Queuing theory is the formal study of waiting in line and is an entire discipline within the field of operations management. This article will give the reader a general background into queuing theory, its associated terminology, and how queuing theory relates to customer or patient satisfaction. Queuing theory has been used in the past to assess such things as staff schedules, working environment, productivity, patient waiting time, and patients waiting environment. In hospital, queuing theory can be used to assess a multitude of factors such as prescription fill-time, patient waiting time, patient counseling-time, and staffing levels. The application of queuing theory may be of particular benefit in hospitals with high-volume outpatient workloads and/or those that provide multiple points of service. By better understanding queuing theory, service managers can make decisions that increase the satisfaction of all relevant groups — patients, employees, and management.

**KEYWORD:** patient satisfaction; queuing

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**INTRODUCTION**

Waiting in lines or “queues” seems to be an general phenomenon in our day to day life. Think about the many times you had to wait in line in the last month or year and the time and frustration that was associated with those waits. Whether we are in line at the grocery store checkout, the barbershop, the stoplight, hospital or in the pharmacy, “waiting our turn” is part of our everyday life.

Queuing theory is the formal study of waiting in line and is an entire discipline within the field of operations management. The purpose of this article is to give the reader a general background into queuing theory and queuing systems, its associated terminology, and how queuing theory relates to customer or patient satisfaction. Also, past and present applications of queuing technology and what staffs can do to manage patient or customer queues more effectively will be discussed. Finally, automated queuing technology will be described.

Queuing theory utilises mathematical models and performance measures to assess and hopefully improve the flow of patients through a queuing system. Queuing theory has many applications and has been used extensively by the service industries. Queuing theory has been used in the past to assess such things as staff schedules, working environment, productivity, patients waiting time, and patients waiting environment. In hospital, queuing theory can be applied to assess a multitude of factors such as registration fill-time, patient waiting time, patient counseling time, and receptionists and technician staffing levels. The application of queuing theory may be of particular benefit in receptionists with high-volume outpatient workloads.
and/or those that provide multiple points of service, such as those in the Department of Veterans Affairs (VA), Department of Defense (DoD), university health systems, and managed care organizations. Problematic queuing systems (ie, long lines) can lead to the patient’s perceptions of excessive, unfair, or unexplained waiting time—resulting in significant detrimental effects on the patient’s overall satisfaction with the service transaction.

**QUEUING SYSTEMS AND TERMINOLOGY**

On the surface it may seem like queuing is just simply waiting in a line. To most patients, the waiting experience is all that matters. However, waiting in line is just a part of the overall queuing system. A queuing system (also known as a processing system) can be characterised by four main elements: the arrival, the queue discipline, the service mechanism, and the cost structure.

The arrival is the way in which a patient arrives and enters the system for service. Whenever patients arrive at a rate that exceeds the processing system rate, a line or queue will form. Arrivals may come in singly or in batches; they may come in consistently spaced or in a completely random manner. A potential patient can also leave if, on arrival, he or she finds the line too long—this is called balking.

The queue discipline is the rule for determining the formation of the line or queue and the order in which jobs are processed. There may only be one line and jobs are processed first-In, first-Out or FIFO. Others may have more than one line to give certain patients priority such as express lanes in reception counter.

The service mechanism describes how the patient is served. It includes the number of servers and the duration of the service time—both of which may vary greatly and in a random fashion. The service time may be similar for each job or it could vary greatly.

The cost structure specifies the payment made by the patient and the various operating costs of the system. Other elements that impact the queue structure and performance include the number of service counters and the number and speed of servers.

**THE IMPORTANCE OF QUEUING MANAGEMENT**

Hospital, like other service oriented industries, functions in an increasingly competitive environment. Speed of service has been shown to provide businesses a competitive advantage in the marketplace. In addition; the literature reveals several studies documenting patient dissatisfaction with long waiting times and indicates that this is a pervasive problem in hospital practice and a common source of anxiety and dissatisfaction among patients and, in many cases, hospital staffs.

Speed of delivery is being emphasised increasingly and can be partly attributed to increased competition and the value a patient places on his or her time. We live in a society who has come to expect film development and eyeglasses to be ready in an hour or less. A brief story told from the patient’s perspective will help to further illustrate this point:

I just arrived at my local hospital to get a new prescription filled and to pick up a few other things. There is a line of four people at the registration counter and another six people sitting in the waiting area. By the time I get to the counter to hand the cashier/technician my prescription, 5 minutes have passed. I ask how long the wait will be and I am told 30 to 40 minutes. I go about my shopping and return to the pharmacy 35 minutes later. Again, there are people in line at the register and it takes me another 5 minutes to find out that my prescription is
not ready. Feeling weary and somewhat frustrated, I have a seat in the waiting area. As I sit there, I watch people come and go and wonder, “Wasn’t I here before that guy?” At last my name is called! I pay the cashier and my pharmacy encounter is complete. However, I don’t feel good about it. Why did I have to wait so long? Did others get special priority over me? Maybe another hospital or pharmacy will service my needs better? Am I a satisfied patient or customer?

