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Research on the optimize doctor-patient matching in China

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Abstract. In China, patients are given the opportunity to know background information about their doctors, and patients choose their doctors to see. Due to the shortage of medical resources and the uncertainty of the quality of medical services, as well as some external factors, patients will prefer to choose well-known doctors in the hope of getting a better medical experience. In order to match the preferred healthcare resources, they may choose to lie to increase the chance of visiting the doctor. This study adopts a combination of theoretical modeling and algorithmic simulation. Through theoretical analysis, a framework model of doctor-patient matching is established. Doctors with different skills and experience, who select patients according to their conditions and their own preferences in the matching process, as well as patients with different conditions and preferences, who want to receive treatment by matching to a suitable doctor, are clarified. The Deferred Acceptance algorithm is written and operated to simulate the matching process where patients apply to doctors and doctors are screened based on their priorities. Analyze and evaluate the performance of Strategy-Proofness and Pareto Efficiency in matching by iterating the algorithm. In this case, the DA algorithm establishes a stable match between the patient and the physician despite the possibility that the patient may deceive his/her preferences. However, patient behavior may affect the efficiency and fairness of the matching process, highlighting the importance of transparency and integrity of the doctor-patient matching system.

Keywords: Deferred Acceptance, Strategy-Proofness, Pareto Efficiency, Doctor-patient relationship.

1. Introduction

China has experienced several major reforms of its health-care system, which have had a profound impact on the doctor-patient relationship in China. Public hospitals are the backbone of China's medical institutions, but are under pressure from insufficient funding and self-reliance requirements. Although the standard of medical care has been improving and the level of medical services has become more sophisticated, the gap between health demand and supply still exists. High drug prices, difficulties in seeking medical advice, and unreasonable use of medication are problems that have plagued the public's access to medical care in recent years. The people's demand for medical services has grown substantially, and problems such as high prices for existing medicines and overmedication have led to an imbalance between supply and demand, putting pressure on the medical system. It wastes limited medical resources, causes tension between doctors and patients, and affects people's trust in the entire medical system [1]. On top of that, China's medical resources are unevenly distributed, with high-quality medical resources mainly concentrated in big cities and well-known hospitals, resulting in patients' demand for famous doctors far exceeding the supply. When studying the doctor-patient problem, patients will be more likely

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to want to be treated by experienced, qualified and veteran doctors for a better medical experience. Patients can find more experienced doctors by knowing the ability, skill, and preference of the general practitioner through hospital posters and the Internet, as well as by comparing other information about the doctor (e.g., feedback from other patients, the doctor's reputation, and success stories). In order to avoid being treated by a younger doctor, patients may choose to exaggerate their condition to increase their chances of being seen by an experienced doctor. The authors' study showed anecdotal evidence in the mass media that patients often intentionally lie, mislead, and deceive the health care professionals who serve them. In addition to this, WebMD, a health and wellness website, found that nearly 45% of respondents admitted to lying to their doctors, more than 30% lied about diet and exercise, and about 40% lied about following their doctor's treatment plan [2]. Jiang and Yuan believe that this phenomenon may lead to some patients who can only be operated by senior doctors facing long waiting times, leading to deterioration of patients' conditions and affecting the quality and effectiveness of healthcare services [3]. Patients lying to obtain better healthcare resources can increase the burden on the healthcare system, exacerbate the shortage of healthcare resources, and affect the stability and efficiency of the entire healthcare delivery system [4]. Chinese patients can indirectly choose their surgeons by selecting their primary care physicians. Different doctors have different proficiencies and preferences for dealing with different conditions, and if a doctor is assigned to an area in which he does not specialize, his or her specialties will not be fully utilized, and work efficiency will be reduced [3]. Therefore, it is not enough to assign a patient to a physician based on the patient's preference alone; it is necessary to consider both the surgeon's and the patient's preference information, to realize two-way matching between surgeons and patients, and to determine a reasonable and effective physician-patient matching. If only one side of the surgeon's or patient's preference is considered and the other side's needs and preferences are ignored, unstable matching may occur. For example, a particular patient is assigned to a doctor whom he does not like and who is also dissatisfied with the match. Jiang and Yuan showed that in this case, it would be better to have another doctor whose preferences are more closely matched to those of the patient, thus affecting the effectiveness of the existing program [3]. To ameliorate this problem, this study aims to optimize the allocation of healthcare resources by using the Delayed Acceptance DA algorithm from the Stable Marriage Theory to create a stable match between patients and doctors. The effectiveness and fairness of this matching mechanism are also demonstrated using Pareto Efficiency theory.

2. Assumptions and definitions framework mode

Based on the current status quo, it is assumed that in China, the application is provided by the patient to the doctor, but the doctor has no power to reject it. Therefore, we try to apply the DA algorithm to reduce the incentives of patients to lie in order to alleviate the status quo in China. Find a stable match between doctors and patients based on their real needs. To improve the stability and efficiency of the medical service system. Assume in this framework mode:

D is the set of doctors

P is the set of patients

Both patients and doctors have their own preference lists that represent their ordering of doctors and patients, respectively.

