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## Research Article

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# Health resources allocation analyzing of the western China

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## Abstract

**Background:** To achieve the goal "health equity for all", equitable and reasonable allocation of health resources is the basic material guarantee. As an area which owns more developing provinces and minority nationality region than other regions in China, the western China should get more attention in the health resources allocation while there was not.

**Methods:** Lorentz curve, Gini coefficient and Theil index were used to analyze the health resources allocation which including number of health institutions, number of beds, (assistant) medical practitioners, registered nurses in the western China from 2014 to 2018 from two dimension: population and geography.

**Results:** The total health resources shows an increasing tendency from 2014-2018; The Gini coefficients for health resources by population dimension were ranged from 0.057 to 0.13, in geography dimension the Gini coefficients ranged between 0.61 and 0.64. Meanwhile, the Lorentz curve in population dimension had a smaller curvature than in geography dimension; In two dimensions, the intra-group contribution rate of the Theil index was higher than the inter-group.

**Conclusion:** The equity of health resources allocation should be further improved, especially the allocation of health institutions. Moreover, the access to health resources should also by improve by a diversity method.

## Key Word

Western China; Health resources allocation; Gini coefficient

## Introduction

The "Healthy China 2030" Plan which released in 2016 was clearly

emphasized that "Gradually reduce the differences in basic health services and health levels between urban and rural areas, regions and populations to achieve universal health coverage and promote social equity" [1]. To achieve this goal, what is the most significant is optimizing the allocation of health resources and ensure the fair distribution of resources [2]. According to the previous research, as a developing region, the equity of the allocation of health resources in the western China was lower than that in other developed regions [3], which requires more attention but still as shortage. Hence, a research which focus on the equity of the allocation of health resources in the western China seems particularly necessary, and it had also become one of a research hot pot in the recent years.

Base on the background above, in this paper, by using the Gini coefficient, Lorentz curve and Theil index, we analyzed the equity of health resource allocation in the western China, to further promote the equity of health resource allocation, some suggestions were put forward according to the analysis results at the end.

## Data sources Methods

### **Functional regional division**

According to NDRC, the western of China includes 12 provinces, namely Shaanxi, Sichuan, Yunnan, Guizhou, Gansu, Qinghai, Guangxi Zhuang

Autonomous Region, Ningxia Hui Autonomous Region, Tibet Autonomous Region, Xinjiang Uygur Autonomous Region, Inner Mongolia Autonomous Region and Chongqing Municipality. Ethnic minority autonomous regions include The Guangxi Zhuang Autonomous Region, in this paper, we divided the 12 provinces into two area: Ethnic minority area Non-ethnic minority areas. Ethnic minority area includes the Ningxia Hui Autonomous Region, the Tibet Autonomous Region, the Xinjiang Uygur Autonomous Region and the Inner Mongolia Autonomous Region, the rest of the provinces were divided into non-minority areas.

### **Data sources and statistical analysis**

The data in this paper were mainly searched from China statistical yearbook from 2015 to 2019, and the public data which released by the National Health and Family Planning Commission from 2015 to 2019. During searching data what we mainly focused on was the number of beds, health institutions, (assistant) medical practitioners, registered nurses in the western of China from 2014-2018. After searching data, we established a database by using excel2010 to further process data.

### **Lorentz curve**

Lorenz curve is one of the mainly tools to evaluate the equity of resources

or income distribution by income or resources classified according to different groups or regions, after that, coordinate system is constructed with the accumulated percentage of population or land area and the accumulated percentage of various medical resources. Then, draw the coordinate point connected to the zero point and each curve. The fairness is judged according to its distance from the absolute fairness line. The closer it is to the absolute fairness line, the fairer it is, and the worse it is[4].

### **Gini coefficient**

Lorentz curve can evaluate the equity of resources. However, it cannot quantify the specific differences of equity[5], hence, the Gini coefficient is often used to fill this gap. The Gini coefficient is calculated as follows:

$$G = \frac{1}{2n^2\mu} \sum_{i=1}^n \sum_{j=1}^n |y_i - y_j|$$

Where, G stands for Gini coefficient, N for group number,  $\mu$  for resident income,  $Y_i$  and  $Y_j$  for per capita income of group I and J[6].

