Equality of Medical Health Resource Allocation in China Based on the Gini Coefficient Method

Jian JIN¹, Jianxiang WANG², Xiaoyi MA¹, *Yuding WANG¹, Renyong LI³

1. School of Economics, Hebei University, Baoding, P.R.China
2. New Campus Administrative Office, Hebei University, Baoding, P.R.China
3. University of Oulu, FIN 90014 Oulun yliopisto, Finland

*Corresponding Author: Email: wangyudinghbds@163.com

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Abstract

Background: The Chinese government is trying to achieve the goal of “universal access to basic health care services”. However, the inequality of the distribution of health care resources across the country is the biggest obstacle. This paper aims to explore these inequalities and the extent to which the method of analysis influences the perception.

Methods: The indicators of health care resource distribution studied consisted of the number of health care institutions, the number of beds in health care institutions and the number of medical personnel. Data were obtained from the China Statistical Yearbook 2014. The extent of equality was assessed using the Lorenz Curve and Gini Coefficient Method.

Results: Health care resource distribution in China demonstrates inequalities. The demographic Gini Coefficients based on the Lorenz Curves for the distribution of health care institutions, beds in health care institutions and medical personnel are 0.190, 0.070 and 0.070 respectively, while the corresponding Coefficients based on geographical areas are 0.616, 0.639 and 0.650.

Conclusion: The equality of China’s demographically assessed distribution of health care resources is greater than that of its geographically measured distribution. Coefficients expressed by population imply there is ready access to healthcare in all regions, whilst the Coefficients by geographical area apparently indicate inequality. This is the result of the sparsity of population.

Keywords: Health care resources, Inequality, Lorenz curve, Gini coefficient

Introduction

Great changes have taken place in China’s health care industry since 1949. There are increasing numbers of health care resources for the Chinese to choose from, and most people are living longer lives, in better health. However, there is still a marked disparity in the distribution of China’s health care resources, which has led to some social conflicts.

Such a situation is contrary to the ethos of the Communist Party of China and China is trying her best to solve this problem. During its 17th National Congress, the Communist Party of China made it clear that "universal access to basic health care services" is the goal of China’s medical and health care development. In 2010, Wen Jiabao, the then premier of the People’s Republic of China, wrote in one of his papers that, by 2020, China should establish a basic medical and health service system which comprehensively covers both the urban and rural areas, and that all Chinese should be able to enjoy basic health care services.
It is particularly relevant to carry out research on the inequalities in the distribution of health care resources in China in order to enable the country to allocate her finite health care resources to include areas where these could ensure the maximum social benefits.

**Literature review**

Researchers are very focused on the equality of health care resource distribution. The literature shows that there are three distinct approaches to this research:

Firstly, many researchers start from a medical viewpoint, studying the health care resources based on medical knowledge, especially in respect of the distribution of health care resources relevant to particular diseases, while less attention is paid to research based on economics. For example, previous studies (1-3) explored the inequality of health care resource distribution in the fields of cancer, children's health and mal-nutrition, and musculoskeletal issues, respectively.

Secondly, some researchers have paid greater attention to the factors, which influence the extent of inequality of medical, and health resource distribution. For example, Asante (4) studied the factors affecting the equality of health care resource distribution in Ghana, while other scholars (5) probed the factors that influence the level of utilization of medical and health resources in Australia. Further research into the decision criteria for health care resource distribution was conducted by Lalla A da Guindo (6).

Although some research exists on the equality of health care resource distribution in developing countries, such as that of Vivian Welch (7), most studies have concentrated on developed countries, with there being only limited study of developing countries such as China and India.

Therefore, thirdly, although research conducted by Zhang Xiaoyan et al. (8-11) has related to medical and health care resource distribution in China, their research has been from the viewpoint of a single province or city, and has not looked at the country as a whole.

As to research methods, most literature uses quantitative indicators as the analysis instruments for the equality of health care resource distribution. These include the Atkinson index (12), the Theil index (13), the coefficient of variation (14) and the Gini Coefficient (15).