Each patient $p \in P$ has a preference list

Each doctor $d \in D$ has a preference list

Patients may be matched to better doctors by exaggerating their conditions. Theory Strategy proofness is an important concept in mechanism design and game theory. A mechanism or algorithm is said to be strategy-independent if, for any participant, honestly reporting its true preferences is always the optimal strategy, regardless of the reports of other participants. [5] In other words, participants obtain the best outcome by reporting their true preferences and have no incentive to obtain a better outcome by misreporting or manipulating preferences. Pathak and Sönmez [6] argue that Strategy proofness is one of the attributes of DA and can be considered as an element of fairness. By encouraging participants to report preferences honestly, it reduces the likelihood of system manipulation and improves the fairness

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and efficiency of matching. In the allocation of medical resources, the use of strategy-independent matching algorithms can effectively reduce the phenomenon of patient exaggeration, optimize the use of medical resources, and improve the efficiency and quality of overall medical services. Second, each patient has its own Strict preference ranking. means that each element (e.g., doctor or patient) in the preference list has a unique ranking and no two elements are considered equivalent. In this ranking, each preference is explicitly above or below all other preferences, forming a linear, non-repeating order. And the patient applies to the doctor according to his or her preferences, and the doctor has the power of rejection through iteration. Considering the preferences expressed by the patient, the doctor temporarily accepts the application of the top-ranked patient.

3. Pareto efficiency

The DA algorithm is effective in ensuring Pareto efficiency in the matching process in cases where patients are likely to exaggerate their conditions in order to obtain a more experienced doctor. Patient exaggeration does not change the final matching result, thus reducing the incentive for patients to exaggerate their conditions.

3.1. Definition of Pareto efficiency

Lionel Robbins accepts Vilfredo Pareto's definition of efficiency, which states that a given allocation is efficient when and only when it is impossible to change it without incurring a loss to some people [7]. Thus, when reallocating resources, only those changes that improve the welfare of some without causing losses to others are considered welfare improvements. In other words, Pareto efficiency is a state of resource allocation in which no improvement can benefit at least one person without harming others.

3.2. The role of Pareto efficiency

The role of Pareto efficiency in this problem is to ensure that no possible re-matching can make some patient-doctor matches better without making other patient-doctor matches worse. In the China case, every doctor and patient have been successfully matched. Both doctors and patients have literally gotten their first choice, and no other doctors or patients have been made worse off as a result, which also reflects Pareto efficiency. It also means that resources are allocated most efficiently, and no individual can get more resources without harming others. The concept of Pareto efficiency is particularly important in doctor-patient matching because it ensures fair distribution and optimal utilization of healthcare resources. This efficiency is achieved through DA algorithms that ensure that the final matching result is fair and efficient. By taking into account the real preferences of both doctors and patients, DA algorithms reduce the incentives for patients to exaggerate their conditions and increase the efficiency of medical resources. Ultimately, each matching outcome is Pareto efficient, i.e., there is no possible reallocation that can make some doctors and patients more satisfied without harming others. This approach not only optimizes the allocation of resources, but also enhances the trust between patients and physicians and improves the stability and efficiency of the overall healthcare delivery system.

4. Deferred Acceptance Algorithm (DA)

The DA algorithm is a commonly used matching algorithm that was originally used to solve the stable marriage problem. In this algorithm, both parties involved in a match apply and accept based on their own list of preferences. In the last few years, the algorithm has appeared in an "iterative" (or sequential) mechanism for matching students with schools and universities on a very large scale [8].

4.1. Model Setting

Assume that patient P = {1,2,3} and doctor D = { A,B,C}.

Patient's preference list: the patient has a strict order of preference for the doctor, e.g., patient 1's preference is A≿B≿C.

Doctor's preference list: doctors have a strict order of preference for patients. For example, doctor A's preference is 1≿2≿3.

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and the priority order is in order according to Figure 1 and 2.

$\succsim_1$	$\succsim_2$	$\succsim_3$
A	B	A
B	C	C
C	A	B

Figure 1. Patient 1's preference

$\succsim_A$	$\succsim_B$	$\succsim_C$
1	2	3
2	3	1
3	1	2

Figure 2. Doctor A's preference

4.2. Steps in detail

1) Initial application: Each patient applies to the doctor they most wish to see based on their preference list.

2) Physician Screening: Each physician ranks the applicants in their own order of preference and rejects the lowest ranked patients who exceed their capacity. Patients who are temporarily retained will continue to be retained by the physician.