QUEUING APPLICATIONS IN SERVICE INDUSTRIES

Queuing management has been applied very successfully in many service-oriented industries. L. L. Bean, a large telemarketer and mail-order catalog house for high-quality sporting goods and apparel, used queuing theory to optimize staffing levels — resulting in an estimated $500,000 per year savings. The Department of Motor Vehicles in Virginia and Arizona used queuing technology to virtually eliminate long lines and greatly improve customer satisfaction. In addition, they were able to significantly improve employee morale and reduce operating costs.

Queuing models have also been used to plan staffing levels in an outpatient hospital laboratory department and a centralized appointment department in Lourdes Hospital in Binghamton, New York. Queuing models were used to identify an optimal configuration of capacity and staffing levels for both departments. The lengthy delays in answering telephone calls in the centralized appointments department were completely eliminated by rearranging work shifts of current employees.

The Virginia Mason Medical Center in Seattle, Washington used queuing theory and other classic quality management principles to drastically reduce patient waiting time for appointments (42 days to 13), emergency room triage time (45 minutes to 15), and increased staff morale.

Queuing theory has been used extensively in the banking industry to increase business by careful placement of merchandising materials while at the same time alleviating both the actual and perceived amount of time a customer spends waiting in line. Finally, queuing theory has been applied to computer simulation models to help with business decisions and problems.

PATIENT SATISFACTION AND PATIENT BEHAVIOR

In general, patient satisfaction is multi-factorial and is considered a part of overall patient behavior model. Patient behavior evolves over time and is influenced by many factors. Several key factors that greatly influence satisfaction include patient’s expectations, attitudes, and intention about the service provided.

Expectations are the patient’s anticipated beliefs about a product or service prior to the interaction. Attitudes consist of the patient’s evaluations, emotional feelings, and action tendencies toward a product or service that has developed over time. Intentions are the decisions the patient makes about future actions toward the hospital producing the health service. Together, these factors influence the future behavior or the actual future action taken by the patient.

For the most part, these factors are intangible so it is the perceived performance rather than the actual performance that is more critical to patient satisfaction. The main goal of queuing management is to maximise the level of patient satisfaction with the service provided. Therefore, the primary issue in queuing management and patient satisfaction is not the actual amount of time a patient waits for service, but the patient’s perception about that wait and the associated level of satisfaction. A highly satisfied patient will be very likely to provide repeat business and
spread the positive experience by word of mouth (advertising), resulting in increased revenues and profitability. Conversely, a dissatisfied patient will most likely not provide repeat business and will be more than willing to share his or her bad experience with whoever will listen. This will have an obvious negative impact on profits and revenues.

PATIENT SATISFACTION AND WAITING TIME

Patient satisfaction has been defined as the difference between the patient’s perceptions of the experience and his or her expectations, which is many times based on past experience. Although it is possible to manage and decrease actual waiting time and to some extent to manage patient expectations about patient satisfaction, managing the patient’s perception of the queuing experience can be the vital element in satisfaction with the service interaction. The measurement of patient satisfaction as it relates to waiting time is highly qualitative and subjective, and the relationship is generally inverse in nature (i.e., in general, as waiting time decreases, satisfaction increases). This relationship was further expanded by Maister who, in 1985, postulated that satisfaction is dependent on patient perception and patients’ expectation.

Numerous scientific studies, journal articles, and textbooks have been published describing the relationship between customer satisfaction, waiting time, and consumer behavior. For example, one study examined customer attitudes toward waiting times in the hotel and restaurant industry and found that over 70% of all respondents were clearly concerned about waiting times. In fact, those most concerned about waiting times were generally more willing to pay more to avoid waiting in line and believed that quality is worth waiting for. The results of this survey indicate that queues do affect the satisfaction level of customers and their willingness to spend. In addition, this study also suggests that there is a point where a lengthy wait begins to affect the patient’s perception of quality.

Another study examined patient satisfaction with outpatient pharmaceutical services at a large university hospital. This study reported that of the patients who received prescriptions from university physicians and did not fill them at the university pharmacy, 21% went elsewhere to have their prescription filled because of the long waiting time, even though prescription prices were less expensive through the university system. Similarly, another study conducted in a large Veterans Affairs hospital reported that pharmacy redesign improved patient satisfaction because of a 50% decrease in patient waiting time.6 Finally, another article describes the relationship between waiting time and satisfaction in the context of social justice or injustice, as the case may be.

QUEUING THEORY IN HOSPITAL

Queuing theory and its application has gotten very little attention from hospital operations management; however, hospital practice could benefit by understanding and applying some of the concepts of queuing theory.

A publication, Operations Management for Pharmacists, briefly discusses queuing theory and customer wait-time management. The authors appropriately acknowledged that the advanced mathematical models used in queuing theory were beyond the scope of the book. Unfortunately, the only suggestion offered by the authors for managing perceived waiting time is to distract the customer by providing entertainment, refreshments, or comfortable conditions, such as television and coffee in the waiting area.

