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Current Situation in China's Organ Transplantation Market and Analysis on the Main Allocation Methodologies: Taking Kidney Transplantation as an Example

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Abstract: Organ transplantation is a surgical operation to rescue a patient who has organ failure by implanting the other people's healthy organ into the patient's body accordingly to save and prolong the patient's life. This is also one of the focuses of today's researches. Organ transplantation started relatively late in China, but since then, organ transplantation made a great progress in China in just a few years. But in the meanwhile, the organ transplantation market in China still faces various problems. This paper uses a large number of data, such as the number of people waiting for organ transplantation in different countries at different times and the distribution data of qualified organ transplant institutions in various regions of China, to analyze the problems faced by China in organ transplantation. It is found that organ transplantation in China, especially kidney transplantation, faces the problems of large demand gap and regional inequality. To meet these challenges, this paper explains four principles of allocation and then introduces two different allocation mechanisms as a reference for improving organ allocation in China.

Keywords: kidney transplantation, organ transplantation, organ allocation system

1. Introduction

1.1. The Background of Organ Transplantation in China

Since the Regulations on Human Organ Transplantation were issued in 2007, organ transplantation in China has begun to have a legal basis. Since then, the organ transplantation has begun to develop in a standardized way in China. The China Liver Transplant Registry (CLTR) and Chinese Scientific Registry of Kidney Transplantation (CSRKT) were started in 2008 and since then all the information including all the qualified medical institutions and all the patients' operative and postoperative information were recorded. In 2011, China promulgated the Amendment to the Criminal Law of the People's Republic of China (PRC) (VIII), adding the crime of organ trading, which made the field of organ transplantation more standardized. In 2010, China launched a pilot project of human organ donation to make organ donation in China more efficient and professional. In 2011, China Organ Transplant Response System (COTRS) was set up and online to use. The system applied the matching principles according to the priority of region, blood type matching, severity of illness and immediate family members of organ donors. The establishment of China Organ Transplant Response System

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makes the organ allocation more scientific and efficient in China. From 2015 to 2021, there were 34606 deceased donor organs in total. From 2016 to 2021, the number of deceased donor organ in China was 4,080, 5,146, 6,302, 5,818, 5,222 and 5,272 respectively [1]. The number of deceased donor organ in China is generally on the rise, which shows that organ donation and transplantation in China are developing rapidly, and the turn point at 2018 shows that the shift from high-speed growth to high-quality development [2]. However, with the booming organ transplantation in China, there are still some problems such as rising demand gap, inequality and inefficiency in organ transplantation.

1.2. Research Purpose

To improve the defects in the kidney transplantation market in China and to make more patients to get treatment, this study explores the problems faced by the domestic kidney transplantation market. After that, this paper compares the allocation principles and matching mechanisms of various countries, hoping to be a reference for improving the organ allocation and sharing in China.

2. Current Situation of Organ Transplantation and Donation

2.1. Demand Gap

In most countries, there are huge shortages of transplanted organs, such as the United States and Britain. In 2003, there were 85,000 people waiting for transplantation in the United States, and 6,000 of them died because they couldn't wait for organs to be transplanted. In the same year, there were 5,600 patients waiting for transplantation in Britain, and 400 people died because they couldn't wait for organs to be transplanted [3]. However, the gap between organ supply and demand in China is even more severe. In recent years, China has been able to complete more than 20,000 organ transplants every year, but there are about 300,000 patients who need organ transplantation are waiting in line, which means that only about two-thirtieth of them can complete the operation [4]. Through this data, it can be seen the huge of demand gap in China. In kidney transplantation, the shortages of organ transplantation resources in various countries are also very serious. Even in Spain, the country with the highest kidney donation rate in the world, there are still having more than 4,500 people waiting for kidney transplantation every year [3]. Almost all countries in the world have the problems of shortages of kidney for transplantation. In South Korea, more than 9,000 people wait for kidney transplantations every year. In Egypt, more than 10,000 people wait for kidney transplantations, but only about 10% of them can get them. In Netherlands, 11,000 people are waiting for kidney transplantations every year. In Japan, there are 14,000 people waiting for kidney transplantations [3].

