

# Research on “Shared Health Care” Service Based on Queuing Model-- Optimization and Evaluation of Breast Cancer Screening of Primary Care

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**Abstract:** With the application of queuing theory model, this paper regards breast cancer screening in primary health care service center as a queuing system. With the help of the tide of sharing economy, it puts forward a joint screening scheme based on M/M/s model under shared mode, and compares it with M/M/1 model of non-shared mode, shortens patient waiting time by sharing medical resources, plans existing resources reasonably, and enhances the comprehensive strength of primary health care system so as to optimize the screening of breast cancer at the grass-roots level.

**Keywords:** Queuing model; Shared health care; Primary health care; Disease screening

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## 1 Introduction

With the continuous improvement of the level of science and technology, under the background of “Internet plus”, the concept of sharing economy has infiltrated into the medical industry. At the same time, the strategy of “Health of China” points out that China should deepen the reform of the medical and health system, comprehensively establish a basic medical and health system, a medical security system and a high-quality and efficient medical and health service system, and improve the modern hospital management system with Chinese characteristics so as to strengthen the

medical and health service system at the grass-roots level and the construction of general practitioners<sup>[1]</sup>. Breast cancer is the malignant tumor with the highest incidence in women. Annual Report of 2012 China Cancer Registration shows that the incidence and mortality of female breast cancer increased significantly from 2000 to 2011<sup>[2]</sup>. Due to the complex cause of this disease, measures for breast cancer prevention have been strengthened throughout the country to diagnose and treat the patient early so as to reduce the mortality rate of breast cancer patients<sup>[3]</sup>. In the three-level system of disease prevention, primary prevention is more difficult. Secondary prevention is the key point, and its main means is to screen the disease. Through rapid, simple and effective detection methods, people who may be sick but look healthy are distinguished from those who do not have the disease. The purpose of screening is to diagnose and treat the patient's disease as early as possible. Screening can also achieve the purpose of primary prevention from the perspective of etiology, so as to find the high-risk groups for the target diseases of population, so as to take corresponding measures to prevent. The graded diagnosis and treatment system divide the primary health care into first level medical institutions, and the improvement of its diagnosis and treatment ability and service level helps to meet the growing medical service needs of the people, and it is also the main force for large-scale disease screening. This paper regards the disease screening of primary health care as a queuing

system, puts forward a joint screening scheme under the sharing health mode, and compares it with the non-shared mode scheme. The queuing theory model is used to compare the waiting time of patients under various optimization schemes of primary health care, and obtain the optimization schemes with different control factors.

## 2 Queuing model

A typical medical service queuing model includes patient arrival, patient queuing, medical consultation, and patient leave. The arrival of patients can be regarded as the input process of the queuing model, and the patient queue is the queue of the queuing system. There is the rule of first-come-first-served service in queuing. The primary medical service center is the service platform, which is changeable. After the patients leave, the patient and the primary service center constitute a medical service queuing system according to the number of service stations to construct the M/M/1 and M/s models.

## 3 Model establishment

### 3.1 Objects of screening

Women aged 35 to 69 in a certain district of a city are selected as screening objects. Through health education on breast diseases, all women who participate in breast cancer screening are examined after signing a consent form, which is unified to the primary health care community service center for disease screening. The community health service center appoints one physician to screen the breast cancer in the area, who will adopt the screening scheme with a combination of breast clinical physical examination, breast X-ray examination, breast ultrasound examination and breast magnetic resonance imaging examination. All lesions are based on pathological examination, and those with positive results for clinical physical examination and the suspected will be further examined by X-ray examination. The suspected patients with X-ray examination were diagnosed by ultrasound and magnetic resonance imaging<sup>[4]</sup>.

### 3.2 Model parameters

$\lambda$  is the average arrival rate of the screening object;  $\mu$  is the average service rate of the primary medical station;  $s$  is the number of the primary medical station;  $\rho$  is the service intensity;  $W_q$  is waiting time for

the screening object to enter the service queue to be examined.

