New System for Chinese Hospital System Registration-What Are the Alternatives Ways and How They Work

Muyu Lei

Case Western Reserve University, Cleveland, 44106, U.S.A
mxl1323@case.edu

Abstract. The hospital registration system in China is a system that dispense hospital slots ordered based on the patients' registration time. This mechanism could face a problem of unfairness among patients; patients who have better registration devices tend to have a partial advantage over others and neglect the urgency difference among patients. Many alternative methods of registration have been raised to seek better solutions, including lottery mechanism, parallel matching system, and Gale Shapley method. These methods have been summarized into a presentative math model and have been evaluated based on their efficiency and equality based on pareto efficiency and the presence of blocking pairs and tried to find out the practical use of all these systems. Although some methods could be better in some special circumstances, the serial registration policy is still the most efficient and fair matching mechanism for most of the time. Thus, policymakers should continue refining its technological safeguards and tiered-urgency protocols to sustain its legitimacy and accessibility.

Keywords: Hospital registration, Game theory, Matching mechanism.

1 Introduction

1.1 Research Background and Theme

Waiting for a hospital slot for a long time has always been a challenging experience. Many patients reported that they felt depressed when they found out that the hospital was an outpatient facility [1]. Today, in China, many patients are still struggling to find a way to book an available hospital slot that suits their time preference. For most patients, online registration is their only practical way to register for a hospital slot [2]. One of the important ways they are registered is through a healthcare registration app, Alipay Healthcare. This is an app that allows patients to choose their preferred timeslots. Once they choose a timeslot, it is not available to other patients, and they can only choose another slot [3].

1.2 Research purpose and Significance

Many problems with the Alipay Healthcare system have been reported. First, since this first-come come first-served get mechanism heavily relies on the speed of the internet, wealthy individuals who could afford better computers and faster internet would have

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an unfair advantage in this slot registration race. Also, slot-gragetcoding makes this even more impartial; by using the code, slot-grabbing could register thousands of times in a second, registration for most slots for resale in the under-regulated market, allowing most patients to get tickets at a normal price. To solve this problem, some alternative methods have been proposed in previous studies. Based on surveys, researchers could evaluate these studies and find out what is important for patients: many patients would put convenience as their major influencer [4], while they would also consider effectiveness, stability, and fairness [5]. These influences could be a useful tool to evaluate the usefulness of the alternative method.

1.3 Research Method and Structure

In this research, these mechanisms have been summarized into a matching game: In this game, we assume that, for patients, they would want a slot with their preferred time; while for doctors, they could only provide treatment at certain time slots based on the hospital schedule, they are indifference for most of the time, although sometimes they have slight preference. Here, many alternative theories have been proposed, including the Lottery, the Parallel Matching Mechanism, and the Shapley method. These mechanisms had been compared based on the qualities that would affect the patients in previously mentioned surveys: firstly, it would be based on efficiency; the comparison would be based on checking Pareto efficiency, to see if there is any change that can be made to improve the overall efficiency. Also, the stability of the system would be checked; this includes checking for blocking pairs, pairs that would prefer each other over their current matching. Also, the fairness would be checked to see if the most needed patient gets an advantage in the matching.

2 Serial Dictatorship

2.1 Experiment

Serial Dictator is a kind of matching game that is currently used in China. This is a matching system based on a fixed priority order, where the agent with the highest priority gets to choose first. Then the second priority agent gets to choose and so on. This is a Pareto effect system that has high efficiency [6, 7].