The supply of kidneys in China is also not optimistic. At the end of 2016, there were 521,000 dialysis patients in China, an increase of 73,000 compared with 2014 and an increase of about 200,000 compared with 2013. However, in 2017, a total of 9,464 kidney transplantation operations were completed nationwide, which means that only one out of every 55 dialysis patients in 2016 can receive kidney transplantation in the following year (the ratio of supply and demand of kidneys is 1: 55) [5]. The large demand gap shows that the organ donation rate in China still needs to be improved. Although the number of organ donations in China is increasing, the organ donation rate per million population in China is still low compared with other countries. In 2017, compared with Spain, which ranked first with the organ donation rate of 46.9 per million people, China's organ donation rate per million people was only 3.67 [3]. In 2010, referring to Table 1, there were only 0.03 organs per million people in China, which means that there were only about 40 organ donors in China, while there were about 8,000 organ donors in the United States, 1,695 donors in France, 1,151 donors in Spain, 1,045 donors in Germany and 1,151 donors in Britain in the same year [3]. As shown in Figure 1, even in

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2021, the ratio of living organ donors in China is 2.3, which is still far behind from the highest rate in Turkey, which is 52.6 [1].

Table 1: Worldwide main countries organ donors in 2021 [3].

Country	Donors
USA	7998
France	1695
Spain	1615
United Kingdom	1151
China	40

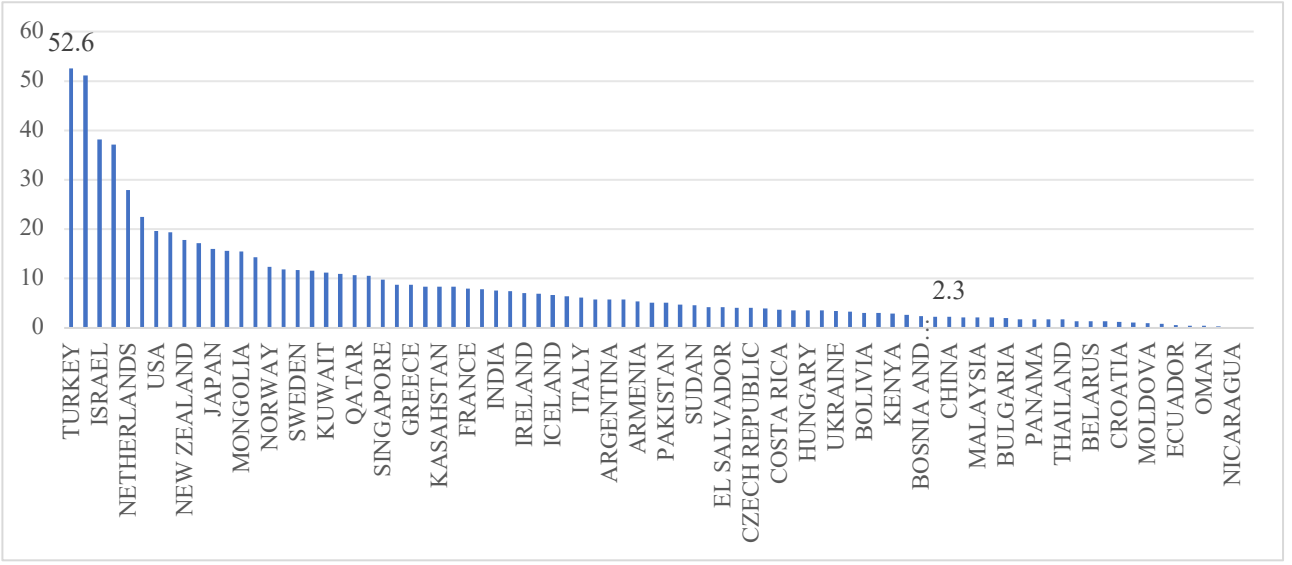

Figure 1: Worldwide living organ donors' rate 2021 (pmp) [6].

2.2. Regional Inequality

The development level and education level of citizens in different regions of China are imbalanced. Therefore, the medical level and the number of donated organs in different regions of China are different, which will inevitably lead to geographical inequality in the kidney transplantation market in China. A survey of patients' willingness to transplant and donate organs in the First People's Hospital of Kunming shows that education, occupation and whether they have heard of organ transplantation all have influenced on their willingness to transplant and donate organs [7]. The higher educational background and the higher proportion of people who have heard of organ transplantation lead to the higher rate of organ transplantation and donation. Doctors and teachers, who are highly educated, have a higher acceptance rate of organ transplantation and donation. The educational resources in different regions of China are different, and the education level of residents in some underdeveloped areas in China is lower than that in the developed areas. This leads to great differences in people's willingness to donate in different regions, and eventually leads to different organ donation rates. Therefore, the inequalities of organ supplies are severe in different regions in China.

