Trend and equity of general practitioners' allocation in China Based on the Data from 2012-2017

Qianqian Yu (yqq_7921@163.com)
Weifang Medical University https://orcid.org/0000-0001-8439-4366

Wenqiang Yin
Weifang Medical University

Dongmei Huang
Weifang Medical University

Kui Sun
Weifang Medical University

Zhongming Chen
Weifang Medical University

Hongwei Guo
Weifang Medical University

Di Wu
Weifang Medical University

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Qianqian Yu[1], Wenqiang Yin[2*] Dongmei Huang[3], Kui Sun[4], Zhongming Chen[5], Hongwei Guo[6], Di Wu[7]

1. School of public health and Management, Weifang Medical University, China, yqq_7921@126.com
2. School of public health and Management, Weifang Medical University, China, yinwq1969@126.com
3. School of public health and Management, Weifang Medical University, China, hdongm@126.com
4. School of public health and Management, Weifang Medical University, China, weiyiguanli@163.com
5. School of public health and Management, Weifang Medical University, China, czm3306196@163.com
6. School of public health and Management, Weifang Medical University, China, weiyiguanli@163.com
7. Department of English, Weifang Medical University, China, wfhag@163.com

CORRESPONING AUTHOR: Wenqiang Yin
Post address: School of public health and Management, Weifang Medical University, Baotong street No.7166, Weifang 261053, China
Phone: (+86) 0536-8462561
E-mail address: yinwq1969@126.com

Abstract

Background: The aim of this study is to evaluate the trend and equity of general practitioners allocation at the national level in mainland China including 22 provinces, 5 autonomous regions and 4 municipalities based on the data from 2012-2017, and provide reference for regional health planning and rational allocation of general practitioners.

Methods: We treat the data of general practitioners from 22 provinces, 5 autonomous regions and 4 municipalities (except Taiwan, Hong Kong Special Administrative Region and Macao Special Administrative Region) as the research materials. The population and geographical area of each region are obtained from China Statistical Yearbook (2013-2018). The general practitioners' data are from China Health and Family Planning Yearbook (2013-2018). We use the Lorenz curve, Gini coefficient and agglomeration degree to analyze the equity of general practitioners in population and geographical area allocation in China.

Results: In 2017, the total number of general practitioners in China was 252,727, and the number of general practitioners per 10,000 residents was 1.82. The number of

general practitioners accounted for 7.45% of the total number of practicing (assistant) doctors. From 2012 to 2017, the Gini coefficient for general practitioners based on population fell from 0.31 to 0.24, while the Gini coefficient based on geographical area remained unchanged at 0.73. The agglomeration degree based on population increased from 0.72 to 0.73 in the west region, among of which Tibet, Shaanxi, etc. was about 0.5. And the one in Eastern region dropped from 1.477 to 1.329, while in Zhejiang province, Beijing and Shanghai then were much higher than 1. The one in Middle region rose from 0.646 to 0.802, but in Heilongjiang and Hunan provinces they were lower. The agglomeration degree based on geographical area in western region increased from 0.270 to 0.277, among which Tibet, Qinghai and Xinjiang were lower than 0.1. In eastern region it fell from 1.447 to 1.329, and the ones in Shanghai, Beijing, Tianjin and Zhejiang province are much higher than 10. The degree in middle region increased from 1.149 to 1.423, among which Heilongjiang was lower.

Conclusions: The number of general practitioners in China has increased significantly, but the total allocation is still insufficient. China has a fairly fair allocation of general practitioners' resources based on population size, which is improving constantly. However, the equity distribution based on geographical area is poor and does not change much in recent years. The distribution of general practitioners in different regions is uneven and with large regional differences. In western region, there is a shortage of general practitioners in terms of population size and geographical area, while in eastern region, there is an excessive concentration of resources. We propose that concerning departments should establish and improve the incentive mechanism and performance appraisal mechanism of general practitioners to improve the occupational attractiveness. They can use the Internet+ to empower general practitioners' service capacity and efficiency. The government should increase their input for western region and take some measures to encourage eastern region to support western area. We should strive to develop medical education in western regions to cultivate more better general practitioners and achieve balanced development in different regions.

keywords: General practitioners, Resource allocation, Equity evaluation, Agglomeration analysis

Introduction

General practice is a comprehensive medical specialty oriented to communities and

families, integrating clinical medicine, preventive medicine, rehabilitation medicine and humanities and social sciences. Its main purpose is to emphasize the long-term comprehensive and responsible care oriented towards the maintenance and promotion of overall health, and to integrate the individual and group health. General practitioner is a new type of doctor who has received special training in general practice to perform the high-quality, convenient, cost-effective and integrated health care services for individuals, families and communities.

General practice has gone through three stages in China. In the late 1980s, the concept of general practice was introduced and began to be studied in China. From 1993 to 2011, general practice was formally established as a discipline and a few universities had it. The establishment of General Practice Branch of the Chinese Medical Association is a symbol. From 2011 till now, general practice has entered a stage of comprehensive development. In 2011, the Issuance of the Guidance Opinions of the State Council on the Establishment of General Practitioners' System is an important sign which shows that China's general practice has been attached great importance by the state and promoted its development. President Xi Jinping pointed out to strengthen general practitioners team in the 19th national congress of the communist party of China (CPC) in 2017. The Opinions on Improving the Incentive Mechanism for the Cultivation and Use of General Practice issued by the state council in 2018 was the policy guarantee for the career development of general practice in China. At present, the discipline status of general practice has been established, which is the need to recommend the healthy construction of China, the important support to deepen the health reform, the important content to improve the medical service system, and the foundation to improve the health level of the people.

The training system of general practitioner education in China mainly includes college education, post-graduate education and continuing education. The college education includes general practice concept and basic theory training. The post-graduate education mainly includes 5+3 mode, with a 3+2 mode as a supplement. And continuing education includes job transfer training and continuing career development.

In 2011, The Guidance Opinions of the State Council on the Establishment of General Practitioners System proposed the establishment of a unified and standardized general practitioners training system which is a "5+3" mode. The "5+3" mode refers to the five years undergraduate education in clinical medicine (including traditional

Chinese medicine) which is followed by three years of standardized training of general practitioners. The three-year standardized training of general practitioners can be carried out in two ways: "post-graduate standardized training" and "postgraduate education of clinical medicine". The specific ways are determined by the provinces (districts and municipalities). The Standardized Training Certificate for Resident Physicians is issued by the department of general medicine in a unified format.

The government issued the policy of "assistant general practitioners training" because of the shortage of general practitioners and the poor basic area condition, etc. The "3+2" assistant general practitioners training mode is tentatively implemented for 10 years. Since 2016, graduates of three-year medical specialties working in the underdeveloped rural areas can register as assistant general practitioners after the two-year training of clinical skills and public health in state-recognized training bases and obtaining the qualification of assistant medical practitioners. The provincial health and family planning administrative departments should issue the uniform Certificates of Qualification for the Training of Assistant General Practitioners to those students who passed the examination according to relevant provisions of the state, and it is valid nationwide.

The construction of standardized training of general practitioners lays the foundation and direction for the future construction of general practitioners in China. However, in order to solve the urgent shortage of general practitioners, the country advocates the cultivation of qualified general practitioners through multiple channels, and the job transfer training of in-service doctors is one of the main ways. Usually it is held by the provincial health authorities. The training targets are mainly practicing (assistant) physicians engaged in front-line clinical work in township hospital, community health service center(station), village clinics and basic medical institutions. At present, the state also encourages physicians in the secondary and above hospitals to participate the job transfer training. When the students passed the training examination, the relevant provincial departments will issue the Certificate of Qualification for Post Training of General Practitioners.

Due to the current situation in China, we have adopted various channels to train general practitioners. By 2025, China will initially form a team of general practitioners with "5+3" general practitioners as the main body and "3+2" assistant general practitioners as the supplement.

The importance of equity evaluation of general practitioner resource allocation

The World Health Organization points out that the access to health is everyone's right, and everyone has the right to access to basic medical and health services [1].Based on the theory of general practice, general practitioners can treat 80% to 90% of the common diseases, frequently-occurring diseases, senile diseases and chronic diseases in the primary medical institutions, and are the main body of providing continuous, individual and comprehensive primary medical and health services, known as the "gatekeeper" of residents' health[2]. Therefore, the equity of general practitioner resource allocation is of great significance to residents' access to basic medical and health services. It includes two aspects. One is population allocation equity that is the number of health human resources per thousand people in different regions should be equal. The second is geographical distribution equity, that is, the public's equity of the spatial distance of health human resources. The number of health human resources in each square kilometer of different regions should be equal [3].