According to the researches by Zhang nan, Peng rong et al, The Gini coefficient value range is [0,1].The closer it gets to 0, the fairer it is. On the other hand, the closer it is to 1, the less fair it is. It is generally believed that: Gini coefficient less than 0.3 means the resources allocation is in a best fair state;0.3~0.4 is the normal state; A level of alert above 0.4; Above

0.6 is in a dangerous state of high unfairness[7, 8].

### **Theil index**

Theil index is the major tool to measure fairness, and its value range is [0,1]. The smaller the value is, the better its fairness is. Its calculation formula is:

$$Theil - l = \sum_{i=1}^n P_n \log \frac{P_n}{y_n} \quad (\text{formula 1})$$

$$T_{inter} = \sum_{g=1}^k P_j \log \frac{P_j}{y_j} \quad (\text{formula 2})$$

$$T_{intra} = \sum_{g=1}^k P_j T_j \quad (\text{formula 3})$$

$$Theil = T_{inter} + T_{intra} \quad (\text{formula 4})$$

Where,  $P_n$  refers to the proportion of the population of each province in the total population;  $P_j$  is the proportion of the population of each region in the total population; Each  $y_n$  is the proportion of resources of each province in the total number of resources on this dimension.  $y_j$  shows the proportion of resources of each region in the total number of resources[9, 10]

## **Results**

### **The basic situation of health resources allocation in the western China from 2014 to 2018**

According to table 1 to Table 3, the distribution of health resources in 12

provinces in western China from 2014 to 2018 showed a trend of continuous growth. Among them, Tibet had the worst health resource allocation overall. By 2018, Tibet had 0.5 health institutions, 4.88 beds, 2.44 occupational (assistant physician) and 1.62 registered nurses per 1,000 people. In terms of the distribution of health institutions, Yunnan had the highest level which attained 1.55 health institutions per 1,000 people in 2018; In the aspect of beds distribution, Xinjiang were than other provinces in the western China with 7.19 beds per 1,000 people in 2018. As for the distribution of health technicians, Inner Mongolia was the best among other provinces in the western China with 2.90 licensed (assistant) physicians and 3.02 registered nurses per 1,000 people in 2018

### **Lorentz curve of health resources in western China from 2014 to 2018**

From the perspective of Lorentz curve analysis, Figure 1 shows the result that the Lorentz curve based on population dimension was closer to the absolute fairness line overall than based on geographical dimension. Among them, based on population dimension, health institutions got a more curved Lorentz curve than others. Furthermore, we can see from Figure 2 that the degree of bending of the four curves were similar based on geographical dimension, compared with the Lorentz curve in the population dimension (Fig. 1), they were further away from the absolute fairness line. This indicates that the distribution of health

resources in geographical dimension had less equitable than that according to population dimension.

### **Gini coefficient of health resources in western China from 2014 to 2018**

According to the Gini coefficient analysis in western China from different dimensions (Table 4), the Gini coefficients of beds, health institutions, practicing (assistant) physicians and registered nurses calculated in geographical dimension were between 0.60 and 0.63, showing a highly unfair state, while the four health resources were in the best fair state with all Gini coefficients were less than 0.2 in population dimension. Meanwhile, in the population dimension, the distribution of beds was best the other three, with the Gini coefficient between 0.057 and 0.058.

In addition, base on the Figure 3, we can see that the Gini coefficient in population dimension present a downward trend, meanwhile, the Gini coefficient of registered nurses showed the most obvious downward trend in 2017 among the four health resources, while the Gini coefficient based on geographical area presents an overall upward trend which can be seen in the Figure 4.

According to the results above we can draw a conclusion that the distribution of beds based on population dimension was most equitable,

the improvement effect of the equity of registered nurses was the most obvious, and the inequality of the distribution of health resources based on geographical dimension tends to worsen.

### **Theil index of health resources in western China**

Base on the Thiel index analysis of different dimensions that shown in Table 5 and 6, the total Thiel index of health resources in the two dimensions presented tendency of  $T_{\text{population}} > T_{\text{geographical}}$ . Moreover, the Thiel index in the two dimensions shows a status of intra-group higher than inter-group. This result implied that the distribution of health resources was more equitable in the population dimension than in the geographical dimension, and the inter-group also had a higher equity of health resources allocation than the inter group.