According to Figure 2, the number of medical institutions with kidney transplantation qualifications varies greatly in different provinces and cities in China. By the end of 2019, Guangdong Province, the province with the largest number of qualified medical institutions for kidney

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transplantation in China, had 18 qualified kidney transplantation institutions, 18 times more than Tibet Province or Tianjin Province.

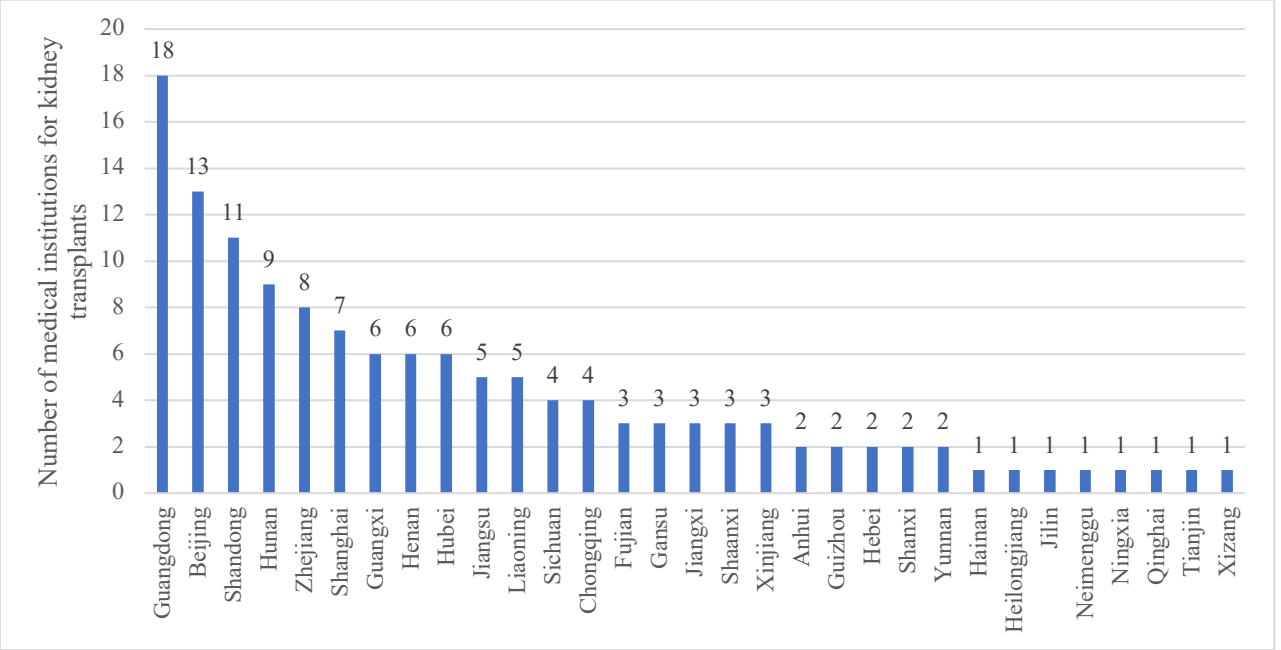

Figure 2: Geographical distribution of medical institutions for kidney transplant in China [8].

3. Methodology and Discussion

In view of the defects of organ transplantation in China described in this paper, this study will explore the organ allocation systems and the allocation principles around the world to analyze the advantages and disadvantages of these mechanisms in order to improve the existing organ transplantation system in China.

3.1. Allocation Principles

3.1.1. Utility Principle

The principle of utility is to maximize the overall happiness and interests. One application of the principle of utility in organ transplantation is to allocate resources in a way that saves the most lives. However, each available organ can only save one life in organ transplantation, so it needs to consider another embodiment of the utility principle in organ transplantation, the prognosis allocation. Prognosis allocation means giving priority to those who benefit the most from scarce resources, that is, giving priority to patients who may survive the longest after transplantation. When determining the overall utility of transplantation, the following factors need to be considered. First, survival rate of patients, this includes whether the patient will die while undergoing transplantation or waiting for transplantation. Second, the potentially harmful consequences, this includes related short-term morbidity and long-term morbidity. Third, whether the transplanted organ can survive for a long time which affects the retransplant rate of patients. Fourth, the quality of life of patients after transplantation. Finally, whether the patient has the possibility to take an alternative therapy. However, although the principle of utility maximizes the overall interests of patients, those patients with poor prognosis are likely to be abandoned, so the equality of this principle is still questionable.