Scholars at home and abroad use different methods to evaluate and analyze the equity of health resource allocation. One of the researchers used concentration indexes to evaluate the equity of Japanese dental resources allocation [4]. Another used concentration indexes based on population size to evaluate the equity of resource allocation according to wealth since the health-care reform of China[5]， and others used concentration index to measure the magnitude of the unequal distribution of health human resource in mainland China. A decomposition analysis was employed to quantify the contribution of each determinant to the total inequality [6]. In terms of the resource allocation of general practitioners, the researchers used Lorenz curve, Gini coefficient, Theil index and gray prediction method to analyze the fairness of the resource allocation of general practitioners in different time periods. [7-10].

This study aims to analyze the current situation and trend of Chinese general practitioners' resource allocation based on the statistical data of Chinese general practitioners from 2012 to 2017. Gini coefficient was used to discuss the equity of overall general practitioner resources' allocation according to the geographical area and population in China. And agglomeration analysis was used to evaluate the equity of different areas according to the geographical area and population. This study aims to refer the evidence to further optimize the allocation of general practitioner in China.

Methods

Data sources

Data of general practitioners from 31 provinces, autonomous regions and municipalities (except Taiwan, Hong Kong Special Administrative Region and Macao Special Administrative Region) were used as the research materials. Year-end population (population) and jurisdiction area (geography) of each region were obtained from China Statistical Yearbook (2013-2018)[11-16].General practitioners' data comes from China Health and Family Planning Yearbook (2013-2018) [17-22].The number of general practitioners in this study refers to the total number of practitioners (assistants) who have registered as general practitioners or who have obtained general practitioner training certificates. Eastern region, central region and western region are divided according to China Health Statistics Yearbook in 2018. Eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainantotal11regions.Middle region include Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunantotal8regions. Western region include Inner Mongolia, Chongqing, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang total 12 regions.

Analysis methods

Lorenz curve and Gini coefficient

Lorenz curve is a kind of curve that reflects the average degree of national income distribution proposed by American statistician M.O.Lorenz. The more curve of the Lorenz curve, the more unequal of the income distribution. On the contrary, the bigger the curve bends, the smaller the income distribution, which indicates the inequality. This study ranked 22 provinces, 5 autonomous regions and 4 municipalities under their jurisdiction according to the number of general practitioners per capita. Then, Lorenz curve was constructed according to the distribution of service population by taking the cumulative percentage of general practitioners as the vertical coordinate and the cumulative percentage of population as the horizontal coordinate. On the other hand, the 22 provinces, 5 autonomous regions and 4 municipalities were ranked according to

the number of general practitioners per square kilometer. The Lorenz curve distributed by the geographical area was constructed by taking the cumulative percentage of general practitioners as the vertical coordinate, and the cumulative percentage of population as the horizontal coordinate.

According to Lorenz curve, Gini coefficient is to judge the equity of income distribution defined by Albert Hirschman who is an American economist. Gini coefficient is between 0 and 1, which is an important analysis index used to comprehensively investigate the status of income distribution differences among residents internationally. The calculation formula of Gini coefficient is G= sigma (XiYi+ 1- xi +1Yi), where Xi is the cumulative percentage of serving population and geographical area of group i; Yi: cumulative percentage of GPS in group i. The Gini coefficient is less than 0.2 which means absolute fair (best state);0.2-0.3 is fair (good state); 0.3-0.4 is basic fair (normal state); 0.4-0.5 is unfair (alert state); and 0.5 is very unfair (dangerous state).

Agglomeration analysis

The Gini coefficient is used to measure the health resource allocation equity and cannot compare the differences of resource allocation in different regions. In this study, agglomeration analysis is introduced to measure the agglomeration degree of health resource in a region and to measure the difference among different groups. The agglomeration analysis of general practitioners' resource includes two dimensions which is based on the geographical area and population. The formula of agglomeration degree based on geographical area is HRADi = (HRi/Ai)/(HRn/An).The HRi represents the number of general practitioners in the i region, and the HRn represents the total number of general practitioners in China. The Ai represents land area in the i region, and the An represents the land area in China. The formula of agglomeration degree based on population is HRADi/PADi=(HRi/Pi)/(HRn/Pn). The PADi represents population agglomeration degree in the i region. The HRi and the HRn have the same meaning as the above. Pi represents the number of population in the i region , and the Pn represents the total number of population in China.

Evaluation criteria: If agglomeration degree based on geographical area is equal to 1, it means that the allocation of general practitioners is absolutely equitable in this region. And if agglomeration degree based on geographical area is closer to 1, the equity of distribution in terms of geographical area is better. If the agglomeration degree based on population size is equal to 1, it means that the allocation of general practitioners is absolutely equitable in this region. And if agglomeration degree based on the population is closer to 1, the equity of distribution in terms of population is better.

Results

1 Trend of General Practitioners in China from 2012 to 2017

Status of general practitioners in 2017: The number of general practitioners in China is 252,717, among which 13,943 in the east, 63,269 in the central and 49,975 in western, accounting for 55.19%, 25.04% and 19.78% respectively. The average number of general practitioners per 10,000 population is 1.82, with 2.42 in the east, 1.46 in the central and 1.33 in the west respectively. According to the analysis of every provinces, autonomous regions and municipalities directly under the central government, the number of general practitioners per 10,000 population in Tibet and Shaanxi is less than 1, the number of general practitioners per 10,000 population in 4 provinces, including Zhejiang, Shanghai, Beijing and Jiangsu, is higher than 3. In Shandong, Henan and other 23 provinces the number is all below the national average.

General practitioner deployment trends in 2012-2017: The total number of general practitioners in our country has increased from 109794 to 252717 in 2012-2017, and the number of general practitioners has increased by 130.2% in the past five years. In 2012-2017, the average growth rate of general practitioners per 10,000 inhabitants in China was 17.58%, with the average growth rates in the eastern, central and western region being 15.25%, 22.93% and 18.06%, respectively. From the analysis of every provinces, autonomous regions and municipalities under the Central Government, the average growth rates of Tibet, Guizhou and Jilin ranked the top three which were 46.01%, 36.08% and 33.24% respectively.

Table 1 Number of general practitioners per 10,000 population in each region of

China in 2012-2017 (person)

Area	2012	2013	2014	2015	2016	2017	Average growth rate%
Total	0.81	1.07	1.27	1.37	1.51	1.82	17.58
East	1.19	1.50	1.71	1.83	2.03	2.42	15.25
Central	0.52	0.70	0.91	1.05	1.16	1.46	22.93
West	0.58	0.86	0.99	1.06	1.14	1.33	18.06
Beijing（E）	3.93	4.00	3.82	3.81	3.87	3.96	0.15
Tianjin（E）	0.77	0.97	1.07	1.39	1.54	2.41	25.63
Hebei（E）	0.48	0.92	1.17	1.25	1.25	1.33	22.61
Shanxi（C）	0.71	0.81	0.99	1.10	1.13	1.72	19.36
Inner mongolia（W）	0.67	0.95	1.17	1.23	1.26	1.58	18.72
Liaoning（E）	0.75	0.80	0.86	0.83	0.96	1.44	13.94
Jilin（C）	0.45	0.61	0.84	1.05	1.24	1.89	33.24
Heilongjiang（C）	0.54	0.75	0.97	1.13	1.17	1.19	17.12
Shanghai（E）	2.24	2.47	2.85	3.04	3.29	3.51	9.40
Jiangsu（E）	1.90	2.22	2.48	2.61	3.15	3.43	12.54
Zhejiang（E）	2.24	3.10	3.57	3.90	4.04	5.39	19.20
Anhui（C）	0.53	0.72	1.12	1.20	1.39	1.67	25.80
Fujian（E）	0.69	0.96	1.13	1.33	1.49	1.76	20.60
Jiangxi（C）	0.46	0.54	0.66	1.73	0.79	1.14	19.90
Shandong（E）	0.70	0.79	0.92	1.01	1.14	1.36	14.21
Henan（C）	0.50	0.68	0.89	1.09	1.27	1.63	26.66
Hubei（C）	0.65	0.87	1.05	1.19	1.19	1.52	18.52
Hunan（C）	0.39	0.59	0.75	0.90	0.96	1.03	21.44
Guangdong（E）	0.75	1.11	1.34	1.38	1.67	2.03	22.04
Guangxi（W）	0.66	0.86	0.95	0.97	1.05	1.28	14.17
Hainan（E）	0.47	0.65	0.81	0.96	1.08	1.22	21.02
Chongqing（W）	0.55	0.74	0.84	0.95	1.03	1.26	18.03
Sichuan（W）	0.58	1.11	1.21	1.27	1.25	1.37	18.76
Guizhou（W）	0.30	0.43	0.69	0.89	1.04	1.40	36.08
Yunnan（W）	0.69	0.91	0.87	0.90	0.99	1.09	9.58
Xizang（W）	0.11	0.21	0.34	0.50	0.61	0.73	46.01
Shaanxi（W）	0.49	0.53	0.73	0.56	0.72	0.93	13.67
Gansu（W）	0.54	0.82	1.05	1.27	1.45	1.46	22.01
Qinghai（W）	0.81	1.31	1.51	1.63	1.67	2.06	20.52
Ningxia（W）	0.40	0.60	0.71	1.85	0.97	1.36	27.73
Xinjiang（W）	0.86	1.20	1.45	1.57	1.68	1.81	16.05

E, C and W in parentheses refer to eastern, middle and western region, respectively

Analysis of the fairness of Gini Coefficient of Chinese general practitioner resource allocation

Show in table 2, the Gini coefficient of the number of general practitioners in China decreased from 0.31 to 0.24 in 2012-2017 according to the population allocation, and the Gini coefficient of the number of general practitioners maintained at 0.72-0.73 according to the geographical area allocation. It can be seen that the fairness of the number of general practitioners in China according to the population allocation is better, but the fairness of the number of general practitioners according to the geographical area allocation is worse. Figure 1 and figure 2 respectively show the Lorenz curves

from population and geographical area allocation.