In this paper, we measured the degree of inequality of the demographic and geographic distribution of health care resources in China, by analyzing them using a Lorenz Curve and Gini Coefficient approach.

**Data resources and research methods**

**Data resources**

To inform our proposed research methods and purposes, we collected data on the total populations, geographic areas, the number of health care institutions, the number of beds in health care institutions and the number of medical personnel for 31 provinces (autonomous regions and municipalities) in China. Because of data inconsistence, the Hong Kong and Macao Special Administrative Regions and Taiwan province were not included. All of the data were taken from *China Statistical Yearbook 2014*.

**Comparison of methods for measuring inequality**

1) **The statistical distribution method**

One of the most important methods for measuring inequality is the Statistical Distribution Method. According to Chen Jiandong (16), there are two kinds of statistical distribution function. One is the type of distribution function with no more than two parameters; the other is that with more than two parameters. The Pareto distribution (17), Lognormal distribution (16), Gamma distribution (18), Weibull distribution (19), Log-logistic distribution (20) and Lomax distribution (21) are the most common distribution functions with only two parameters. The Pareto-lognormal distribution (22), Log-gamma distribution (23), Generalized beta distribution of the second kind (24) and the Dagum distribution (25)
are the most common distribution functions available for working with more than two parameters. Although several varieties of distribution function exist, and each has its advantages, few of them can be used effectively to fit all the different types of resource distributions, which imply that the practical application of the methods described above is limited.

2) Indicator methods
Using indicators is a very broad approach to measuring inequality, as this can include both absolute and relative indicators. According to Wan Guanghua (26), the Kolm index (27) is the best known of the absolute indicators, while, of the relative indicators, the Atkinson index, Theil index, coefficient of variation and the Gini Coefficient are those, which are familiar to most people. The main feature of the Kolm index is that its value is closely connected with the units of measurement. Given this, it is essential to conduct nondimensionalization when we analyze data using the Kolm index. If not, large deviations will occur.

One of the main features of the Atkinson index is its ability to reveal the inequality of resource distribution. However, when we analyze data with the Atkinson index, the social welfare function corresponding with it simply takes into consideration the quantity of the resources shared by the whole population, without considering the relative position of each person on the ladder of possession of resources.

The Theil index ranges in value from 0 to 1. The smaller the value, the fairer the distribution of resources, and vice versa. Compared with the Gini Coefficient, the Theil index is more likely to overestimate inequality. The coefficient of variation is the ratio of the standard deviation to the mean, and is used to reflect the degree of dispersion. The bigger its value is, the higher the degree of dispersion, and vice versa. Unfortunately, the main drawback of the coefficient of variation is that it fails to describe the dispersion within groups adequately.

3) Lorenz Curve and the Gini Coefficient Method
The Gini Coefficient is frequently used as an index to reflect the inequality of income distribution. The value of the Gini Coefficient varies from 0 to 1. A region with complete equality will have a value of 0 while a region with no equality will be denoted by 1. According to general international standards, a Gini Coefficient that is smaller than 0.3 represents a particularly equitable condition, 0.3-0.4 is the normal condition, while greater than 0.4 raises concern, and a value greater than 0.6 indicates a dangerous state.

The Lorenz Curve (28) was first developed by the America statistician Max O. Lorenz in 1905, as a graphical representation of income distribution. The X-axis represents the cumulative percentage of the population, ranked in increasing order of income - that is, beginning with those people with the lowest incomes and ending with those with the largest. The Y-axis represents the cumulative percentage of the income of the corresponding percentage of the population. The line between the origin of the coordinates and the corresponding vertex is the line of perfect equality. The actual extent of inequality is reflected by the area between Lorenz Curve and the line of perfect equality. Thus, the less deviation from the line of perfect equality, the more even the distribution.