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3.1.2. Equity Principle

The goal of the principle of equity is to provide all patients who meet the medical conditions of organ transplantation with equal opportunities. One of the equity allocation methods is to allocate organs that can be transplanted through the random selection, such as lottery. Under the lottery system, the distributor knows little about the receiver, so this will ensure that the distribution mechanism is unbiased, which will ensure the equality of the distribution system. However, this system ignores individual differences, which will lead to waste of resources and harm to the interests of some patients. For example, a young and healthy donor kidney can be transplanted to a 90-year-old man, or a patient with confirmed symptoms can't even get a donor kidney after waiting for a long time. Another method is the first-come first-served method. Like lottery distribution, this method seems to be equal, but ignores the differences between individuals.

3.1.3. Priority to the Worst-Off Patient

This distribution method gives priority to individuals who need treatment most, such as the most seriously ill or the youngest. This is because if people who are seriously ill are not treated in time, they will die soon, and if young people are not treated, their life span will be the shortest. The first option is to give priority to patients with serious illness. However, this choice does not consider the situation after treatment. Even after treatment, postoperative complications will still make patients live in pain, which means that the high cost of using scarce resources can only bring small benefits. In addition, this distribution method ignores patients with mild illness. The adoption of this method means that patients with mild illness are likely to have to wait until their condition worsens before they can get treatment. Another option is to give priority to the youngest patients, but this also fails to consider the situation after treatment, and it almost completely cuts off the possibility of the elderly being treated. In fact, elderly people are much more likely to get sick than young people, so they need more donor organs. While the number of patients younger than 50 years of age added to the wait-list for kidney transplantation has remained relatively constant during the last decade, the number of waitlisted patients over 65 years of age has tripled [9]. Therefore, this method is not equal for the elder.

3.1.4. Transparency and Autonomy

This principle holds that individuals should have the right to make their own decisions if their choices do not harm others. In other words, donors are allowed to bypass the official organ distribution process and donate to recipients with successful blood type matching. This method also can't ensure fairness, because some patients will use this method to buy the organs from donors, or exchange their organs with their relatives and friends to get the opportunity of organ transplantation. For example, in 2004, Todd Krampitz had liver cancer. In order to get treatment, Todd Krampitz encouraged people to donate organs in the media. This man wants people to donate the organ to himself directly, not to official institutions. As a result, one family did not give the liver to the system to save the person closest to death, but give it to Krampitz [10].

3.2. Allocation System and Algorithm

3.2.1. Allocation System

In the United States, the old kidney allocation system was used until December 2014 [11]. On the basis of local transplant hospitals, this system gives priority to candidates with the highest scores in

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each category. These scores are accumulated according to waiting time, matching degree, survival possibility of transplanted organs, age and so on.

The advantages of the system lie in that the score-based algorithm is simple, comprehensive and flexible, which includes almost all principles and any principle can be easily converted into scores and adjustable. However, its disadvantages are also obvious. First, because this system is allocated according to the listing time of transplant institutions, prejudice against race or economic status may lead to inequality in the allocation of transplanted organs. Second, old kidney allocation system is not fully considered the principle of maximizing interests. This mechanism does not take into account the matching of kidneys with age-appropriate patients, so some young patients need to replace new kidneys soon after transplanting aging kidneys.

In December 2014, UNOS/OPTN improved and implemented the new kidney allocation system [9]. The new kidney allocation system expanded the area of donor bank, which greatly improved the equality. At the same time, the new system implemented life-span matching, which made the donor kidney get the maximum utilization. In addition, the new system reduces the differences in blood types and dialysis years, reduces the differences in opportunities for ethnic groups to obtain transplants, which makes the distribution of kidney transplants more equal.

3.2.2. Top Trading Cycles Algorithm

Top Trading Cycles (TTC) algorithm is an optimal matching algorithm for one-way selection scenarios. One-way selection scenario means that only one of the two matching parties has the right to choose. TTC algorithm is an effective donor matching mechanism in renal transplantation.

The specific application steps of TTC algorithm are as follows: (1) Let the donor with the right blood type or the deceased with the right blood type match the patient, let the patient get as many donor kidneys as possible and form a circulation; (2) Patients who have already received a donor kidney are excluded and continue the matching among the remaining patients; (3) Repeat until everyone gets a donor kidney.

For the advantages of this algorithm, first, TTC algorithm is pareto efficient. In other words, TTC algorithm can achieve the most satisfactory distribution for most people without making anyone worse off. Second, TTC algorithm is not affected by policy. This means that no one can get a more satisfactory distribution result by lying about their preferences. For the disadvantage, first, donors may suddenly change their minds. It is illegal to forcibly remove the kidney of a reneged donor. Even if only one donor who once wanted to donate a kidney changes the mind, the donor and the patient whose operation has not been completed in the whole cycle need to be stopped and redistributed. This will slow down the efficiency of kidney transplantation and can even indeed have significant consequences, including the need to find a replacement donor and the potential risks for delays in transplantation. Second, the number of donor kidneys is not enough, so some patients can't get donor kidneys, and they need to wait on the list of patients. They may have to wait for a long time.