Table 2 Gini coefficient of Chinese general practitioner resource allocation in 2012-2017

Variable	2012	2013	2014	2015	2016	2017
Gini Coefficient（configured by population）	0.31	0.29	0.26	0.25	0.24	0.24
Gini Coefficient（configured by geographic area）	0.73	0.73	0.72	0.72	0.72	0.73

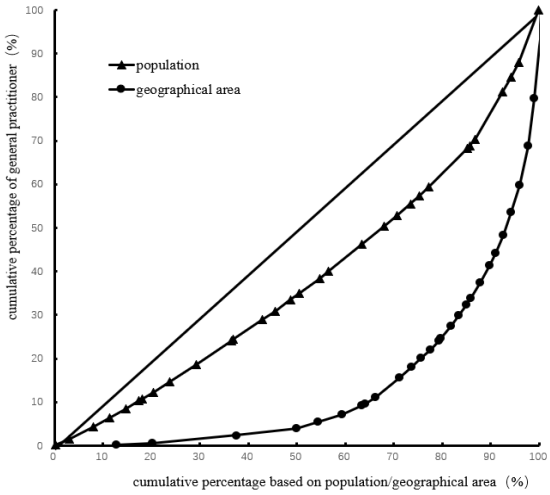

Figure 1 Lorenz curve for distribution of GPs in China in 2012

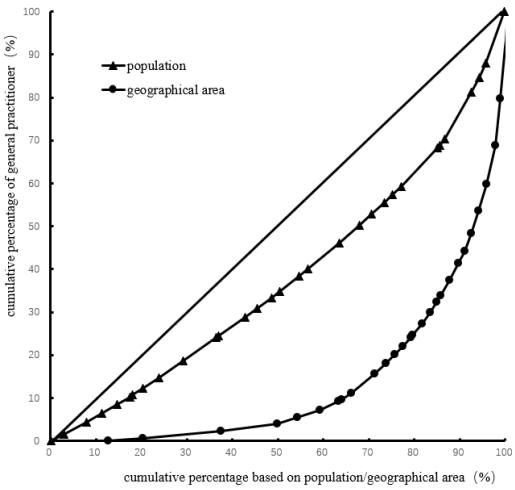

Figure2 Lorenz curve for distribution of GPs in China in 2013

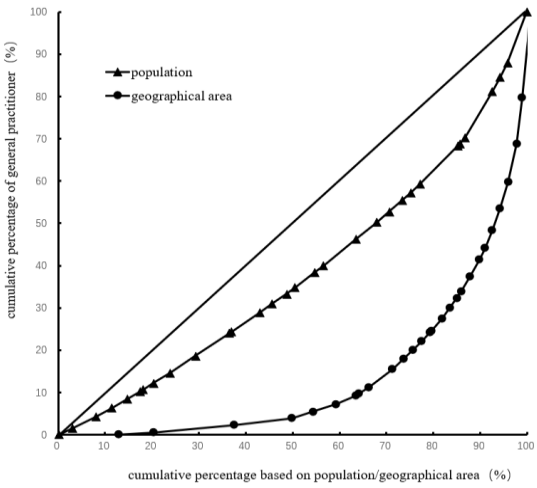

Figure3 Lorenz curve for distribution of GPs in China in 2014

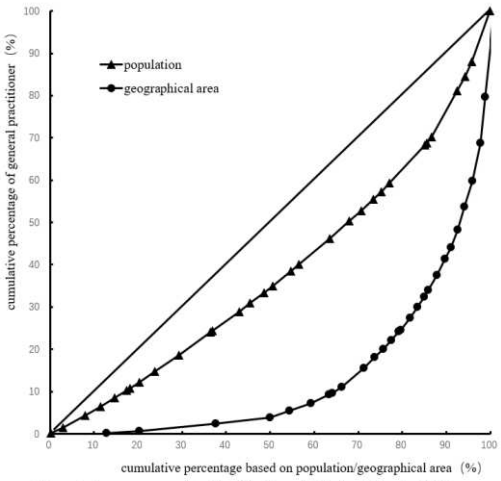

Figure4 Lorenz curve for distribution of GPs in China in 2015

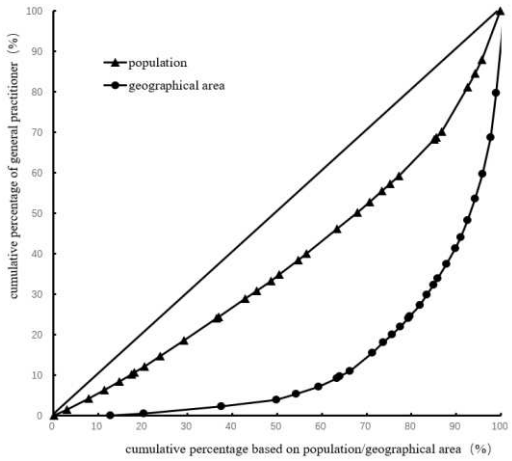

Figure5 Lorenz curve for distribution of GPs in China in 2016

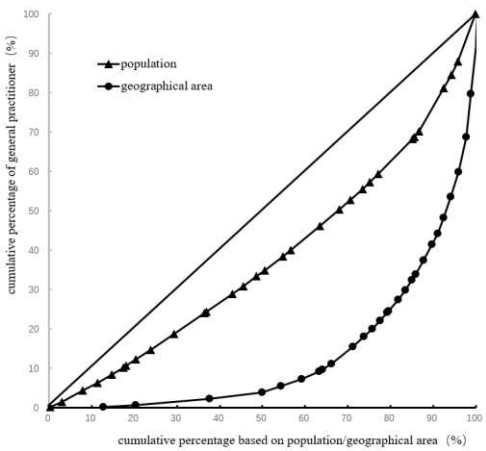

Figure6 Lorenz curve for distribution of GPs in China in 2017

2 Analysis of the concentration of general practitioners in different regions of China

(1) Overall situation in 2017

Aggregation analysis based on geographic area allocation: Based on the analysis of regional classification, Gini Coefficient is 0.27 which is far below 1 in western region so that it is inequitable of the general practitioners' allocation. Gini Coefficient is 1.15 which is slightly higher than 1 in middle region so that it is relatively equitable of general practitioners' allocation. Gini Coefficient is 5.37 which is far higher 1 in eastern region which is far excessive concentration of general practitioner's allocation. From different provinces, autonomous regions and municipalities to analyze, Guangxi's agglomeration degree is equal to 1 which means it is absolutely equitable. The agglomeration degree is less than 1 in Sichuan (0.89), Shanghai(0.66), Ningxia Hui (0.53) etc. other regions and this indicated the inequity of general practitioners' allocation based on the geographic area. Tibet (0.01), Qinghai (0.06), Xinjiang (0.1), Inner Mongolia (0.13), Gansu (0.34), Heilongjiang (0.36), Yunnan (0.51), Ningxia(0.53), Shaanxi (0.66) and other areas have low agglomeration degree which indicated the very inequity of general practitioners' allocation based on the geographic area[6].The agglomeration degree of general practitioners in other provinces and cities is higher than 1. Some of them exceeds 10 such as 51.198 (in Shanghai), 19.899 (in Beijing) and 11.968 (in Tianjin), 10.970(in Zhejiang) which indicates that the general

practitioners' allocation is over-concentrated based on the geographical area.

Agglomeration analysis by population allocation: The eastern, middle and western region are 1.33,0.80,0.73,respectively.The data shows that the radio of middle and western region is less than 1,indicating that the general practitioner resources is insufficient from the population allocation, and the radio of eastern region is higher than 1, indicating that general practitioners is too concentrated based on the population allocation. From the perspective of different provinces, autonomous regions, and municipalities, there is a difference in the fairness of population allocation. The resource allocation of general practitioners in Xinjiang(1) is absolutely fair; The ratios of Fujian (0.97), Jilin (1.04), and Shanxi (0.95) approached 1, indicating that their general practitioner resources are fairly fair according to the population allocation. However, the ratios of Zhejiang (2.96), Beijing (2.18), and Shanghai (1.93) are in the top three, which is far greater than 1, indicating that the GP resources in these areas are too concentrated according to the population allocation. The ratio of 23 provinces and municipalities such as Tibet (0.4), Shaanxi (0.51), and Hunan (0.56) is less than 1, indicating that the resources of general practitioners are relatively scarce, and the population allocation is insufficient.