The Gini Coefficient calculated based on the Lorenz Curve is an ideal index for measuring the extent of inequality. In this paper, the Lorenz Curve and Gini Coefficient have been chosen to study the equality of health care resource distribution across China, as they are truly able to reflect the current situation in this respect.

Comparative analysis of inequality in health care resource distribution within China
For this paper, 31 regions (provinces, autonomous regions and municipalities) in China were studied and the number of health care institutions, the number of beds in health care institutions, and the number of medical personnel were used as the indicators of health care resources in each region.
Table 1: Basic information on health care resource distribution in China

| Region         | Population (10,000 persons) | Geographic area (10,000 square km) | Number of health care institutions (unit) | Number of beds in health care institutions (10,000 beds) | Number of medical personnel (individuals) |
|----------------|-----------------------------|------------------------------------|------------------------------------------|----------------------------------------------------------|-------------------------------------------|
| Beijing        | 2115                        | 1.68                               | 9683                                     | 10.4                                                     | 263146                                    |
| Tianjin        | 1472                        | 1.13                               | 4689                                     | 5.77                                                     | 106527                                    |
| Hebei          | 7333                        | 18.77                              | 78485                                    | 30.35                                                    | 492012                                    |
| Shanxi         | 3630                        | 15.63                              | 40281                                    | 17.26                                                    | 283860                                    |
| Inner Mongolia | 2498                        | 118.3                              | 23257                                    | 12.01                                                    | 195952                                    |
| Liaoning       | 4390                        | 14.59                              | 35612                                    | 24.19                                                    | 338443                                    |
| Jilin          | 2751                        | 18.74                              | 19913                                    | 13.32                                                    | 200184                                    |
| Hei Longjiang  | 3835                        | 45.48                              | 21369                                    | 18.92                                                    | 279122                                    |
| Beijing        | 2415                        | 0.63                               | 4929                                     | 11.43                                                    | 192333                                    |
| Jiangsu        | 7939                        | 10.26                              | 30998                                    | 36.83                                                    | 551113                                    |
| Zhejiang       | 5498                        | 10.2                               | 30063                                    | 23.01                                                    | 427072                                    |
| Anhui          | 6030                        | 13.97                              | 24645                                    | 23.6                                                     | 353799                                    |
| Fujian         | 3774                        | 12.13                              | 28175                                    | 15.61                                                    | 261784                                    |
| Jiangxi        | 4522                        | 16.7                               | 38902                                    | 17.43                                                    | 269819                                    |
| Shandong       | 9733                        | 15.38                              | 75426                                    | 48.97                                                    | 819348                                    |
| Henan          | 9413                        | 16.7                               | 71464                                    | 42.98                                                    | 716306                                    |
| Hubei          | 5799                        | 18.59                              | 35631                                    | 28.82                                                    | 411184                                    |
| Hunan          | 6691                        | 21.18                              | 62210                                    | 31.41                                                    | 442224                                    |
| Guangdong      | 10644                       | 18                                 | 47835                                    | 37.84                                                    | 708036                                    |
| Guangxi        | 4719                        | 23.6                               | 33943                                    | 18.72                                                    | 334849                                    |
| Hainan         | 895                         | 3.4                                | 5011                                     | 3.21                                                     | 63468                                     |
| Chongqing      | 2970                        | 8.23                               | 18926                                    | 14.74                                                    | 197667                                    |
| Sichuan        | 8107                        | 48.14                              | 80037                                    | 42.66                                                    | 596001                                    |
| Guizhou        | 3502                        | 17.6                               | 29177                                    | 16.67                                                    | 221575                                    |
| Yunnan         | 4687                        | 38.33                              | 24264                                    | 21.01                                                    | 265531                                    |
| Tibet          | 312                         | 122.8                              | 6725                                     | 1.1                                                      | 24653                                     |
| Shaanxi        | 3784                        | 20.56                              | 37137                                    | 18.51                                                    | 321908                                    |
| Gansu          | 2582                        | 45.44                              | 26697                                    | 11.61                                                    | 160695                                    |
| Qinghai        | 578                         | 72.23                              | 6020                                     | 2.95                                                     | 44685                                     |
| Ningxia        | 654                         | 6.64                               | 4231                                     | 3.11                                                     | 47609                                     |
| Xinjiang       | 2264                        | 166                                | 18663                                    | 13.73                                                    | 189578                                    |