3) Recursive Application: In a subsequent step, all rejected patients will reapply based on the next physician on their preference list. Each physician combines the new round of applicants with the previously retained applicants, again sorted by priority, and rejects the lowest-ranked patients who exceed their capacity. Patients who are not rejected will continue to be retained by the physician.

4) Termination condition: the process terminates when no new rejections occur. Each physician is matched with the final retained patients and patients not accepted by any physician are not matched.

4.3. Application to the doctor-patient matching problem regarding the explanation of patient's exaggerated condition

In this example, however, we will hypothesize that Patient 3 lies about wanting to be matched to Doctor A. By iterating the DA algorithm

Patient 3 proposes a match to Doctor A, who rejects it. The preferred patient that should be Doctor A's first choice is Patient 1, and Patient 1 has been matched successfully. In addition to this, Patient 3's second choice is Doctor C. Patient 3 proposes a match to Doctor C, who accepts.

Doctor C's preferred patient is Patient 3, so Doctor C and Patient 3 have been matched successfully.

The patient submits a ranked list of preferences to the doctor and iterates until a stable match is reached, which ensures that no patient has an incentive to deviate from their assigned doctor. Balinski and Sönmez show that the DA algorithm is considered to be the "best" fairness mechanism because it is policy-proof and because it has the advantage of being policy-proof This is because it is strategy-proof and Pareto better than any other fairness mechanism (i.e., it is constrained to be efficient) [9].

4.4. Summary

By using the Deferred Acceptance Algorithm, patients apply to physicians based on their preferences, and physicians screen patients based on their priorities. The algorithm ensures that the final match is stable, and because the Deferred Acceptance Algorithm has Strategy-Proofness, the patient has no incentive to manipulate the match by exaggerating the condition. This matching method takes into account both the patient's preferences and the doctor's priorities, thus optimizing the doctor-patient

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matching process, reducing the patient's incentive to exaggerate his or her condition, and improving the overall efficiency and fairness of healthcare services.

5. Conclusion

In China's healthcare system, it is a common phenomenon that patients exaggerate their conditions in order to be matched with more experienced doctors. To alleviate this situation, the Deferred Acceptance Algorithm is used for doctor-patient matching. The algorithm takes into account the real preferences of both the doctor and the patient to ensure Strategy-Proofness and Pareto efficiency in the matching process. The patient applies to the doctor based on his or her preferences, and the doctor filters the patients based on his/her priorities, accepting the top-ranked patients for now and rejecting those who exceed the capacity. Rejected patients continue to apply to the next preferred physician until the matching process stabilizes.

Strategy-Proofness is a key attribute of Deferred Acceptance Algorithm, which ensures that participants honestly report the true preference as the optimal strategy, reducing the possibility of system manipulation. In healthcare resource allocation, strategy-independence reduces patients' incentives to exaggerate their conditions, optimizes resource utilization, and improves the efficiency and quality of overall healthcare services.

Pareto efficiency in the matching process ensures that no rematch can make some doctors and patients better off without harming others. This efficiency is achieved through the Deferred Acceptance Algorithm, which ensures fair matching results and efficient resource utilization, enhances trust between patients and physicians, and improves the stability and efficiency of the overall healthcare delivery system. Deferred Acceptance Algorithm can establish stable matching between patients and physicians despite the possibility of patients deceiving their preferences. However, patient behavior may affect the efficiency and fairness of the matching process, highlighting the importance of transparency and integrity of the doctor-patient matching system.

When it comes to resource allocation and solving the problems facing China's current healthcare system, Deferred Acceptance Algorithm is, in fact, an effective solution. In contrast, China's healthcare delivery system is markedly different from that of the U.K. Under the study by Ruth Leibowitz, Susan Day, and David Dunt, it was found that the RCT designed by the U.K. GP system, which integrates a nurse telephone counseling service (with the help of experienced, specially trained nurses using decision-support software) within an integrated healthcare co-op with the co-op's routine practice (receptionists recording call details and then passing them on to doctors) [10]. In other words, the allocation of doctor-patient resources is made by the GP, who first diagnoses and treats the patient and then refers the patient to a specialist. This allocation effectively reduces the tendency of patients to disguise their condition and helps to improve the efficiency of the whole healthcare delivery system. This is because patients cannot choose a specialist directly and must be referred through a GP. Even if a patient exaggerates his or her condition, he or she still needs to go through the assessment and judgment of the GP, whose professional judgment can, to a large extent, filter out unnecessary exaggeration and misreporting. This system ensures rational utilization of medical resources and improves the efficiency and fairness of overall medical services. At the same time, the key role of GPs in primary care and referral also enhances patients' trust in the healthcare system and reduces unnecessary doctor-patient conflicts. Therefore, the GP healthcare system in the UK is taken as the object of study in the following research. This will help to gain a deeper understanding of how the doctor-patient resource allocation mechanism works and can also provide references and insights for solving the problems faced by China's healthcare system.

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