（2）Trends in the concentration of general practitioners in 2012-2017

Trend analysis of agglomeration degree according to geographical area configuration: from 2012 to 2017, the agglomeration degree decreased from 5.370 to 4.900 in eastern region, and increased from 1.149 to 1.423 in middle region, and while decreased from 0.270 to 0.227 in western region. From the analysis of agglomeration degree in different provinces, autonomous regions and municipalities, it is relatively high in Shanghai, Jiangsu, Beijing and Guangdong in 2012, but it has declined in recent years. For example, in Shanghai, it decreased from 73.877 to 51.198 in 2012-2017, down by 30.70%. In Beijing it dropped from 43.382 to 19.899 in 2012-2017, down by 54.13%. In Jiangsu it dropped from 12.290 to 9.772 in 2012-2017, down by 20.49%, and resource allocation gradually became fair. The agglomeration degree in Tibet, Qinghai, Xinjiang and Inner Mongolia was relatively low in 2012 and the fluctuations

was not obvious in recent years. For example, in Tibet it increased from 0.002to 0.008 in 2012-2017, an increase of 300%. In Qinghai, it increased from 0.056 to 0.065 in 2012-2017, which is increased by 16.07%. From 2012 to 2017, Xinjiang remained by 0.101 without change. In Inner Mongolia it increased from 0.124 to 0.128, an increase of 3.23%.

Trend of agglomeration degree based on population allocation

In 2012-2017, in eastern region the agglomeration degree is higher which is between 1.477-1.329, and the change tends to be fair year by year. Middle region allocation tends to be fair which is between 0.646-0.802, but in western region it is slightly lower which is 0.722-0.729. In the meantime, it also tends to be fair, and the general practitioners have better fairness according to the population allocation. From the analysis of different provinces, municipalities and autonomous regions, the agglomeration degree of Shanghai, Jiangsu and Beijing in 2012 was relatively high, but it has declined in recent years. For example, in Beijing it fell from 4.97 to 2.177 in 2012-2017 and decreased by 56.20%. In Shanghai it fell from 2.797 to 1.932 in 2012-2017 and decreased by 30.93%. In Jiangsu it fell from 2.353 to 1.889 in 2012-2017and decreased by 19.72%. The resource allocation gradually became fair. In 2012, the agglomeration degrees of Tibet, Guizhou, Hunan, Ningxia and Jilin provinces were relatively low, but in recent years they become more equitable. For example, in Tibet it increased from 0.138 to 0.403 in 2012-2017 and increased by 192.03%. In Guizhou it increased from 0.367 to 0.77 in 2012-2017 and increased by 109.81%. In Hunan it increased from 0.483 to 0.564 in 2012-2017 and increased by 16.77%. In Ningxia it increased from 0.502 to 0.747 in 2012-2017 and increased by 48.80%. In Jilin it increased from 0.552 to 1.039 in 2012-2017 and increased by 88.22%. We find that the general practitioners in China tend to be equitable based on the population allocation.

Table 3 Agglomeration degree of general practitioner of China in 2012-2017 (by geographic area)

Region	2012	2013	2014	2015	2016	2017	Growth rate%
The eastern region	5.370	5.154	4.989	4.896	4.949	4.900	-8.75
The central region	1.149	1.159	1.285	1.366	1.358	1.423	23.85

The western region	0.270	0.302	0.297	0.291	0.285	0.277	2.59
Beijing（E）	43.382	34.025	27.882	25.658	23.523	19.899	-54.13
Tianjin（E）	8.046	7.911	7.581	9.168	9.272	11.968	48.74
Hebei（E）	1.618	2.352	2.544	2.503	2.275	2.015	24.54
Shanxi（C）	1.424	1.245	1.284	1.304	1.223	1.545	8.50
Inner Mongolia（W）	0.124	0.132	0.138	0.133	0.123	0.128	3.23
Liaoning（E）	1.952	1.566	1.419	1.246	1.301	1.610	-17.52
Jilin（C）	0.574	0.591	0.682	0.785	0.829	1.040	81.18
Heilongjiang（C）	0.385	0.403	0.439	0.465	0.432	0.361	-6.23
Shanghai（E）	73.877	62.382	61.139	59.386	58.064	51.198	-30.70
Jiangsu（E）	12.290	10.862	10.246	9.893	10.777	9.772	-20.49
Zhejiang（E）	10.153	10.657	10.354	10.432	9.823	10.970	8.05
Anhui（C）	1.992	2.034	2.705	2.673	2.827	2.828	41.97
Fujian（E）	1.829	1.933	1.933	2.102	2.142	2.113	15.53
Jiangxi（C）	1.090	0.960	1.006	1.012	1.002	1.199	10.00
Shandong（E）	3.749	3.219	3.157	3.195	3.305	3.261	-13.02
Henan（C）	2.472	2.539	2.796	3.154	3.335	3.541	43.24
Hubei（C）	1.765	1.790	1.822	1.908	1.734	1.833	3.85
Hunan（C）	1.066	1.224	1.327	1.471	1.413	1.263	18.48
Guangdong（E）	3.863	4.319	4.458	4.235	4.686	4.801	24.28
Guangxi（W）	1.136	1.122	1.060	1.000	0.986	1.003	-11.71
Hainan（E）	1.040	1.081	1.144	1.258	1.279	1.216	16.92
Chongqing（W）	1.732	1.751	1.706	1.774	1.742	1.782	2.89
Sichuan（W）	0.839	1.219	1.124	1.088	0.979	0.887	5.72
Guizhou（W）	0.513	0.566	0.764	0.910	0.969	1.082	110.92
Yunnan（W）	0.713	0.713	0.580	0.554	0.552	0.506	-29.03
Tibet（W）	0.002	0.004	0.005	0.007	0.008	0.008	300.00
Shaanxi（W）	0.776	0.635	0.749	0.526	0.611	0.661	-14.82
Gansu（W）	0.285	0.326	0.354	0.396	0.407	0.341	19.65
Qinghai（W）	0.056	0.069	0.068	0.068	0.063	0.065	16.07
Ningxia（W）	0.342	0.389	0.395	0.433	0.452	0.530	54.97
Xinjiang（W）	0.101	0.108	0.111	0.114	0.111	0.101	0.00

Table 4 Agglomeration degree of general practitioner of China in 2012-2017 (by population)

Region	2012	2013	2014	2015	2016	2017	Growth rate%
The eastern region	1.477	1.405	1.359	1.332	1.344	1.329	-10.02
The central region	0.646	0.65	0.722	0.767	0.764	0.802	24.15
The western region	0.722	0.801	0.787	0.771	0.753	0.729	0.97
Beijing（E）	4.97	3.74	3.027	2.775	2.557	2.177	-56.20
Tianjin（E）	0.997	0.907	0.847	1.01	1.017	1.324	32.80
Hebei（E）	0.595	0.858	0.927	0.911	0.828	0.733	23.19
Shanxi（C）	0.876	0.762	0.786	0.798	0.75	0.947	8.11
Inner Mongolia（W）	0.834	0.889	0.929	0.895	0.834	0.867	3.96
Liaoning （E）	0.93	0.748	0.682	0.603	0.634	0.790	-15.05

Jilin（C）	0.552	0.571	0.662	0.765	0.819	1.039	88.22
Heilongjiang（C）	0.669	0.704	0.771	0.826	0.775	0.652	-2.54
Shanghai（E）	2.797	2.307	2.262	2.218	2.177	1.932	-30.93
Jiangsu（E）	2.353	2.079	1.966	1.904	2.08	1.889	-19.72
Zhejiang（E）	2.766	2.898	2.826	2.845	2.67	2.962	7.09
Anhui（C）	0.659	0.670	0.888	0.873	0.921	0.917	39.15
Fujian（E）	0.860	0.900	0.897	0.972	0.988	0.970	12.79
Jiangxi（C）	0.572	0.502	0.527	0.53	0.524	0.627	9.62
Shandong（E）	0.867	0.741	0.726	0.734	0.756	0.746	-13.96
Henan（C）	0.620	0.638	0.705	0.795	0.841	0.896	44.52
Hubei（C）	0.804	0.813	0.83	0.868	0.789	0.836	3.98
Hunan（C）	0.483	0.549	0.595	0.658	0.632	0.564	16.77
Guangdong（E）	0.932	1.034	1.064	1.004	1.103	1.119	20.06
Guangxi（W）	0.820	0.8	0.755	0.710	0.698	0.707	-13.78
Hainan（E）	0.592	0.606	0.639	0.70	0.711	0.673	13.68
Chongqing（W）	0.690	0.689	0.67	0.694	0.678	0.692	0.29
Sichuan（W）	0.715	1.036	0.956	0.923	0.829	0.752	5.17
Guizhou（W）	0.367	0.403	0.546	0.650	0.691	0.770	109.81
Yunnan（W）	0.855	0.850	0.69	0.659	0.657	0.602	-29.59
Tibet（W）	0.138	0.201	0.272	0.362	0.404	0.403	192.03
Shaanxi（W）	0.601	0.491	0.582	0.408	0.475	0.513	-14.64
Gansu（W）	0.668	0.763	0.829	0.928	0.956	0.801	19.91
Qinghai（W）	1.003	1.226	1.198	1.191	1.107	1.131	12.76
ningxia（W）	0.502	0.561	0.564	0.616	0.641	0.747	48.80
Xinjiang（W）	1.075	1.122	1.147	1.145	1.109	0.997	-7.26