Data source: China Statistical Yearbook 2014

Overall comparative analysis of three zones (East, Central and West)
The basic situation regarding the distribution of health care resources in China is shown in Table 1. In order to compare the differences, we allocated the 31 regions into those of the eastern, central and western zones. Thus, the overall situation is shown in Fig. 1.

Fig. 1 shows that the east obviously has advantages over both the central and western zones, whether it is in the number of health care institutions, the number of beds in health care institutions or the number of medical personnel. The mean level of health care resources in the east is 1.274 times that in the central area, and 1.386 times that in the west. Fig. 1 also clearly shows that, in respect of the number of medical personnel, the west is especially lacking, some regions of the latter zone having up to 1.623 times fewer. Overall, the central zone is superior to the west in all respects, although the difference between the two zones is barely 1.083 times in average.

Comparative analysis of per capita health care resource distribution in different regions
In order to have a better understanding of the situation of per capita health care resource distribution in different regions, we calculated the per capita resources, and sorted the data by the number of health care institutions per 10,000 persons. The data are given in Table 2.

Available at: [http://ijph.tums.ac.ir](http://ijph.tums.ac.ir)
Fig. 1: Differences in health care resource distribution among eastern, central and western zones of China

Table 2: Per capita health care resource distribution in different regions in 2013

| Region           | Number of health care institutions per 10,000 persons | Number of beds in health care institutions per person | Number of medical personnel per 10,000 persons |
|------------------|-------------------------------------------------------|------------------------------------------------------|------------------------------------------------|
| Shanghai         | 2.041                                                 | 0.005                                                | 79.636                                         |
| Tianjin          | 3.185                                                 | 0.004                                                | 72.359                                         |
| Jiangsu          | 3.904                                                 | 0.005                                                | 69.414                                         |
| Anhui            | 4.087                                                 | 0.004                                                | 58.675                                         |
| Guangdong        | 4.494                                                 | 0.004                                                | 66.52                                          |
| Beijing          | 4.579                                                 | 0.005                                                | 124.431                                        |
| Yunnan           | 5.177                                                 | 0.004                                                | 56.657                                         |
| Zhejiang         | 5.468                                                 | 0.004                                                | 77.678                                         |
| Hei Longjiang    | 5.572                                                 | 0.005                                                | 72.782                                         |
| Hainan           | 5.597                                                 | 0.004                                                | 70.892                                         |
| Hubei            | 6.144                                                 | 0.005                                                | 70.906                                         |
| Chongqing        | 6.372                                                 | 0.005                                                | 66.555                                         |
| Ningxia          | 6.468                                                 | 0.005                                                | 72.775                                         |
| Guangxi          | 7.193                                                 | 0.004                                                | 70.958                                         |
| Jilin            | 7.238                                                 | 0.005                                                | 72.76                                          |
| Fujian           | 7.466                                                 | 0.004                                                | 69.365                                         |
| Henan            | 7.592                                                 | 0.005                                                | 76.095                                         |
| Shandong         | 7.749                                                 | 0.005                                                | 84.179                                         |
| Liaoning         | 8.112                                                 | 0.006                                                | 77.094                                         |
| Xinjiang         | 8.242                                                 | 0.006                                                | 83.725                                         |
| Guizhou          | 8.331                                                 | 0.005                                                | 63.267                                         |
| Jiangxi          | 8.603                                                 | 0.004                                                | 59.666                                         |
| Hunan            | 9.298                                                 | 0.005                                                | 66.096                                         |
| Inner Mongolia   | 9.312                                                 | 0.005                                                | 78.456                                         |
| Shaanxi          | 9.866                                                 | 0.005                                                | 85.523                                         |
| Sichuan          | 9.873                                                 | 0.005                                                | 73.517                                         |
| Gansu            | 10.339                                                | 0.004                                                | 62.232                                         |
| Qinghai          | 10.419                                                | 0.005                                                | 77.338                                         |
| Hebei            | 10.704                                                | 0.004                                                | 67.099                                         |
| Shanxi           | 11.097                                                | 0.005                                                | 78.203                                         |
| Tibet            | 21.552                                                | 0.004                                                | 79.006                                         |
From the perspective of the number of health care institutions per 10,000 persons, we can roughly divide the regions into four groups. Those regions with 5 or fewer institutions per 10,000 persons are classified into the first group. The second group was greater than 5 but less than 10. Similarly, the third group was from 10 to 20. The number of Tibet is greater than 20, and Tibet falls into the fourth group. We can see from the above data, that the number of health care institutions per 10,000 persons ranges chiefly from 5 to 10, and this includes 2/3 of the regions. Meanwhile, what can also be seen is that the differences between regions are extremely significant. Shanghai is the most salient case, having the fewest institutions per 10,000 persons (2.041), while Tibet has the most institutions per 10,000 persons (21.552), the latter figure being more than 10 times larger.