4. Conclusion

In order to improve the organ allocation system in China, this paper first discusses the defects of organ allocation system in China from the aspects of demand gap and inequality. After that, this paper explains the advantages and disadvantages of different allocation principles in organ transplantation to make reference for organ allocation system in China. These four distribution principles are: utility principle, equity principle, allocation based on giving priority to the worst-off patient and the principle of transparency and autonomy. Then, this paper explains how the old kidney allocation system works, and explores the advantages and disadvantages of the system. After that, this paper mentioned the improvement of the new kidney allocation system. Finally, this paper introduces the

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running process of TTC algorithm and its advantages and disadvantages in the application of renal transplantation.

There are seldom researches on the allocation mechanism of organ transplantation in China in recent years, and most of the researches focus on treatment, ethics and postoperative reaction. There are also relatively few specific mechanisms and data about organ transplantation allocation. Through the analysis of the specific defects of organ transplantation and kidney transplantation in China, this paper hopes to attract people's attention to the allocation mechanism of organ transplantation. At the same time, it is hoped that the analysis of allocation principles and mechanisms in this paper can contribute to the improvement of organ transplantation and kidney transplantation allocation system in China in the future. In the future, perhaps China can improve the existing allocation mechanism of organ transplantation, and solve the problems of large demand gap and regional inequality. At that time, perhaps more people will participate in organ donation in China, and people's attention and understanding of organ transplantation will increase.

References

[1] *IRODaT. The Number of Deceased Donor Organ in China. Retrieved from https://www.irodat.org/?p=database&c=CN&year=2015#data*

[2] *Huang, J.F, Zhang, Z.J., Guo, Y.H., Zhao, H.T., Ma, X.D., Hu, S.S, Zheng, S.S., Shi, B.Y., Wang, H.B., Chen, J.Y., Chen, J.L., Chen, L.P., Chen, S.P., Chen, Z.H., Du, B., Hu, C.X., Huang, J., Jin, H.L., Li, X.S., Liu, S., Meng, L.G., Shi, Y, Sun, Y., Xu, X., Zhang, T.Y., Zhang, W., Zheng, Z., Zhou, Z.S. and Zhou, Z.Y. (2020) Report On Organ Transplantation Development in China (2015-2018).*

[3] *Dai, S.P. (2015). Study on the Construction of Organ Donation System for Chinese Citizens. Retrieved from https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CDFDLAST2016&filename=1016031059.nh*

[4] *Economic Information Daily. Involve the Whole Society in Relay for Life to Improve the Rate of Voluntary Organ Donation. Retrieved from https://kns.cnki.net/kcms2/article/abstract?v*

[5] *Dong, P.X., Liu, X.F., Zhao, H., Huang, L.M., and Li, D.Y. (2023) Comparative Study on Legislation of Organ Donation at Home and Abroad. Medicine and Philosophy, 44, 53-57.*

[6] *IRODaT. (2020) International Registry in Organ Donation and Transplantation. Retrieved from https://www.irodat.org/img/database/pdf/Irodat%20year%202021%20_%20Final.pdf*

[7] *Li, C., Wang, Y.J, Ma, J.T., Zhou, Z.G., Jiang W.H., Yang L.H. and Li L. (2012) Investigation on the Willingness of Inpatients to Organ Transplantation and Donation. Chinese Journal of Bases and Clinics in General Surgery, 19, 478-485.*

[8] *Huang, J.F. China Organ Transplantation Development Report (2019). Retrieved from http://opac.lib.uibe.edu.cn/opac/book/83e5d150610bd9967dc7228ff794fe99*

[9] *Curtis, J.J. (2006). Ageism and Kidney Transplantation. American Journal of Transplantation, 6, 1264-1266.*

[10] *Chicago Tribune. (2023) Jumping to the Front of the Line for An Organ Transplant is Unfair. Retrieved from https://www.chicagotribune.com/news/ct-xpm-2004-09-01-0409010047-story.html*

[11] *Melissa, Y., Yeung, P., Coates, T. and Kam-Tao, L. (2022). Kidney Organ Allocation System: How to Be Fair. Retrieved from https://doi.org/10.1016/j.semnephrol*