### **Thiel index contribution rate analysis**

From the perspective of population dimension, beds, health institutions, medical (assistant) practitioners and nurses were all showed that the intra-group contribution rate greater than the inter-group contribution rate. Among them, the contribution rate of both health institutions and registered nurses in the group reached more than 90% (Table 7). Meanwhile, contribution rate of licensed (assistant) physicians was kept rise, and the contribution rate of beds present a decline tendency. The

above results indicated that the inequity of health resource allocation based on population and geographical dimension was mainly came from intra-groups (Table 8). In the population dimension, and health institutions and registered nurses existed the most obvious intra-groups inequity distribution. Moreover, the intra-groups inequity distribution of medical (assistant) practitioners showed an increase tendency, while it was decreased in beds distribution.

## Discussion

### **The overall health resources showed an increasing trend, while the equity improvement was not obvious except for registered nurses**

From 2014 to 2018, per one thousand people have health institutions, health and technical personnel and the number of beds, registered nurses in western China showed a trend of steady growth which indicated that Chinese government got a satisfactory result in increasing health resources, and residents' medical needs had been better meet. Among them, nurses per 1,000 had the most significant increase, Yunnan and Chongqing had an average annual growth rate of 23%. In comparison, the growth rate of health institutions per thousand people was relatively slow, the most significant growth rate was in Xinjiang with only 2.3%. Moreover, Ningxia, Chongqing and Inner Mongolia had a negative growth rate with -0.05%, indicated that the allocation of health

institutions need to be strengthened, which is consistent with the research results of Ma Lu et al. [11]

Although health resources in western China present a growing trend but expect for the register nurses got a relative obvious improvement effect with Gini coefficient changed from 0.071 to 0.041 in the population dimension, other health resources allocation equity did not have an obvious improvement. In addition, the number of health institutions Gini coefficient is relatively high which means its fairness is poorer among the four health resources.

### **The geographical dimension of health resource allocation equity needs to be improved**

According to the Gini coefficient analysis in different dimensions, the Gini coefficients of the number of health institutions, beds, medical (assistant)practitioners and registered nurses in the geographic dimension were higher than those in the population dimension, with the coefficients that all higher than 0.6 which present a highly unfair state, and it also implied that health resources allocation fairness has great improvement in geographical dimension. This can be owing to that currently the main way China choose to allocation the health resources was based on population. Meanwhile, Xinjiang, Inner Mongolia, Tibet et

al have the characteristics of the sparsely populated, which can lead a poor equity in geographical dimension, this and Luo Ning, Chen Yuan consistent findings [12, 13].

### **The fairness difference mainly comes from the intra-group**

According to the analysis of Theil index contribution rate in the two dimensions, the intra-group contribution rate was all over 60%, higher than the inter-group, which proved that the unfair difference in distribution mainly comes from within regions, which is consistent with the research results of Chang Xiang and Sun et al[14, 15].

### Suggestions

#### **Strengthen government functions in the allocation of health resources to further promote fairness**

Low equity and low efficiency of health resource allocation can affect the health equity of residents[16]. To promote the equity of health resources, we need to rely not only on the market, but also on the overall arrangement of the government. Therefore, the government should strengthen its functions in the allocation of health resources, to improve the equity in the allocation of health resources in the underdeveloped areas in western China, and further realize the goal of "health equity for all" which emphasized in the "13th Five-Year Plan" and the "Outline of

healthy China 2030 Plan”.

### **Strengthen the distribution equity in health institutions**

Health institutions play a significant role in ensuring the health of the population. Hence, a high equity of health institutions allocation is quite necessary which require the government to pay more attention to the fairness of the distribution of health institutions and improve the service capacity of health institutions to lay a solid foundation for the improvement of residents' health.

### **Increase access to health resources by using a diversity of tools**

The equity of geographical distribution of health resources will affect the accessibility of health resources, thus affecting the health equity of residents[17]. Since the distribution of health resources in geographical dimension was not that satisfied based on the analysis results above, the government needs to strengthen the equity of health resources based on geographic through tiered medical services, medical treatment alliance, strengthen economic investment, Internet hospital and other diversity methods to improve the accessibility of health resources[18-20].