The agents:

P = {p1,p2,...,pm} be the set of patients in a class

S = {s1,s2,...,sn} be the set of slots in the class

(si is ordered by time and s1 is the earliest, if a slot of doctor A and another one of B are at the same time, than the order is random between them)

The matching process:

$$\pi : A \rightarrow N,\ \pi(A\,i) \tag{1}$$

The number of seconds between the time when a patient gets a slot and the time when the slot is released.

hi is matched with aj (j is the one that π (a j) is the smallest among the remaining patients that are not matched with hk($1 \leqslant k \leqslant j-1$) if the patient doesn't exist, hi keeps spared.

$$\Omega : A \rightarrow N, \Omega(ai) \quad (2)$$

This Ω is calculated by the rule of priority, such as Ω(emergency)=3,Ω(pregnant)=2, Ω (regular)=1

hi is matched with aj (j is the one that Ω (a j) is the biggest in the remaining patients that are not matched with hk (1≤k≤j-1) if the patient doesn't exist, hi keeps spared.

2.2 Results and Discussion

The serial dictatorship showed a strong efficiency: based on the definition of Pareto efficiency, there is no way to reallocate goods such that at least one person would be better off without making someone else worse off in the serial dictatorship. Therefore, it should be considered efficient. For stability, there seems to be no blocking pairs; there is not any pairs would prefer each other than their current match, which means they can't come out with a better deal for them, but it could be unstable since agents have more significant influence on the outcome by selecting earlier, and the later agent could possibility dissatisfied with their result. For fairness, it might be controversial, as the priority agent would have a significant impact on the result. Other factors, such as the emergency of the patient, could also be a concern: a patient with a more serious problem might not receive special care under this mechanism [7]. Additionally, there are social factors worth noting. Individual utility maximization doesn't necessarily mean the maximization of the social overall utility. There might be a potential change across the priority that would increase the overall utility that could be abandoned [8].

Also, the ability of the system to maintain stability by exchanging the occupied slots for patients could help in the practical use [9]. They could form a matching cycle. Therefore, the patients find their favorite slots.

Although this mechanism might raise controversy about its fairness, it has high efficiency and high stability, which leads to significantly fewer conflicts among the patients, making this the most prevalent tool in the hospital to distribute its registration slots. This explained why some hospitals are still using this technique.

3 Lottery System

3.1 Experiment

The lottery system is a matching system that assigns matching groups based on randomized alignment. Each agent would get a result based on their randomized result. This seems to be an efficient way of assigning the patient, but it could result in potential problems.

The agents:

P = {p1, p2, …, pm}

P be the set of patients in a class

S = {s1, s2, …, sn}

S be the set of slots in the class (si is ordered by time and s1 is the earliest, if a slot of doctor A and another one of B are at the same time, than the order is random between them)

The matching process:

Assigned a random assignment π, an assignment that give each agent in P a new order $P\pi$, whereas π : p1,p2,...,pn→p π (1),p π (2),...,p π (n). Matching would be made based on the assignment: $A(P\pi(i))=Sn$ whereas $Sn \in S$ and all the patient would be assigned to a slot.

3.2 Results and Discussion

The efficiency of this system has a dramatic conflict, on one hand, in terms of Pareto efficiency: A lottery system can be Pareto efficient if participants' allocations cannot be improved without making someone else worse off, because each slots are randomly assigned; however, in terms of allocative efficiency. The system doesn't guarantee that the most preferred resources for all participants are allocated — a less-preferred outcome could still be efficient if no one can be made better off without making someone else worse off.

For stability, this system is very likely to be an unstable system since the randomly assigned slots are likely to have blocking pairs. They would likely do the switch to improve their positions, leading to instability. For fairness, the agents are treated fairly since they have equal chances of getting their preferred slots. For those who need the emergency slot, their lottery choice would be weighted. So distributive justice could be somewhat solved.

Although this system has a high level of efficiency, it is not likely to be a good mechanism for the hospital registration process. Since the high level of instability could create conflict within the patients, and the unfairness between different patient groups would make this conflict even worse. In real life, the lottery system could only be used in a small number of patients, who do not have urgency.

4 Parallel Matching Mechanism

4.1 Experiment

The Parallel Matching Mechanism is a system designed to allocate limited resources to participants across multiple independent and different channels. These channels operate simultaneously, allowing for the efficient and fair allocation of resources based on the specific needs or characteristics of the participants in each channel.