Analysis of the proportion and registration rate of general practitioners

According to the analysis of general practitioners in China, the proportion of general practitioners in practice (assistant) physician increased from 4.20% to 7.45% in 2012-2017. Although the number of general practitioners has increased, the proportion of general practitioners is still relatively low that is far less than the one in developed countries. The proportion of the western region is the lowest which is only 6.34% in 2017, and it is higher in the eastern region which is 9.09%. From the perspective of specific provinces and cities, Zhejiang (17.05%), Jiangsu (12.70%), Shanghai (12.50%), Tianjin (9.12%), and Beijing (9.10%) ranked the top five in the country. However, Tibet (3.25%), Shaanxi (3.84%), Hunan (4.07%), Heilongjiang (5.08%) and Ningxia (5.09%) ranked the last five in the country.

The registration rate of general practitioner is only 38% at the end of 2017, and

there are 96,000 enrolled in general medicine major among of 253,000 qualified general practitioners. The registration rate increased from 33.86% in 2012 to 38.08% in 2017. It has a faster growth in eastern region from 36.19% to 41.75% in 2012-2017. The second is in the western region which increased from 26.39% to 30.82% in 2012-2017.And the registration rate increased from 33.99% to 35.73% in 2012-2017 in the central region. From the perspective of specific provinces and cities, the top five of registration rate is Shanghai (67.82%), Tibet (62.75%), Guangdong (54.32%), Beijing (54.30%) and Jiangsu (46.83%) in 2017. In 2012-2017, the top five of the growth rate in registration rate is Tianjin (192.07%), Shandong (100.71%), Qinghai (68.85%), Ningxia (64.66%) and Guangxi (56.44%).

Table 5 Number of general practitioners in 2012-2017(person)

Category	2012	2013	2014	2015	2016	2017
Number of general practitioners	109 794	145 511	172 597	188 649	209 083	252 717
Among them: number of people registered as general medicine major	37 173	47 402	64 156	68 364	77 631	96 235
Number of people who obtained the general practitioner training certificates	72 621	98 109	108 441	120 285	131 452	156 482
Number of general practitioners per 10,000 population	0.81	1.07	1.26	1.37	1.51	1.82

Table 6 General practitioner registration rate in 2012-2017 (%)

Region	2012	2013	2014	2015	2016	2017
Total	33.86	32.58	37.17	36.24	37.13	38.08
The eastern region	36.19	36.13	40.45	39.94	40.79	41.75
The central region	33.99	31.11	34.96	34.8	35.57	35.73
The western region	26.39	24.39	30.84	28.11	28.93	30.82
Beijing（E）	50.46	50.33	51.34	52.53	52.32	54.3
Tianjin（E）	15.89	19.41	28.24	30.83	44.61	46.41
Hebei（E）	23.33	22.96	24.37	23.24	24.46	26.47
Shanxi（C）	29.58	28.23	31.32	36.37	39.02	27.24
Inner Mongolia（W）	32.1	32.31	38.51	35.14	35.43	34.07
liaoning（E）	40.01	28.78	32.14	28.67	37.71	46.2
Jilin（C）	33.23	34.58	36.67	32.27	37.2	31.5
Heilongjiang（C）	31.76	24.78	28.28	29.31	30.13	31.49
Shanghai（E）	62.45	67.28	72.78	68.97	72.31	67.82

Jiangsu（E）	36.63	34.83	38.12	38.32	35.03	46.83
Zhejiang（E）	31.25	33.21	39.81	37.61	35.94	23.99
Anhui（C）	40.68	39.96	41.74	40.15	40.65	44.46
Fujian（E）	28.72	25.76	28.52	28.7	30.35	35.42
Jiangxi（C）	33.49	33.35	35.89	34.56	33.48	23.97
Shandong（E）	18.33	24.8	28.05	28.59	31.39	36.79
Henan（C）	33.12	26.42	29.75	31.38	32.01	39.41
Hubei（C）	31.72	27.4	33.89	32.34	31.57	32.62
Hunan（C）	37.57	37.81	41.98	41.12	41.65	40.91
Guangdong（E）	34.96	38.39	46.99	49.74	53.01	54.32
Guangxi（W）	19.79	23.72	32.58	28.67	24.84	30.96
Hainan（E）	42.99	42.59	45.74	46.06	47.26	45.37
Chongqing（W）	25.31	22.04	28.89	26.92	27.76	33.99
Sichuan（W）	31.13	21.96	23.2	20.87	22.16	22.96
Guizhou（W）	40.7	36.86	46.56	44.58	43.35	41.96
Yunnan（W）	19.99	18.24	22.19	18.07	20.69	27.26
Tibet（W）	52.94	53.73	77.06	70.81	64.36	62.75
Shaanxi（W）	18.2	19.46	36.71	28.17	25.64	23.56
Gansu（W）	26.93	27.68	32.1	32.13	33.85	29.81
Qinghai（W）	27.06	29.68	33.83	27.37	38.47	45.69
Ningxia（W）	25.38	30.36	39.49	34.69	43.73	41.79
Xinjiang（W）	31.38	29.08	35.49	34.12	34.83	35.21

Conclusions

1.The number of general practitioners in China has been increasing greatly, but the total allocation is still insufficient and stressful work

Our government recently pays high attention to the development of general practice and the talent training of general practitioners. According to *Guidance of the State Council on the Establishment of a General Practitioner System* issued in 2011, it is pointed out that by 2020, there should be 2~3 qualified general practitioners for every 10000 urban and rural residents. The results showed that the number of general practitioners of our country increased from 109794 to 252717 in 2012-2017, with an increasing number and a good momentum of development. However, 7.45% of executive (assistant) doctors were general practitioners by the end of 2017 which was 1.82 general practitioners per 10,000 population. It was 1.33 general practitioners per 10,000 population in the western region. The shortage of general practitioners leads to high work pressure, low job satisfaction and easy job burnout [23-25]. Since the construction of general practitioner education and training system in China started late, the construction of general practitioner system and theoretical research still need to be

improved urgently. It is still difficult to achieve the goal of 2~3 qualified general practitioners per 10,000 residents. In addition, general practitioners account for 30%~60% of the total number of doctors in developed countries, compared with China, and there is still a big gap. Therefore, some advice to point. first, the government should continue to strengthen the training of general practitioners, and build more reasonable and standardized general practitioners training bases in order to strengthen the construction of general practitioners' teachers. Second, GPS work support system should be established to adjust working strength of general practitioners. Using Internet +" to assign general practitioner realizing online sign up, online consulting and disease diagnosis etc. And that will reduce their pressure and improve the service efficiency [26-28].

2. The fairness of the number of general practitioners allocated according to population is good, but it allocated according to geographical area is poor, and there are regional differences between eastern and western regions.

By calculating, the Geordie Coefficient of the number of general practitioners allocated according to the population in China decreased from 0.31 to 0.24 in 2012-2017, which is fair, but the Geordie Coefficient allocated according to the geographical area is 0.72-0.73, which shows extremely unfair. It shows that the fairness of general practitioners in population allocation is higher than that in geographical area allocation in our country. China's regional planning of health resources is mainly based on the allocation of health resources per 10,000 population, so it is fair in population allocation, and it has shown a trend towards more equitable development in recent years. The analysis of aggregation degree reflects the differences between different regions. From the perspective of the eastern, central and western regions, the aggregation degree based on the population is 1.33, 0.80 and 0.73 respectively. The resources of general practitioners in central region are insufficiently based on the population allocation, and while those in eastern regions are too concentrated. The aggregation degree based on the geography is 0.27 in the western region, which is relatively poor in equity, and1.3 is fair in the central region and 5.37 is the excess of general practitioner resources in eastern region. They are very unequitable in the western region both based on the geographical area or population to allocate the general practitioners. There are several reasons. First, it is the poor geographical environment, most of which are plateau and desert. Secondly, it is the underdeveloped economic situation which reduced the

attractiveness of the region. The per capita disposable income was 20130.3 yuan in the western region and 33414.0 yuan in eastern region in 2017. And the third reason the western region is not fit for people to live where with the thin air, low pressure and low oxygen content. Many projects of equalization of basic public health services involve door-to-door visits, and the size of service area will also become an important factor for the smooth completion of the work which needs to attract the attention of the government and relevant departments [29-30]. General practitioner should play the role of health gatekeeper and expenditure gatekeeper in western region. Two advice can be offered here: first, the government should strengthen macro-control and increase the intensity of financial input to the western region. The government should encourage the hospitals in large and medium cities to help grassroots hospital in order to guarantee the construction and echelon reserve of general practitioner in western region [31]. Secondly, the government should formulate reasonable resource allocation standards and development plans based on the actual conditions in the western region, and take measures to meet the needs of them. In addition, Chinese medical resources will be tilted to western region to avoid widening the inequality.