Based on the per capita number of beds in health care institutions, chiefly between 4 and 6, the disparity between the different regions is not as great. That means, the distribution of beds in health care institutions across the regions is relatively fair. From the standpoint of the number of medical personnel per 10,000 persons, mainly between 60 and 80, the differences between the 31 regions are generally significantly smaller than the differences in the number of health care institutions per 10,000 persons.

Comparative analysis of health care resource distribution in different geographical areas

In order to analyze further, the situation in respect of health care resource distribution in different regions, we considered the actual geographical area, computed the resources per unit area, and then sorted the data by the number of health care institutions per unit area, as shown in Table 3.

| Region     | Number of health care institutions per 10,000 square kilometers | Number of beds in health care institutions per square kilometer | Number of medical personnel per 10,000 square kilometers |
|------------|-----------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------|
| Tibet      | 54.76                                                           | 0.01                                                           | 200.76                                                 |
| Qinghai    | 83.34                                                           | 0.04                                                           | 618.65                                                 |
| Xinjiang   | 112.43                                                          | 0.08                                                           | 1142.04                                                |
| Inner Mongolia | 196.59                                                         | 0.1                                                            | 1656.4                                                 |
| Hei Longjiang | 469.85                                                         | 0.42                                                           | 6137.25                                                |
| Gansu      | 587.52                                                          | 0.26                                                           | 3536.42                                                |
| Yunnan     | 633.03                                                          | 0.55                                                           | 6927.5                                                 |
| Ningxia    | 637.2                                                           | 0.47                                                           | 7170.03                                                |
| Jilin      | 1062.59                                                         | 0.71                                                           | 10682.18                                               |
| Guangxi    | 1438.26                                                         | 0.79                                                           | 14188.52                                               |
| Hainan     | 1473.82                                                         | 0.94                                                           | 18667.06                                               |
| Guizhou    | 1657.78                                                         | 0.95                                                           | 12589.49                                               |
| Sichuan    | 1662.59                                                         | 0.89                                                           | 12380.58                                               |
| Anhui      | 1764.14                                                         | 1.69                                                           | 25325.63                                               |
| Shaanxi    | 1806.27                                                         | 0.9                                                            | 15657                                                 |
| Hubei      | 1916.68                                                         | 1.55                                                           | 22118.56                                               |
| Chongqing  | 2299.64                                                         | 1.79                                                           | 24017.86                                               |
| Fujian     | 2322.75                                                         | 1.29                                                           | 21581.53                                               |
| Jiangxi    | 2329.46                                                         | 1.04                                                           | 16156.83                                               |
| Liaoning   | 2440.85                                                         | 1.66                                                           | 23196.92                                               |
| Shanxi     | 2577.16                                                         | 1.1                                                            | 18161.23                                               |
| Guangdong  | 2657.5                                                          | 2.1                                                            | 39335.33                                               |
| Hunan      | 2937.2                                                          | 1.48                                                           | 20879.32                                               |
| Zhejiang   | 2947.35                                                         | 2.26                                                           | 41869.8                                                |
| Jiangsu    | 3021.25                                                         | 3.59                                                           | 53714.72                                               |
| Tianjin    | 4149.56                                                         | 5.11                                                           | 94271.68                                               |
| Hebei      | 4181.41                                                         | 1.62                                                           | 26212.68                                               |
| Henan      | 4279.28                                                         | 2.57                                                           | 42892.57                                               |
| Shandong   | 4904.16                                                         | 3.18                                                           | 53273.6                                                |
| Beijing    | 5763.69                                                         | 6.19                                                           | 156634.5                                               |
| Shanghai   | 7823.81                                                         | 18.15                                                          | 305290.5                                               |
What we can see from the table is that the differences are dramatic, regardless of whether we consider them from the perspective of the number of health care institutions per 10,000 square kilometers, the number of beds in health care institutions per square kilometer or the number of medical personnel per 10,000 square kilometers. Simply focusing on the number of health care institutions per 10,000 square km; it is not hard to see that Tibet has the fewest, with a value of 54.76, while the largest value belongs to Shanghai, with 7823.81, the latter value being 143 times greater. For the number of beds in health care institutions per square kilometer, the corresponding maximum value is 1850 times greater than the minimum. In the case of the number of medical personnel per 10,000 square kilometers, the disparity is 1520 times. This means that difference in health care resource distribution, by geographical area, between the different regions is exceedingly large, and the distribution of health care resources per unit area shows significant inequality.