## **Conclusion**

Base on the research above, we found that the major differences in

allocation of health resources were existing in geographical dimension and the intra-group (the contribution rates in intra-group were all over 60%), which may impact the accessibility of health resources. Moreover, the equity of allocation of health institutions were relatively poor, which were badly in need of promotion. And these two problems are also the key factors related to the health of people. Hence, the stakeholders which include government, health institutions and so on should pay more attention in solve the problems to improve the equity of allocation of health resources.

### **Availability of data and materials**

The data in this paper obtained from China statistical yearbook from 2015 to 2019, and the public data which released by the National Health and Family Planning Commission from 2015 to 2019

### **Abbreviations**

NDRC: National Development and Reform Commission

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### ***Contributions***

Zheng Wang, Haoyu He and Xi Liu: Prepared all the figures and table

Wrote the main manuscript text, **contributions were consistent**.

Qiming Feng and Bo Wei: methodology designed. All authors read and approved the final manuscript.

### **Ethics approval and consent to participate**

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to and the appropriate ethical review committee approval has been received.

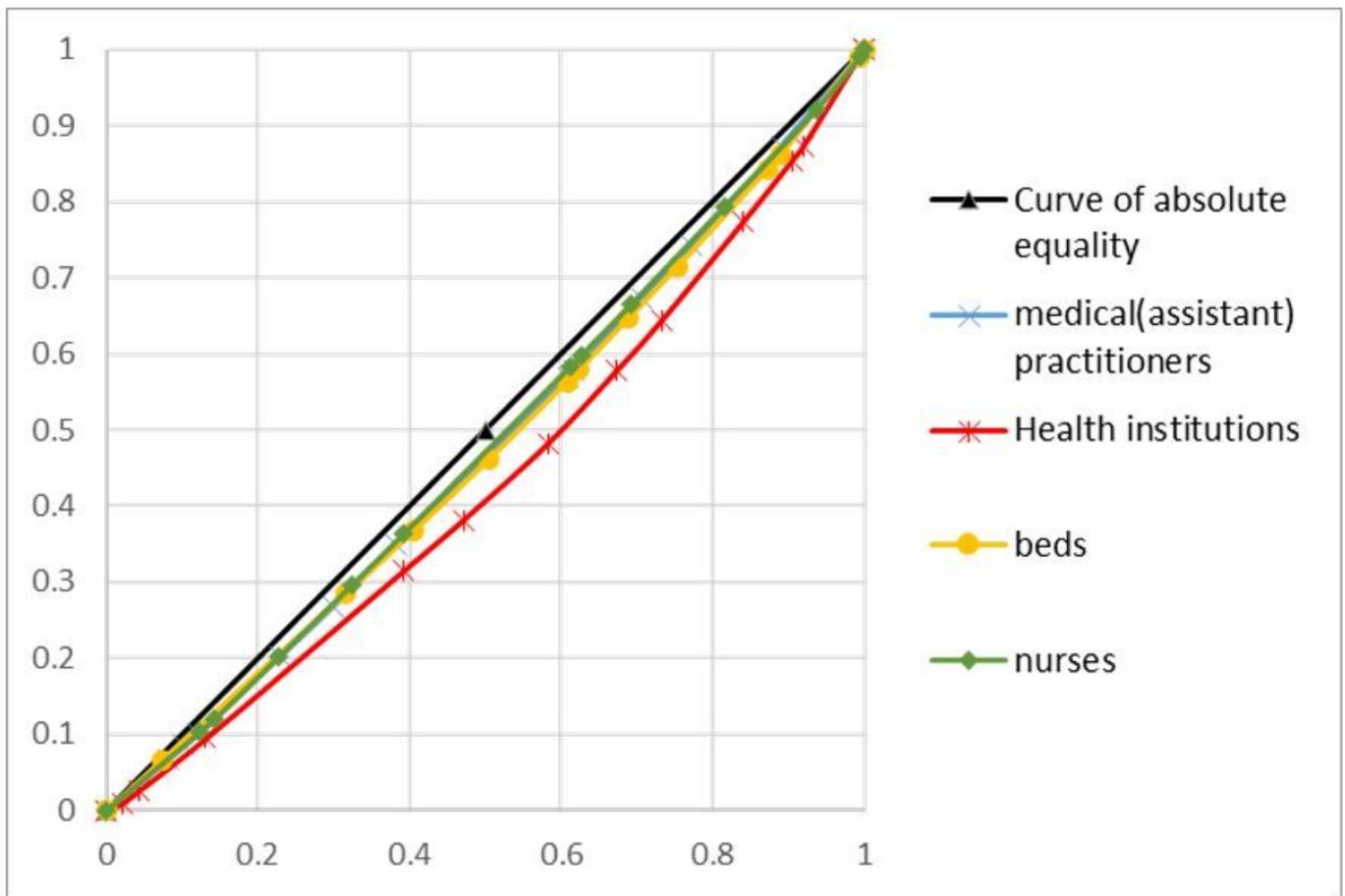
**Consent for publication**

Not applicable

**Competing interests**

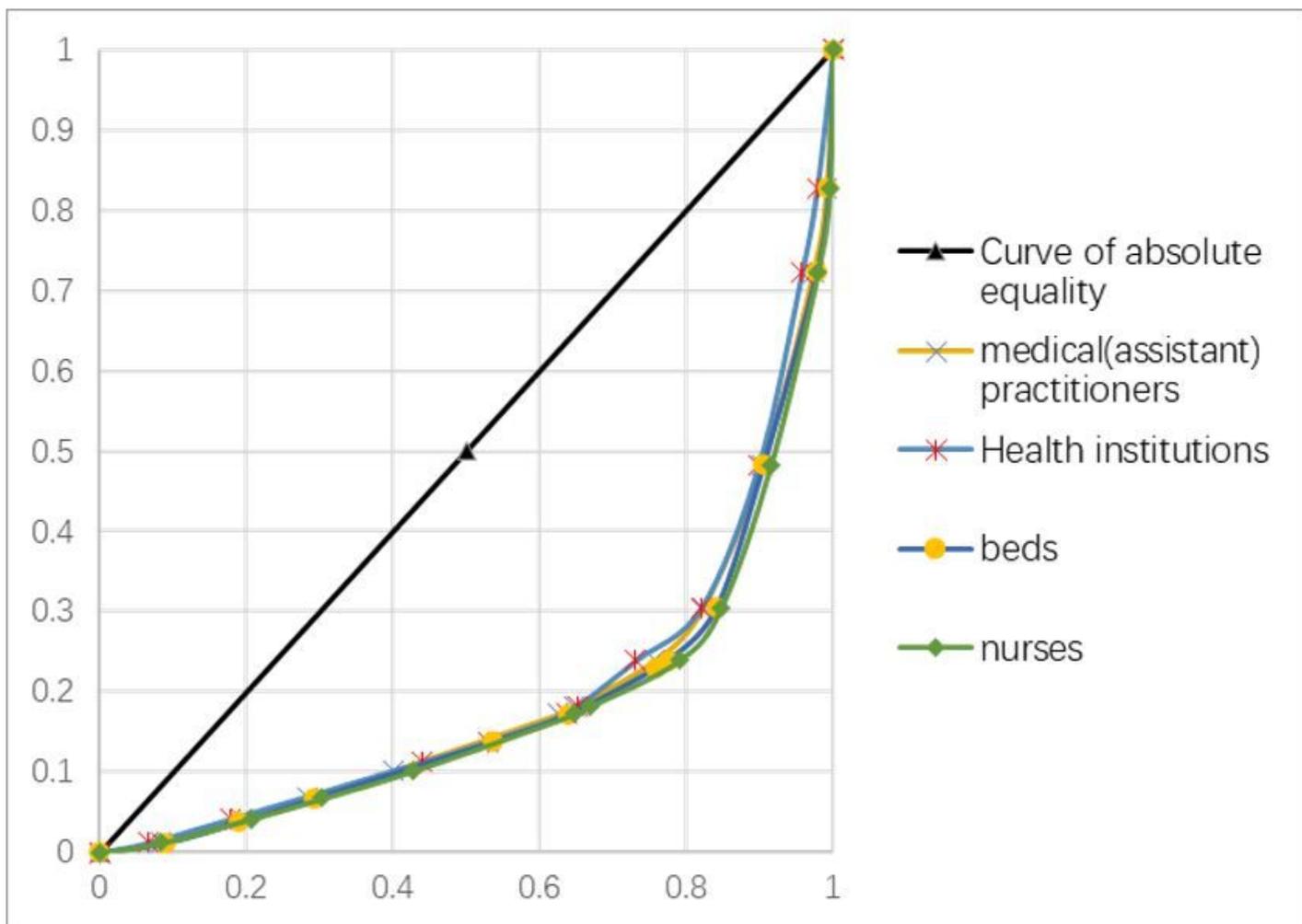
The authors declare that they have no competing interests