A literature search revealed few published articles in the area of hospital practice and queuing theory. Donehew and colleagues used queuing theory to address prescription queues and
work measurement assessment of prescription fill times. Similarly, Boyce and colleagues sought to determine the impact of a computerised waiting time program on order turnaround time in a hospital pharmacy.

Perhaps the most common and useful application of queuing theory in hospital operations is to reduce patient waiting time and maximise staff effectiveness. Lin and colleagues used workflow analysis and times study to identify factors leading to excessive waiting times in an ambulatory pharmacy at the University Hospital Inc. (TUH), Cincinnati, Ohio. In another study, also by Lin, work measurement and computer simulation were used to assess the reengineering of community pharmacies to facilitate patient counseling. Although queuing theory was never mentioned in these articles, the authors used many concepts similar to queuing theory’s and their results could be instrumental in designing queuing applications for reducing patient waiting time and improving staff utilisation.

In a study by Moss, queuing theory was used to assess the relationships among the number of pharmacy staff members, prescription dispensing process, and outpatient waiting times. He used a mathematical queuing model to estimate the probability of waiting time exceeding a given value, when prescription arrival and service rates and number of servers are known. The study revealed that the major factors determining outpatient waiting time were the arrival pattern of prescriptions at the pharmacy, sequencing of work, and percentage of staff at work.

Finally, Vemuri used computer simulation with a queuing model to assess patient waiting time in the outpatient pharmacy at the Medical College of Virginia. This study concluded that the most significant factor contributing to patient waiting times was the interaction between pharmacy service providers, specifically the typist and the technician.

Many different mathematical equations can be used to describe queue formation and behavior; however, the decision to choose one over the other is beyond the scope of this article. Although Moss provided the mathematical formula used in his research, most queuing research applications are now completed through some form of computerization due to the complexity of the models and the accessibility of off-the-shelf software and personal computers.

**WHO MIGHT BENEFIT FROM QUEUING APPLICATIONS**

It is true that many hospital or pharmacies do not experience problems with queues. However, there are many hospitals that do experience difficulties with queue formation. For example, hospitals that experience high-volume prescription workload frequently have difficulty in managing workflow and waiting times. This could also be true in hospitals that offer their patients multiple points of service (ie, bank teller design). Hospitals such as those in large managed care organisations, university health systems, and those in the VA and DoD typically fit this description.

It is safe to say that the traditional methods employed by hospitals to distract patients (eg, comfortable waiting area, coffee house, and television) would be of limited benefit in hospitals that fill in excess of 1,000 prescriptions per day and have patient waiting times that commonly exceed 1 to 2 hours for consultation.

Recently, however, automated queuing technology has been successfully developed and applied in areas of hospital practice that specifically address patient waiting times. Prior to this innovation, the most advanced queuing applications to manage patient waiting times in hospitals was a consecutive number ticketing system commonly found in barber shops and grocery stores.
QUEUING TECHNOLOGY IN HOSPITAL

Automated queuing technology (AQT) is primarily utilised in the federal sector and includes numerous hospitals in the DoD and the VA. However, several prominent nonfederal health organizations utilise AQT. Both the DoD and the VA operate very busy outpatient hospital departments, some filling in excess of 2,500 outpatient prescriptions and servicing over 1,000 patients daily.

Automated queuing systems are typically PC based systems that can track a multitude of useful information that was previously very difficult to quantify for hospital managers. Hospitals utilizing AQT can easily track variables such as patient arrival and departure time; patterns of arrival, prescription fill time, waiting time, and individual staff member productivity. In addition, AQT can track numerous points of service and different service categories (ie, certain patients may get priority service or can be used to track patient counseling) if desired.

Finally, AQT can also provide hospital patients with information that can directly improve their queuing experience, such as with a ticket with a unique number and the estimated wait time. This makes for a less confusing, more relaxed, and much more positive waiting environment for the patient.

CONCLUSION

Queuing theory is a powerful management tool that often gets overlooked, especially in hospital operations management. Proper application of this effective management tool can yield impressive results. There are volumes of additional material on queuing theory and in fact this paper has only touched the surface. The goal of this paper was to give the reader a general understanding of concepts, current technology, and applications of queuing theory as it relates to patient satisfaction and waiting time.

Undoubtedly, there are numerous factors—physical, psychological, and emotional, to name a few—that affect a patient’s perception of the waiting experience. By better understanding queuing theory and the various measures associated with patient waiting time, service managers can make decisions that have a beneficial impact on the satisfaction of all relevant participants: patients, employees and management. There are several tools such as computer simulation, modeling, and automated queuing technology that can assist in this process improvement endeavor.

Waiting in line will always be prevalent in our society and in our hospitals. As the health care industry continues to evolve, staffs are under continued and growing pressure to do more and more. Wouldn’t it be nice to practice hospital in a setting where the worry and burden of wait time management was eased, even eliminated — keeping patients happy and decreasing the anxiety of those behind the counter trying to provide the best hospital service?

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