Although such comparative analysis means that we can readily appreciate the marked disparity of health care resource distribution across the different regions, it is inevitable that there is bias due to the simple comparison of single indicators. For a more thorough understanding of this inequality, we can investigate it more deeply by using the analysis tools, which have been developed to research income inequality in economics - the Lorenz Curve and the Gini Coefficient.

Relative theory on measuring inequality of health care resource distribution with the Lorenz Curve and Gini Coefficient Method

Different methods of calculating the Gini Coefficient

The general algorithm for calculating the Gini Coefficient uses the area enclosed by the Lorenz Curve and the line of perfect equality, A, and the area located to the bottom right of the Lorenz Curve, B, as shown in Fig. 2.

Here, the Gini Coefficient $G = \frac{A}{A+B}$
where $A+B = \frac{1}{2}$

The X-axis represents the cumulative percentage of the population ordered in relation to the factor under investigation, and the corresponding Y-axis represents the cumulative percentage of the factor under investigation.

According to Zhou Qinghua (29), algorithms for obtaining the Gini Coefficient can be roughly classified into three types, the slab method, the curve fitting method and the bow area method.

We can estimate the Gini Coefficient with any of the three methods above, yet the accuracy of estimation differs, depending on the method used. For the slab method, the more segmented the small parts are, the higher the agreement of the estimated and actual values. Furthermore, the accuracy of estimation is related to the gentleness of the Lorenz Curve. The gentler the Curve, the more accurate the estimate. For the curve fitting method, the accuracy of estimation depends on the merits of the fitted curve, so, the better the curve function Y, the more accurate the estimate. For the bow area method, the calculated Gini Coefficient becomes more accurate the greater the curvature of the Lorenz Curve.

Basic idea for assessment of health care distribution with the Lorenz Curve and Gini Coefficient

With the help of this concept, we take the cumulative percentage demographically (or by geographic area) as the X-axis and take the cumulative percentage of health care resources as the Y-axis.
Then we plot the Lorenz Curve with the cumulative percentage demographically (or by geographic area) ranked by the level of health care resources against the cumulative percentage of health care resources corresponding to the population (or geographic area) values, to indicate the equality of health care resource distribution demographically (or by geographic area).