### 3.3 Model analysis

a. M/M/1 model. It is assumed that the arrival of the screening object obeys the exponential distribution because the online appointment time is random; meanwhile, because the physical quality of the screening object is different, so the understanding of the disease and the service time is also different; Assumed that the service time of the medical service center obeys the exponential distribution, the disease screening is carried out by one physician so that it can constitute the queuing model of M/M/1. Through further observation and study of the screening work, there are the following data: the average number of screening objects in each community is 3980 on average, and if 29 screening objects are screened in the community service center every day, the daily arrival rate  $\lambda = 29$ . At the same time, it takes an average of 0.25 hours to complete a disease screening on the calculation basis of normal working days. Community service centers can complete an average of 32 screening cases a day, while the average service rate is  $\mu = 32$  in grass-roots health care stations. Since the grass-roots community is equipped with one screening physician, the waiting time for screening objects to enter the service queue to be examined is as follows using the M/M/1 model of queuing theory:

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{29}{32(32 - 29)} \approx 0.3021 \quad (\text{Working days})$$

Queuing time is too long to carry out the screening, because 0.3021 working day can be regarded as 2.42 hours.

b. M/M/s model. Based on the idea of sharing economy, establishment of shared medical resources, multiple community services of primary health care are selectively combined for breast cancer screening within its jurisdiction, and screening operations are merged to implement joint screening. At this point, the number of grass-roots medical stations in the queuing model will be increased, and the M/M/1 model will be changed and transformed into a resource-sharing M/M/s model. Here, we will increase the number of medical stations, calculate the waiting time for screening objects to enter the service queue and receive inspection respectively, so as to observe the optimal scheme through quantitative data (Table 1).

**Table 1.** M/M/s model

Model	Arrival rate	Service rate	Working day for wait	Waiting time (h)
M/M/2	58	64	0.1510	1.21
M/M/3	87	96	0.1007	0.81
M/M/4	116	128	0.0755	0.60
M/M/5	145	160	0.0604	0.48
M/M/6	174	192	0.5030	0.40

The above table shows the establishment of sharing medical resources. Through joint screening, the objects of screening subjects will have more choice to choose convenient and appropriate community service centers for screening so as to avoid long queues. Based on the man-hour measurement and queuing theory model used by Li Pu *et al*, the longest waiting time that patients can accept is  $34.02 \pm 7.07 \text{ min}^{[5]}$ , and the longest waiting time for objects of screening from queuing to service is 0.5 hours, namely 0.0625 working days. According to the tablet data, when the number of joint screening in grass-roots community service centers is 5, the waiting working day for screening objects is  $0.0604 \leq 0.0625$ , that is the screening work is optimized through the integrated use of resources without any additional cost.

#### 4 Result analysis

According to the data, for the grass-roots breast cancer screening, the M/M/s model with shared resources is significantly better than the M/M/1 model, mainly because it shortens the waiting time of screening objects. If we only consider shortening of waiting time, there are other optimization schemes: (1) To reduce the rate of patient arrival; (2) To enhance the rate of community service. In view of (1) the analysis, the decrease of patient arrival rate and the number of service can shorten the waiting time, but the total number of testing remains unchanged, in order to ensure the integrity of the screening work, it will prolong the screening time and increase the management cost. (2) To enhance the service rate of the community and shorten the waiting time, in terms of the service intensity of doctors, screening physicians must be increased, which will lead to an increase in the cost of human resources. From the equipment technology update, equipment update, speed up the testing speed, while the equipment cost increases; the improvement of personnel technology, the need to increase the cost of capacity enhancement. By comparison, the business

merger and resource sharing of multiple community service centers in primary health care can achieve the goal to shorten the waiting time of screening objects without increasing cost. At the same time, we should pay attention to whether the more resources you share, the better result you have. If there is too much combined joint screening, it will make screening doctors rush back and forth to various community service centers, resulting in reduced service intensity of doctors, thus increasing the waiting time of screening objects, which make the negative result.

Breast cancer is a kind of malignant tumor with a high incidence in women. The influence of traditional culture and the economic level has a certain impact on screening work. At the same time, the State Health and Family Planning Commission and the State Administration of Traditional Chinese Medicine jointly launched the implementation of grass-roots medical and health services, gradually enriched primary medical services, paid attention to disease screening, and established electronic health records for women with the gradual increase in people's awareness of the disease, for which, the breast cancer test results are integrated together, so as to avoid repeated tests and the waste of medical resources. It also facilitates the follow-up and return visit of the screening work. The screening of the M/M/s model under the shared resources can be further extended to other disease screening<sup>[6]</sup>.

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