Application of computer-based queuing theory in public hospital management

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Abstract. With the development of society, People's medical demand increases gradually, improve the quality of hospital services without delay. This paper studies the application of queuing theory model to measure the service efficiency of public hospitals, in order to provide the corresponding theoretical basis for optimizing the service efficiency of hospitals. By using queuing theory model research method, the service efficiency of different departments was analyzed and summarized, and the reasonable plan for different departments'location and medical resources was put forward. The results of the experiment show that departments with more patients can appropriately increase the number of medical staff, improve medical equipment and place it far from the registration hall; those with fewer patients can appropriately reduce the number of medical staff according to the actual situation Put It away from the registration hall. The queuing theory model can be used to measure the service efficiency of different departments in public hospitals, which can improve the service efficiency and patient satisfaction.

1. Introduction
There are a lot of visible and invisible queues or congestion in daily life, such as passenger ticket lines, busy local telephone and so on. With the development of computer science and technology, the research of queuing theory is changing with each passing day, and its application field is also expanding.

With the continuous development of society, People's medical demand is increasing. Due to the randomness of patients'arrival time and the time needed for diagnosis and treatment, it is difficult to arrange the consultation room and doctors reasonably. And different types of patients may need different tests, different tests may be distributed in different locations, and the number of queues may vary greatly. When patients have too many consultation rooms and medical resources are insufficient, patients will wait too long to see a doctor, which may cause patients to miss the best time to see a doctor, patients'satisfaction will drop, resulting in busy work. A clinic with fewer patients could be a waste of resources. Because medical facilities have limited resources such as consultation rooms and doctors, and because national health insurance policies allow patients to choose hospitals, most public hospitals are overcrowded and queues have become an inevitable problem. If hospitals blindly increase the number of doctors and consultation rooms, it will cause unnecessary idle, resulting in a waste of resources. Therefore, a balance point should be sought to minimize the queuing time for different types of patients in order to improve the utilization of resources, improve the quality of services and reduce the cost of services. This is also the problem that the modern hospital must face.
2. Related work
The basic idea of the queuing theory was that in 1909 the Danish mathematician, scientist and Engineer A. K. Herran began working on the design of the automatic telephone, then known as traffic theory. Into the 1950s into the study of transient states and approximation, optimization discussions. Since 1970s, people began to study queueing networks and asymptotic solutions of complex queueing problems, which has become a new trend of modern queueing theory. The research of queueing theory includes three aspects: the system's behavior, the system's optimization and the statistical inference, and the model is set up according to the data. The aim is to design and operate each service system correctly and effectively, and make it play the best effect.

At present, the management of domestic hospitals rely on experience and routine, less use of scientific and quantitative methods. And most of the application of queuing theory in hospital management, is aimed at the registration, medical treatment, medicine and other processes to optimize, and did not take into account the number of patients in different consulting rooms. This time, we will study the queuing time of different types of patients, and combine the actual data to give a reasonable optimization strategy. Queuing theory is an effective method to study the above problems quantitatively and scientifically by mathematical methods. Queuing theory, also known as stochastic service system theory, through the study of public hospital queuing system, scientific, quantitative, accurate description of the probability regularity of queuing system, for different departments to propose the optimal design, to meet the medical needs of different patients to the maximum, from the source to solve the problem of expensive, difficult to see a doctor.

3. Application of queuing theory in hospital management
Queuing theory:
The general queuing process is composed of input process, queuing rules and service process.
The input process refers to the regularity of customer arrival time.
Queuing rules refer to the rules by which customers in the queuing system wait, which can be divided into loss-based, wait-based and mixed-based. The queuing process is divided into two parts: Service Organization and service rules.
The service organization mainly is the single service desk, the multi-service desk series connection, the multi-service desk parallel connection, the service rule divides into first-come-first-service, later-come-later service, the priority service.
To solve the queuing problem, we must first study which model it belongs to. The queuing system model can be represented by the input process (x patient arrival time interval distribution) , service time distribution (Y) , the number of service stations (Z) , the system capacity limit (a) , the number of customers (b) , the service rules (c) , and X / Y / Z / A / B / c.
Application of queuing theory in hospital management:
In the queuing system of the hospital, the patient is selected as the object and the queuing system is established. To patients registered after entering the clinic waiting for the standard, into the queuing system clinic. According to the principle of first-come-first-serve, patients line up and enter the consultation room in turn for treatment. The patients leave the consultation room to express the completion of service and leave the queuing system. According to the related literature and practical test, the distribution of the time between arrival and service does not obey the specific distribution, so it can only do general distribution processing. At this point, the hospital queuing system for D / M / C (agreement in the above-mentioned actual situation can be canceled after three).
The event flow in queuing system includes patient arrival time flow and service time flow. Common distributions are poisson, deterministic, exponential, and Erlang distribution. In this paper, the patient arrival time flow is distributed according to Siméon Denis Poisson Distribution, and the service time is distributed according to index distribution, and we assume that the service time is the same in every clinic. Because the services of each clinic are independent, it can be thought of as a multiple single service desk model, or D / M / 1 model.
The queuing model of public hospital system is analyzed by the General Standard Model: (1) the input process-patient source is infinite, single arrival and independent, the arrival time obeys poisson distribution The arrival process is already smooth (the arrival interval and the expected value, variance are not affected by time). (2) queuing rules-single queue with no restrictions on the team leader, first come first served. (3) Service window-single service desk, each clinic working independently, complementary impact. (4) service hours-all consultation rooms have the same service hours and follow exponential distribution.