As discussed, we are able to construct a Lorenz Curve based on units of population (or by geographic area) and the health care resources available. Supposing the area B is divided into \( n \) parts by the aid of the integral thought with each part being regarded as a small rectangle. We can then obtain the Gini Coefficient from:

\[
G = \frac{A}{A + B}
\]

where \( A + B = 0.5 \)

\[
B = \frac{1}{2} \sum_{i=1}^{n} (Y_i' + Y_{i-1})(X_i - X_{i-1})
\]

where \( Y_i \) is the cumulative percentage of health care resources, and \( X_i \) is the cumulative percentage of the population (A corresponding approach can be used to obtain the Gini Coefficient in respect of distribution by geographic area).

**Analysis based on the Lorenz Curve and Gini Coefficient Method**

*The Lorenz Curve of health care resource distribution assessed against population*

Based on the data in Table 1, we computed the number of health care institutions per 10,000 persons. Then we ranked the regions by this indicator and calculated the cumulative population, the cumulative number of health care institutions, the cumulative percentage of the population and the cumulative percentage of health care institutions. The results are shown in Table 4.

### Table 4: Distribution of the cumulative percentage of health care institutions by the cumulative percentage of population across the different regions of China in 2013

| Region          | Number of health care institutions per 10,000 persons | Number of cumulative population (10,000 persons) | Number of cumulative health care institutions (unit) | Cumulative percentage of population | Cumulative percentage of health care institutions |
|-----------------|------------------------------------------------------|-------------------------------------------------|---------------------------------------------------|-----------------------------------|--------------------------------------------------|
| Shanghai        | 2.04                                                 | 2415                                            | 4929                                              | 1.78                              | 0.51                                             |
| Tianjin         | 3.19                                                 | 3887                                            | 9618                                              | 2.87                              | 0.99                                             |
| Jiangsu         | 3.9                                                  | 11827                                           | 40616                                             | 8.73                              | 4.17                                             |
| Anhui           | 4.09                                                 | 17857                                           | 65261                                             | 13.18                             | 6.7                                              |
| Guangdong       | 4.49                                                 | 28501                                           | 113096                                            | 21.03                             | 13.61                                            |
| Beijing         | 4.58                                                 | 30615                                           | 122779                                            | 22.59                             | 12.6                                             |
| Yunnan          | 5.18                                                 | 35302                                           | 147043                                            | 26.05                             | 15.09                                            |
| Zhejiang        | 5.47                                                 | 40800                                           | 177106                                            | 30.11                             | 18.18                                            |
| Hei Longjiang   | 5.57                                                 | 44635                                           | 198475                                            | 32.94                             | 20.37                                            |
| Hainan          | 5.6                                                  | 45530                                           | 203486                                            | 33.6                              | 20.88                                            |
| Hubei           | 6.14                                                 | 51329                                           | 239117                                            | 37.88                             | 24.54                                            |
| Chongqing       | 6.37                                                 | 54299                                           | 258043                                            | 40.07                             | 26.48                                            |
| Ningxia         | 6.47                                                 | 54954                                           | 262274                                            | 40.55                             | 26.92                                            |
| Guangxi         | 7.19                                                 | 59673                                           | 296217                                            | 44.03                             | 30.4                                             |
| Jilin           | 7.24                                                 | 62424                                           | 316130                                            | 46.06                             | 32.44                                            |
| Fujian          | 7.47                                                 | 66198                                           | 344305                                            | 48.85                             | 35.34                                            |
| Henan           | 7.59                                                 | 75611                                           | 415769                                            | 55.79                             | 42.07                                            |
| Shandong        | 7.75                                                 | 85345                                           | 491195                                            | 62.98                             | 50.41                                            |
| Liaoning        | 8.11                                                 | 89735                                           | 526807                                            | 66.22                             | 54.06                                            |
| Xinjiang        | 8.24                                                 | 91999                                           | 545470                                            | 67.89                             | 55.98                                            |
| Guizhou         | 8.33                                                 | 95501                                           | 574647                                            | 70.47                             | 58.97                                            |
| Jiangxi         | 8.6                                                  | 100023                                          | 613549                                            | 73.81                             | 62.97                                            |
| Hunan           | 9.3                                                  | 106714                                          | 675759                                            | 78.75                             | 69.35                                            |
| Inner Mongolia  | 9.31                                                 | 109211                                          | 699016                                            | 80.59                             | 71.74                                            |
| Shaanxi         | 9.87                                                 | 112975                                          | 736153                                            | 83.37                             | 75.55                                            |
| Sichuan         | 9.87                                                 | 121082                                          | 816190                                            | 89.35                             | 83.76                                            |
| Gansu           | 10.34                                                | 123665                                          | 842887                                            | 91.25                             | 86.5                                             |
| Qinghai         | 10.42                                                | 124242                                          | 848907                                            | 91.68                             | 87.12                                            |
| Hebei           | 10.7                                                 | 131575                                          | 927392                                            | 97.09                             | 95.18                                            |
| Shanxi          | 11.1                                                 | 135265                                          | 967673                                            | 99.77                             | 99.31                                            |
| Tibet           | 21.55                                                | 135517                                          | 974398                                            | 100                                | 100                                              |