# Figures



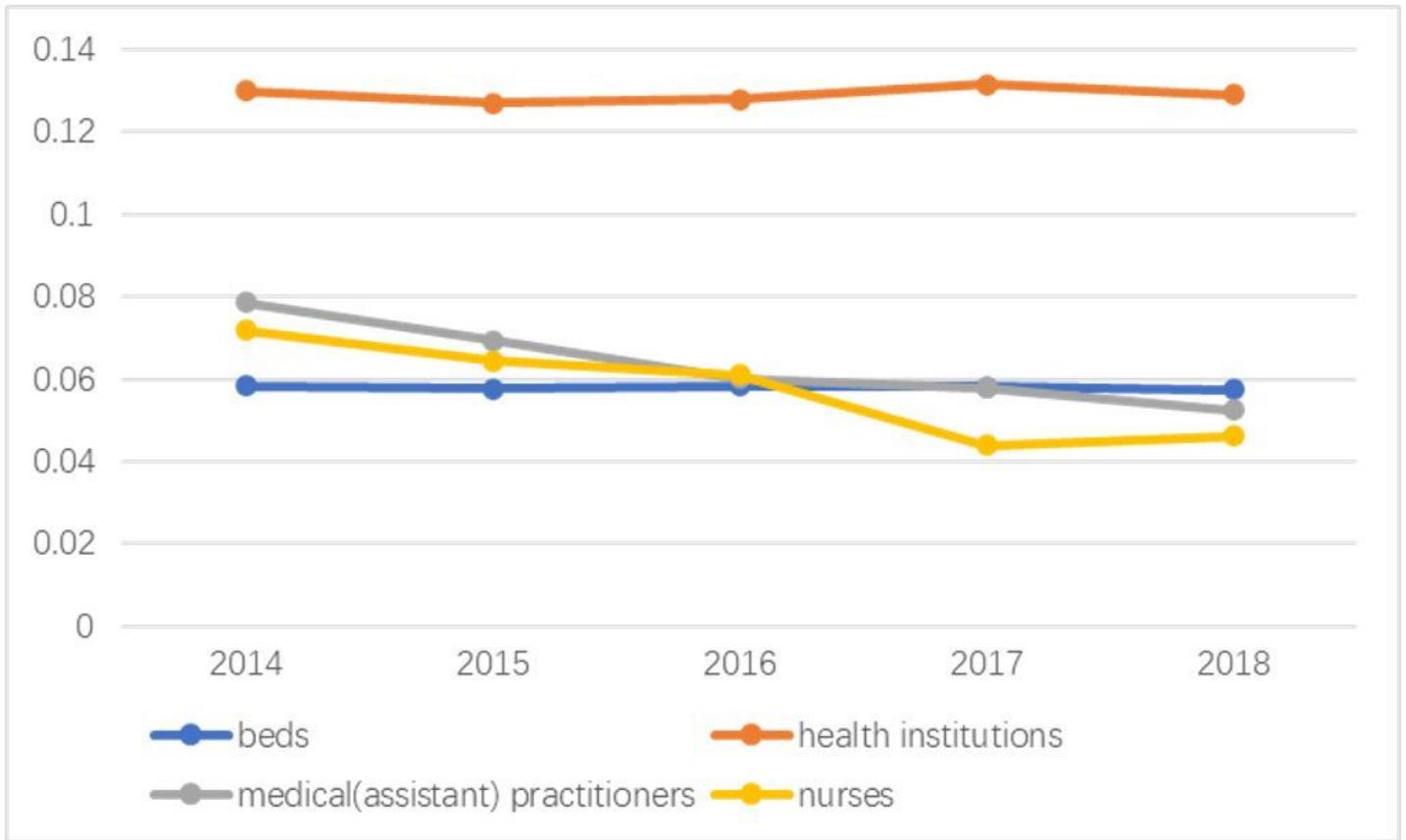
**Figure 1**

Lorentz curve of health resources distribution based on population dimension in western China from 2014 to 2018