3. The equity of general practitioners' allocation has a big gap in different provinces and municipalities in China

Among 22 provinces, 5 autonomous regions and 4 municipalities, aggregation degree based on the population allocation is less than 0.2 in Tibet, Qinghai, Xinjiang and Inner Mongolia. It is less than 0.3 in Gansu and Heilongjiang. And it is less than 0.7 in Yunnan, Ningxia and Shaanxi. The number of general practitioners in above mentioned areas is obviously insufficient based on the population allocation. The agglomeration degree is less than 0.6 in Tibet, Shaanxi, Hunan and other areas. The equity of the above-mentioned areas is insufficient based on the geographical area allocation. However, the agglomeration degree is more than 1 by far in Shanghai, Beijing, Zhejiang and other areas whatever based on the population or geographical area allocation, and that means the allocation of general practitioner is excessively concentrated. Graduate medical students tend to work in eastern region where have abundant resources and the developed economy. Three suggestions can be offered: first, the government should encourage graduate medical students to work in the area which has underdeveloped economy, sparse population and large geographical area. secondly, the government

should improve their remuneration comprehensively, promote policy of professional title which is benefit to expand the career and give preferential policies to children's education. And improve the income of general practitioners[32].Thirdly, the government should vigorously develop the medical education in areas which is with shortage of talents to cultivate general medical talents, and actively carry out standardized training of resident physicians in the "5+3" mode and assistant general practitioners in the "3+2" mode. At the mean time government should ensure their treatment during the training and gradually increase the subsidy standard [33].

Research Limitations: first, this study evaluated the equity of general practitioners allocation based on the hypothesis of resource homogeneity. The study doesn't distinguish the differences in service quality and service ability between different general practitioners. Secondly, this study evaluated the equity of general practitioners allocation based on the population and geographical area. It didn't analyze the economic conditions. However, the higher the level of economic development, the higher the level of education and living standards of its residents and the demand of health human resources will increase accordingly.

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Authors' contributions

QY and WY conceptualized the study and analyze the data. QY write the first draft of the manuscript, DH, KS, ZC, HG and DW comment the manuscript critically. All authors read and approved the final manuscript.

Authors' information

All the authors are from Public Health and Management School of Weifang Medical University except DW. QY is the associate professor whose research interests are health policy and health economic evaluation. WY is the professor whose research interest is health care management. DH is a professor whose research interest is health human resource management. KS is the associate professor whose research interest is hospital management. ZC is a lecturer whose research interests are health emergency management and health economics. HG is the associate professor whose research interest is health policy evaluation. DW is the associate professor whose research interest is medical English who is in the Department of English of Weifang Medical University.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

No ethical approval was required for this study.