It is also assumed that the time between patient arrival and diagnosis is independent of each other.

4. Experiment

Experimental data set and Evaluation Index:

In response, we pulled data from three hospitals in Zhengzhou, whose names and addresses were kept secret because of hospital requirements. The data are all data set within 30 days, which has certain significance to describe the running state of the hospital in the near future. The hospital divided its departments into internal medicine, surgery, gynecology, pediatrics, stomatology, Otolaryngology, this study only studied these six departments. Patients' visiting time was evaluated by repeated experiments in each clinic.

This article aims at the patient's seeing a doctor the time to adopt commonly used five targets

(1) service intensity: describe the efficiency of the service and the degree of utilization of the service organization.

(2) average queue length: refers to the patient's mathematical expectation outside the consultation room waiting for service, records the LQ, the concrete calculation sees the formula (2),

(3) average queue length: the mathematical expectation of the number of patients in the system (both those who are seeing a doctor and those who are waiting in the queue), written as Ls, as shown in formula (3)

(4) average length of stay: the mathematical expectation of the patient's stay in the system (including the waiting time in the queue and the time of receiving the service), as recorded in WS, as shown in formula (4),

(5) average waiting time: refers to a patient in the queuing system waiting time of the mathematical expectation, as Wq, specific calculation formula (5).

\[ \rho = \frac{\lambda}{\mu} \quad (1) \]

\[ L_s = \frac{\lambda}{(\mu - \lambda)} \quad (2) \]

\[ L_q = L_s \rho \quad (3) \]

\[ W_s = \frac{1}{(\mu - \lambda)} \quad (4) \]

\[ W_q = W_s \rho \quad (5) \]

It represents the average arrival rate, the average number of patients per unit time, and the average service rate, the number of patients per unit time can be served (expected value).

Adjustable parameter setting in experiment:

We found out the total number of patients working an average of 10 hours per day in each department. And suppose each section serves one person for 10 minutes.
Table 1. Model parameter setting

| Parameter               | name | unit    |
|-------------------------|------|---------|
| Gynecology              | 1610 | Person  |
| Surgery                 | 4890 | Person  |
| Internal Medicine       | 2760 | Person  |
| Pediatric               | 1100 | Person  |
| Stomatology             | 500  | Person  |
| OTOLARYNGOLOGY          | 560  | Person  |
| Average service rate    | 6    | Person / hour |

Analysis of experimental results:

Figure 1. Service intensity data comparison

Figure 2. Comparison of mean team length data
The above results show that the number of patients waiting in different departments is quite different. When the service hours and the number of service desks are the same, the service intensity of surgeons is obviously more than that of other departments. Patients also queued longer than those in other departments, which means the more doctors' workload, the longer the waiting time, and the longer the waiting time, if you add registration, medicine and all kinds of auxiliary tests. So for departments with more patients, we can increase the number of doctors, which is equivalent to increasing the number of consultation desks, thus reducing the number and intensity of services. In the case of surgery, first of all, the number of service desks was increased from one to five, and all the five consultation areas were busy. Then all patients waited in a queue. By calculating the number of patients per table at this time.
was 97.8, the average patient arrival rate decreased to 9.78. To verify the validity of the model, compare the models before and after the optimization:

![Figure 6. Optimized departure time vs. arrival time image](image1)

![Figure 7. Optimized before departure time and arrival time image](image2)

As can be seen from the above graph, when the number of service desks is 1, the time of arrival and departure of patients varies greatly, which indicates that patients are waiting too long. When the number of service desks increased to 5, the difference between the arrival time and the departure time of patients decreased significantly, which indicated that the text map of patient's medical queue had a significant effect on increasing the number of doctors.

However, in the above model we ignore the location of different departments, different departments of the location, patients spend different time on the road, for the intensive service departments, we can put the department far from the registration desk, which can reduce the average arrival rate of patients
and reduce the service intensity. For the departments with low service intensity, put them near the registration hall. This can increase the doctor's load, reduce the waste of hospital staff resources.

Finally, we analyze the skill level of the doctors. The medical staff's technical level is skilled, is consummate, the diagnosis time is correspondingly shortened, the patient seeks medical treatment the waiting question to be able to obtain the alleviation. In surgery, for example, we reduced the diagnostic time to five minutes.

But any good doctor, when diagnosing a disease, must ask the patient the detailed history and carry out the necessary physical examination. Some experts believe that the consultation time should not be less than 10 minutes, whether it can be further shortened, only as a reference in the work. Waiting time and sojourn time.

5. Conclusion
This paper puts forward some reasonable suggestions for public hospital management by using queuing theory. The data obtained from the queuing model is only for the need of management, providing decision-making tools, and the key is to adjust by the doctor management system, rather than simply according to the results of the calculation. For example, based on the phenomenon of queuing and the results of the model,

We can propose the following improvements: According to the example of the hospital, we can invest in the expansion of the consultation room with more patients, improve the facilities and equipment, increase the number of medical staff, and solve the phenomenon of queuing To solve problems for patients; to improve the doctor's skill level in diagnosis and treatment; to effectively reduce the average time for diagnosis and treatment as well as the degree of fluctuation; to improve efficiency; to shorten the Waiting Time; and the hospital can also adjust the position of the consultation room appropriately. The consultation room with more patients was placed far away from the registration hall, and the Consultation Room with fewer patients was placed near the registration hall. At the same time, we can improve the order of medical treatment, reduce the workload of nursing staff, improve work efficiency, and improve guarantee for creating a good medical environment.

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