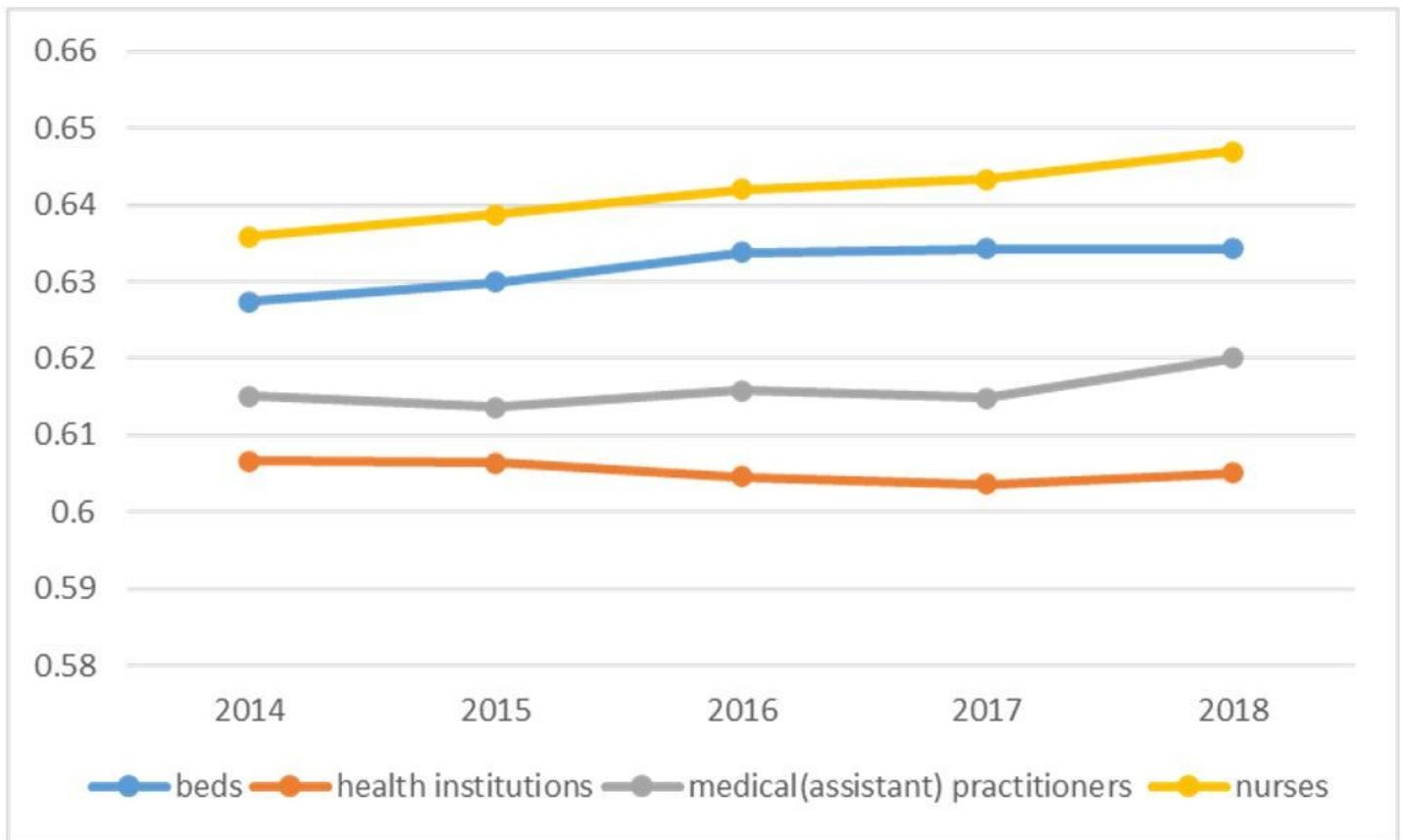
**Figure 2**

Lorentz curve of health resources distribution based on geographical dimension in western China from 2014 to 2018



**Figure 3**

Gini coefficient variation in the population dimension of health resources in western China from 2014 to 2018



**Figure 4**

Gini coefficient variation in the geographical dimension of health resources in western China from 2014 to 2018

## Supplementary Files

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