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Figures

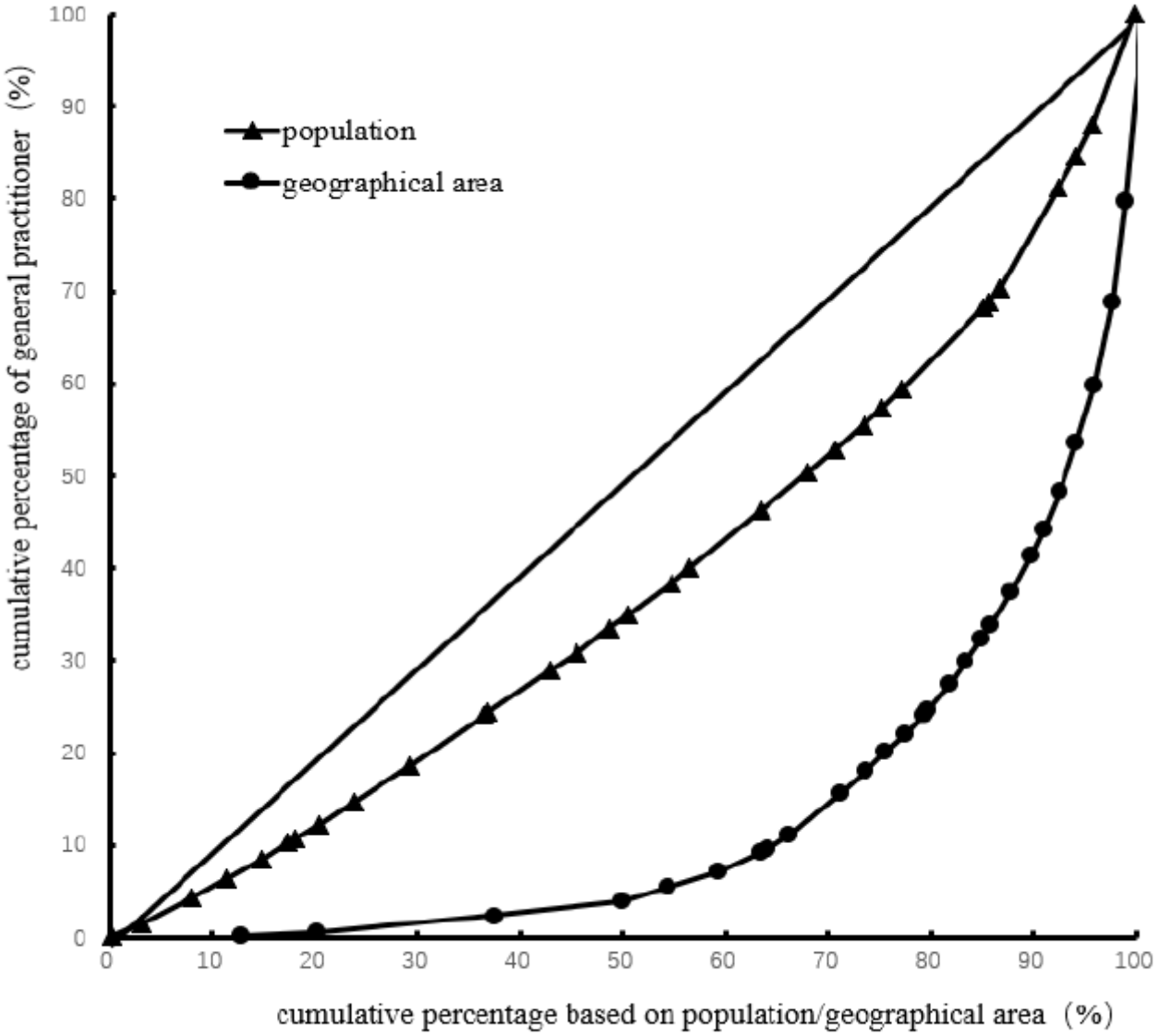

Figure 1 Lorenz curve for distribution of GPs in China in 2012

Figure 2

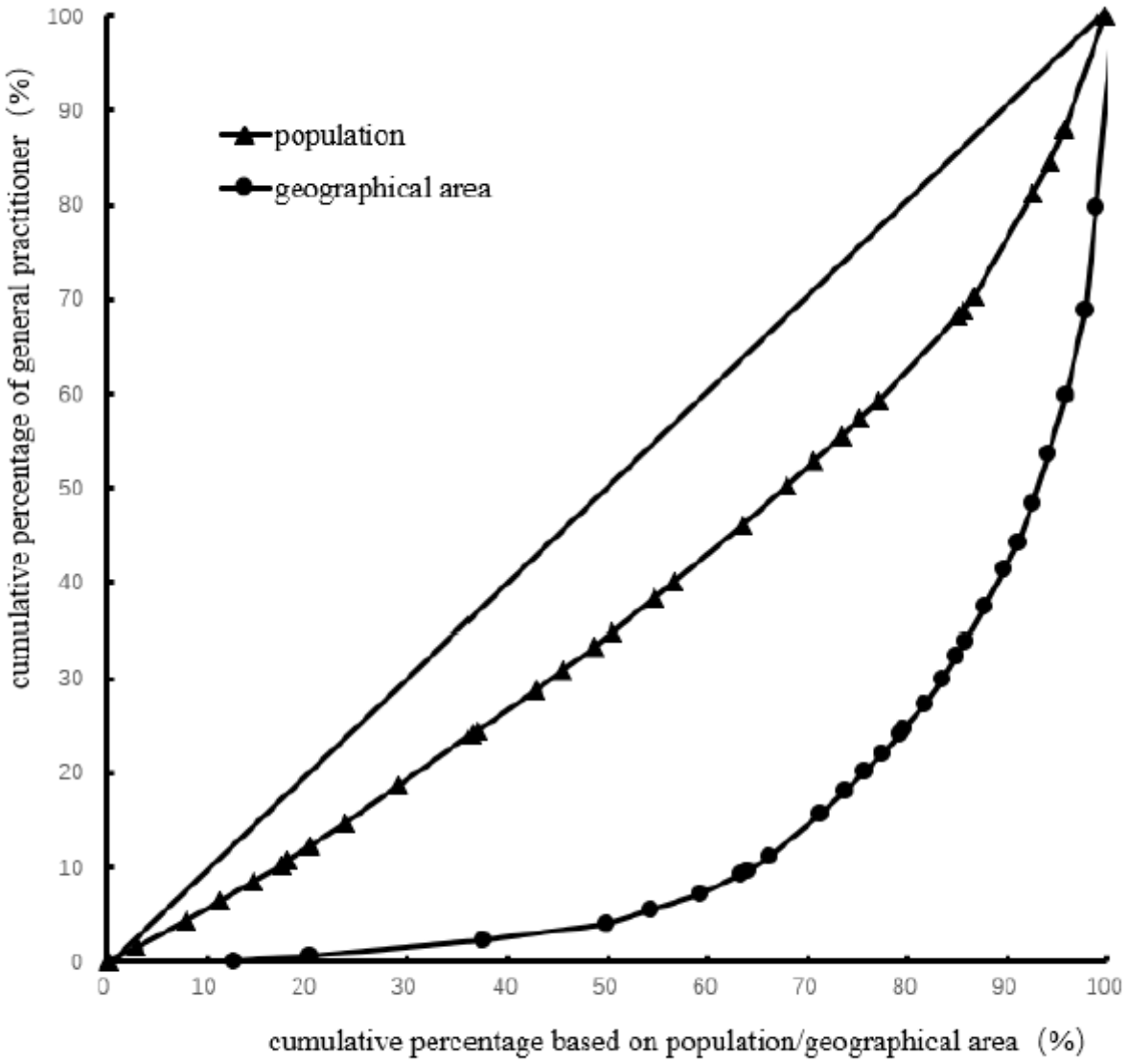

Figure2 Lorenz curve for distribution of GPs in China in 2013

Figure 4

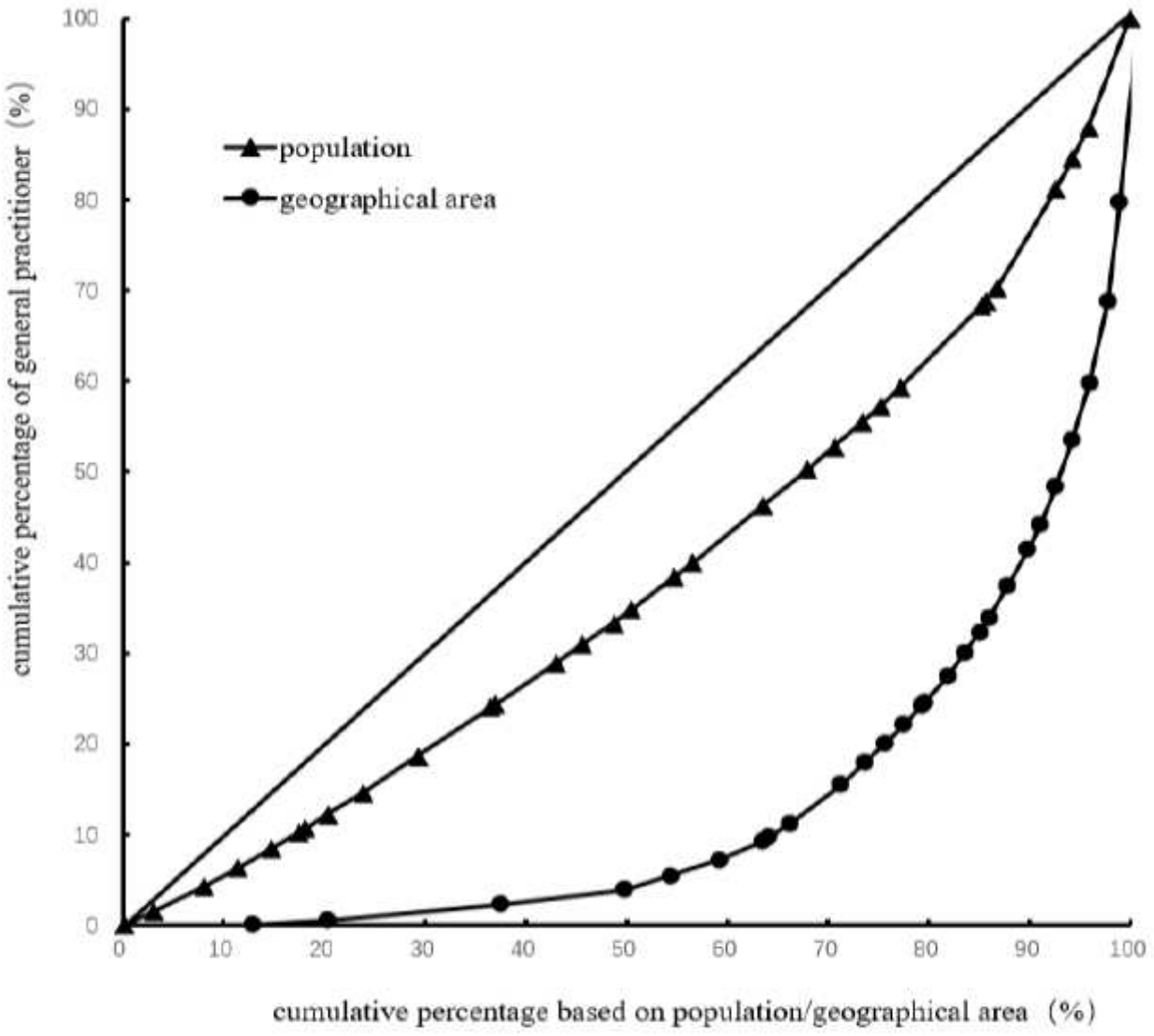

Figure3 Lorenz curve for distribution of GPs in China in 2014

