital patients have proven that the assumption of Poisson arrivals is a good one; this holds true for obstetrics patients as well.

III. LITERATURE REVIEW

Research on the causes of patient and doctor waiting times has been focused on consultations at general hospitals (Park, 2001), where it was shown that healthcare provider characteristics, consultation characteristics, and patient characteristics all had a role in determining wait times (Hwang, 2006). Waiting time and utilization analysis (Yeo et al., 2014) can be used to categorize the literature on the application of queuing theory to healthcare service, which can then be broken down into literature on reneging (Broyles & Cochran, 2007), variable arrival rate (Worthington, 1987), priority queuing discipline (Firms et al., 2015), and blocking (Koizumi et al., 2005); whereas system design (Bruin et al., 2007). Department-level studies have included the Internal Medicine (Hwang, 2006), Orthopaedics (Yeo et al., 2014), Emergency Room (Kim et al., 2009; Mandelbaum et al., 2012), Radiology (Park &Kwang, 2009), and Magnetic Resonance Imaging (MRI) (Green &Saving, 2008) departments, while healthcare centre-level studies included the entire outpatient department (Park, 2001; Ko, 2010; Kim et al., 2008).

Queueing theory provides a mathematical framework for analyzing wait times in healthcare systems (Oscan, 2006). Extensive literature evaluation confirms that queuing theory may be utilized to reduce patient wait times in hospital settings (Green, L.V.2006a; McQuarrie, D.G.,1983; Siddhartha et al.,1996). The use of queuing theory to healthcare service operations has been the subject of several published studies (Adele and Barry, 2005; Vials and Millard, 2003; Vasa Nawala et al.,, 2005). Across India's healthcare system, this essential tool is often underutilized. Green, L.V. (2002), Kim et al. (1999), and many others have studied the effectiveness of queuing analysis in improving service delivery in busy hospital settings like emergency rooms (Green et al, 2006). Appointment systems are crucial to the smooth functioning of hospitals, and queueing is often implemented using either a first-in, first-out system or distinct patient classifications depending on priority, such as the emergency department (Adele et.al, 2005). By determining which patients need less time for care, waiting times may be optimized on a priority basis.

In 1983 (McQuarrie, D.G.) Green (2006a) provides research on queuing theory models and study of how long waits affect patients in the emergency room in Green (2006b) (Siddhartha et al., 1996). Good patient flow results from little queuing, whereas bad patient flow is caused by delays in the line that cause patient suffering (Hall et. al,2006). Resource allocation and capacity planning are useful tools for estimating future health care needs (Murray, S.C.,2000). Queuing theory may be utilized to offer either a precise or an approximate estimate of performance measurements, depending on the probability assumptions applied (Daulat ani et al., 2016). Since these assumptions are seldom met, the findings are approximations (Cochran et al., 2006).

According to the definition provided by Lewis, Bernard, and Booms (1983), service quality is the degree to which an organization consistently exceeds its customers' expectations. Perceived service quality is the result of an assessment process in which customers evaluate the quality of the service they got with their expectations (Greenrooms, 1984). Service Quality Gaps and Strengths (SERVQUAL) is a diagnostic approach advocated by Parasuraman et al. (1991). Numerous service industries, including healthcare, have adopted SERVQUAL as their go-to tool for measuring service quality (Carman, 1990; Kilbourne et al., 2004). The term "service quality" refers to the degree to which a product or service is satisfactory to its intended users (Lewis and Booms, 1983). When a customer's expectations are high yet they get subpar service, they may become dissatisfied (Parasuraman et al., 1988; Lewis and Mitchell 1990).

- *Problem Statement*

The research uses a time study approach to apply queueing theory to the optimization of waiting times in healthcare settings. Over the course of a week, researchers observed the OPD's routine and identified potential bottlenecks by recording the amount of time spent on each stage of a patient's appointment.

The field of operation research known as "queuing theory" analyzes all aspects of waiting in line, from the rate at which customers arrive to the capacity of the waiting area, the average length of time it takes to complete a service, the speed with which customers' requests are fulfilled, and the effectiveness of queue management.

Medical waiting lines may be analysed with the help of queueing theory. Queueing analysis may be utilized for both short-term actions and long-term facility and resource planning in the healthcare sector because of the inherent flexibility of most healthcare systems to deal with unplanned fluctuations.

Waiting times, the number of customers, the number of servers, the number of system spaces, and the kind of customers (who might be humans, data packets, vehicles, or anything else), are all factors that queue theory considers.

Queueing theory is applicable to many different fields in the real world.

➢ *Objectives of the Study*
- Finding the optimal service rate and number of servers to reduce the average cost of being in a queue system and the cost of service is the goal of a queuing model.
- When a group of consumers arrives at once to get a service, this is a classic example of a queuing issue.
- Hospital service efficiency may be greatly enhanced by careful control of patient flow.
- This include taking care of patients when they arrive, providing service to them, and
- Procedure and waiting time, which has a major effect on healthcare delivery.

IV. RESEARCH METHODOLOGY

❖ *Methods for Data Collection & Variables of the Study*

➢ *Methods for Data Collection*
- Primary Data
- Secondary Data

- *Primary Data*

Primary source of data was collected by questionnaire.

- *Secondary Data*

Books and journals were used as secondary sources of information.

Logistics for magazines on the internet.

➢ *Sampling*

The sampling approach used for data collection is convenient sampling. The convenience sampling technique is a non-probability approach.

- *Sampling size*

The number of individuals to be polled is indicated by logistics. Although big samples provide more trustworthy findings than small samples, owing to time and financial constraints,

➢ *Analytical Strategy*

Graphs and charts are used to depict diagrams.

Following the use of the relevant statistical methods, logistical conclusions will be formed.

Findings and recommendations will be provided to make the research more helpful.

V. CONCLUSION/SUGGESTIONS

Since the OPD coordinators have a hard time keeping track of patients on Mondays, Thursdays, and Saturdays—days with the highest patient volume—it is essential to prioritize hospital operations in accordance with need, benefit, and practicality. Signage should be lowered somewhat to draw attention to the new registration counter, which is where the registration forms should be kept. Due to limited space, each patient should be limited to no more than two companions, and those companions should be given instructions on what to do as soon as the patient reaches the main lobby. Managers of waiting rooms may sort people into new and returning categories and ensure that no appointments are booked during doctors' rounds in the clinic. The length of time people think they have to wait may be cut down with the use of amenities like comfortable seating, televisions, air conditioning, etc.

The "When" treatment is offered (i.e., how quickly a patient can get in to see a doctor) is the single most important factor in determining whether or not a patient will be satisfied with their hospital experience. This research analyzes and applies queuing theory to hospital operations to enhance the process efficiency of outpatient departments (OPDs), where patients often spend a significant portion of their time waiting for treatment. It's common knowledge that patients aren't happy when they have to wait a long time in line, and that the feeling of having to wait is far more bothersome to them than the actual waiting itself.

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