The agents:

Parallel Match (p,s)= $\cup 1 \leqslant i \leqslant k$ SDi(si,pi),

where:

SDi is its serial dictatorship sub-mechanism

Pi $\subseteq$ P is the subset of agents assigned to the ith sub-mechanism

si $\subseteq$ S is the subset of hospital resources assigned to the ith sub-mechanism

For $i \neq j$, si $\cap$ sj = $\emptyset$

The matching process:

This match is divided into three parallel processes,

1. Emergency channel: SD1(strict order by emergency)
2. Appointment channel: SD2(strict order by time)
3. General channel: SD3(both emergency and time)

4.2 Results and Discussion

For efficiency, each channel is efficient internally, since there are no ways to make improvements that could improve the overall level within the group. However, it is internally efficient within each channel. However, across each channel. There might be an erroneous gap between these channels. There might be changes that could be made within these channels that could increase the overall effectiveness of the mechanism. Therefore, the overall efficiency of the system could be low.

Also, for the same reasons, the stability would be problematic, as participants may feel they could be better off on a different channel; there could be blocking pairs across the channel. They are also going to feel that it is unfair within the channel, and it may potentially create unfair outcomes.

Different channels could sometimes be a good idea, since there are some hospitals that are putting this into practice. Most hospitals in Beijing are currently using this mechanism of registration [10]; however, the difference between different channels might raise concerns about the fairness among different channels. Patients might think that they could get better slots on different channels, therefore creating conflicts. This conflict, however, could be minimized if there is a requirement blocking.

5 Gale Shapley Method

5.1 Experiment

The Gale-Shapley method is known for Deferred Acceptance Algorithm. This mechanism deferred acceptance, making the stable as its first preference.

The agents:

Let the P be patients and S be the doctor that owns the slot.

Pre(P) be the preference of the patients and Pre(S) be the preference of the doctors.

A(P) be the arrangement of the patients and A(S) be the arrangement of the doctors.

Experiment:

Initialize: Set all A(pi)=null A(pi) and A(sj)=null A(Sj).

While there exists a free patient Pi:

Let Si be the next slot on Pre(Pi) preference list that he has not yet proposed to.

If Sj is free, assign A(pi) to sj and A(sj) to pi.

If Sj is matched to pk, compare pi and pk based on pre(Sj)

Repeat until all patient is matched

5.2 Results and Discussion

For efficiency, the Gale-Shapley method is efficient for proposers but not globally efficient. It maximizes the satisfaction of the proposers while potentially creating suboptimal outcomes for the receiving group.

For Stability: The Gale-Shapley method guarantees stability, as there are no blocking pairs, and the final matching is stable. For fairness: While the method is fair for proposers, it is unfair for receivers, as it does not necessarily allocate the best possible match for them. This creates an inherent bias in favor of the proposers.

This seems to be a good idea. However, in practice, doctors are mostly indifferent to the slots. Making this mechanism hard to work, so sometimes the patient's emergency could be taken into consideration.

6 Conclusion

The serial dictatorship is a useful tool in hospital registration. Its stability allowed it to avoid potential conflict within slots registration, since they would have no motive in changing the slots, and it requires a minimum of steps, making it very efficient in deciding the sequence. Other models have their own advantages: the parallel mechanism could function better in complicated situations, allowing the urgent patients to get more care in the hospital, and the lottery system could be used in small numbers of patients, which allows a quick decision. These models are all very important in the real world and have been used based on their social circumstances.

There are some limitations in the study, however, since practical data are hard to get, and the patients' information needs to be protected. Also, the survey of patients is not inclusive enough; more surveys could be done, and more ethnic groups should be included. Also, for regional, this study has been limited in China only, more study in different regional with different cultural background could be done. This conclusion is more theoretical than practical. In the future, more data could be generated to test our hypothesis.

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