Figure 6

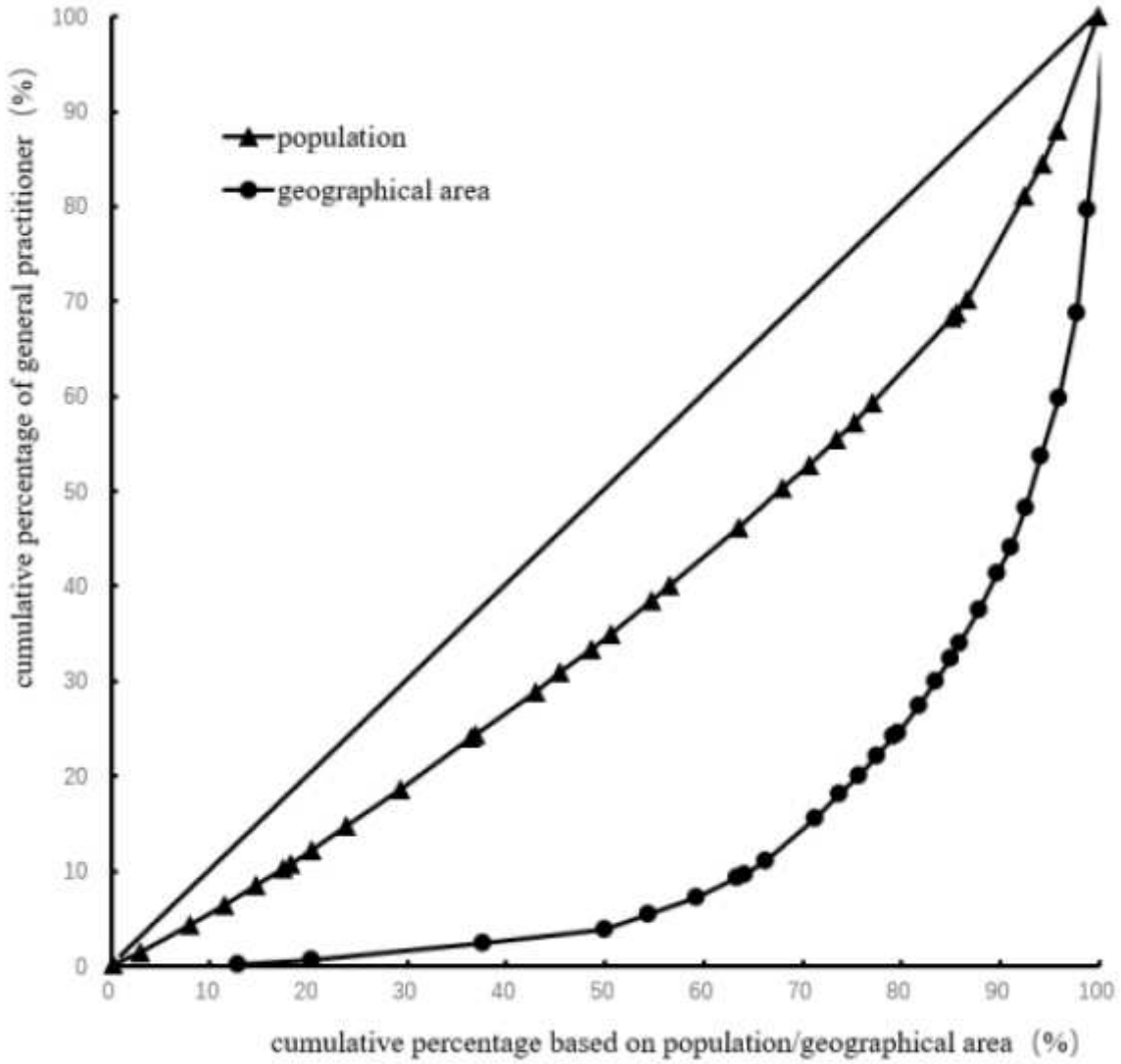

Figure4 Lorenz curve for distribution of GPs in China in 2015

Figure 8

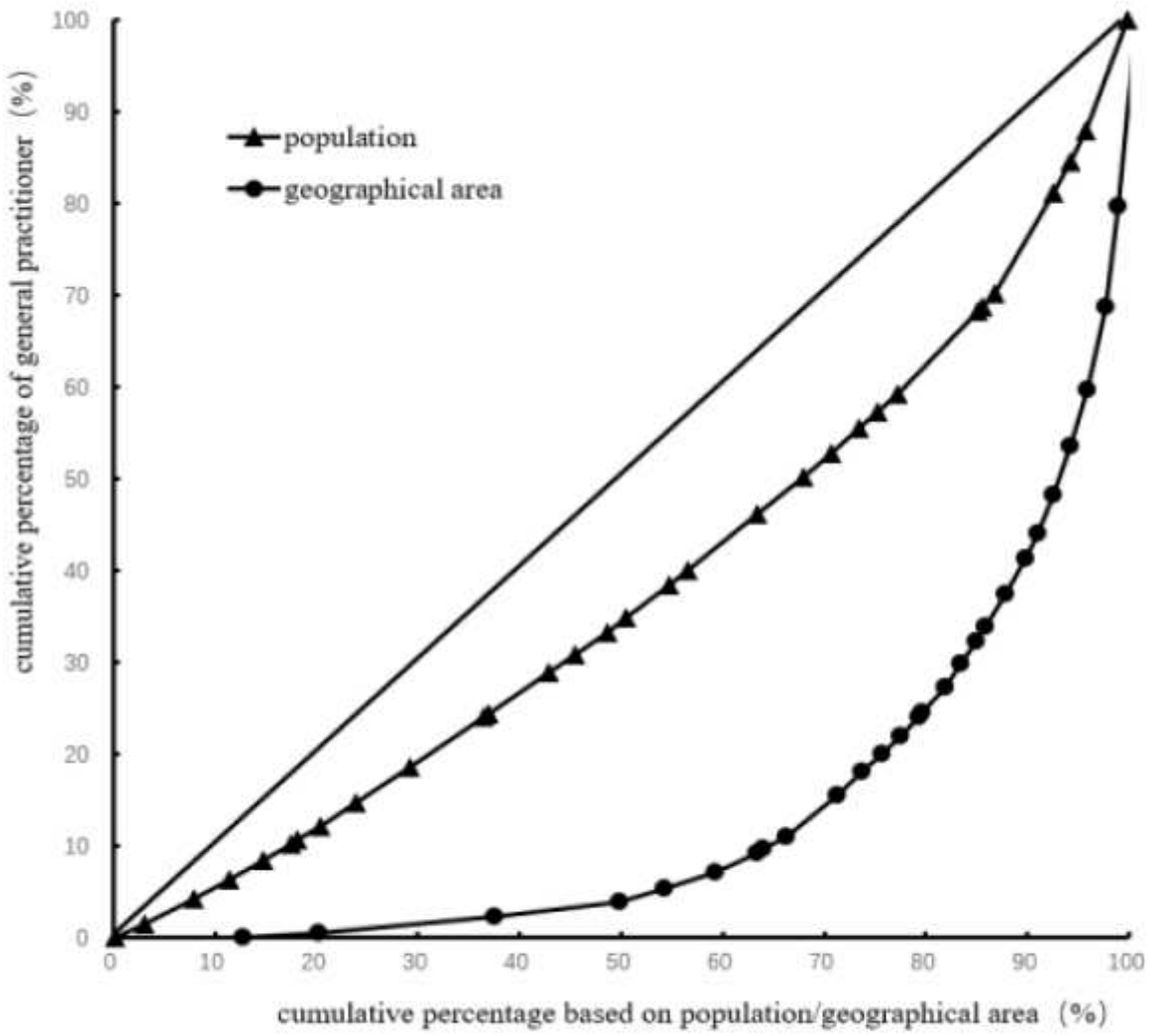

Figure5 Lorenz curve for distribution of GPs in China in 2016

Figure 9

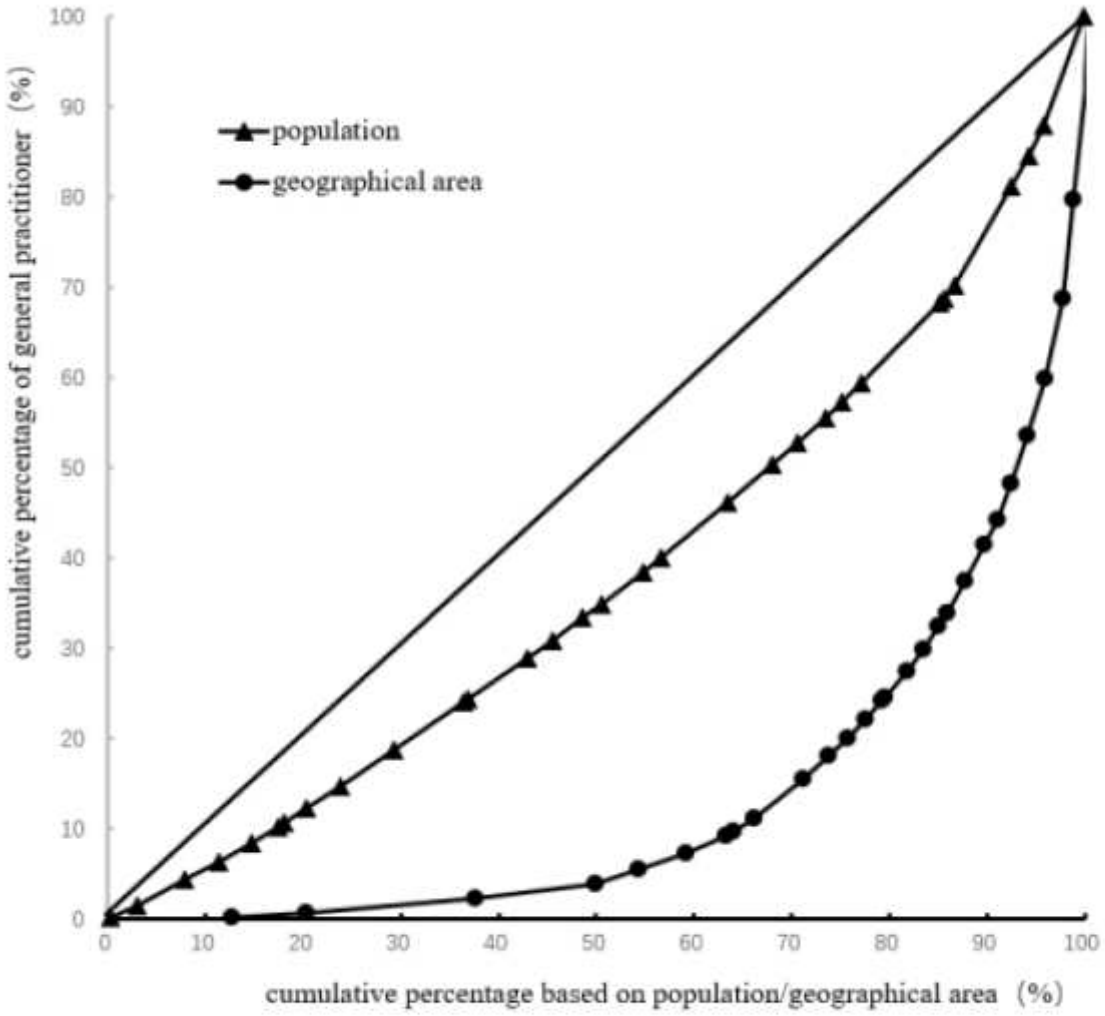

Figure6 Lorenz curve for distribution of GPs in China in 2017

Figure 12