Available at: [http://ijph.tums.ac.ir](http://ijph.tums.ac.ir)
Fig. 3: Lorenz Curve of the distribution of the number of health care institutions by population

As shown in Fig. 3, we can construct a Lorenz Curve for these figures by defining the X-axis as the cumulative percentage of the population and defining the Y-axis as the cumulative percentage of health care institutions. Similarly, Lorenz Curves for the distribution of the number of beds in health care institutions and for the distribution of medical personnel per unit of population can be drawn, as shown in Fig. 4 and Fig. 5 respectively.

Figures 3, 4 and 5 show that the separate Lorenz Curves of the distribution of health care institutions, beds in health care institutions, and medical personnel per unit of population, are all located below the line of perfect equality and that the areas between the Lorenz Curve and the line of perfect equality are all relatively small, which illustrates further the relative equality of the distribution of health care resources by population.

**Lorenz Curve of distribution of health care resources by geographic area**

Based on the data in Table 1, and using a similar approach to that in the previous section, the number of health care institutions per 10,000 square kilometers, the cumulative areas, the cumulative number of health care institutions, the cumulative percentage of areas and the cumulative percentage of health care institutions can be found. The results of sorting these data by the number of health care institutions per 10,000 square kilometers are shown in Table 5.

Fig. 4: Lorenz Curve of the distribution of the number of beds in health care institutions by population

Fig. 5: Lorenz Curve of the distribution of the number of medical personnel by population
**Table 5:** Distribution of cumulative percentage of health care institutions by cumulative percentage of geographic areas in different regions in 2013

| Region    | Number of health care institutions per 10,000 square kilometers | Cumulative areas | Cumulative number of health care institutions | Cumulative percentage of areas | Cumulative percentage of health care institutions |
|-----------|---------------------------------------------------------------|------------------|---------------------------------------------|-------------------------------|-----------------------------------------------|
| Tibet     | 54.76                                                         | 123              | 6725                                        | 12.78                         | 0.69                                          |
| Qinghai   | 83.34                                                         | 195              | 12745                                       | 20.29                         | 1.31                                          |
| Xinjiang  | 112.4                                                        | 361              | 31408                                       | 37.57                         | 3.22                                          |
| Inner Mongolia | 196.6                                                   | 479              | 54665                                       | 49.88                         | 5.61                                          |
| Hei Longjiang | 469.9                                                   | 525              | 76034                                       | 54.61                         | 7.8                                           |
| Gansu     | 587.5                                                        | 570              | 102731                                      | 59.34                         | 10.54                                         |
| Yunnan    | 633                                                          | 609              | 126995                                      | 63.33                         | 13.03                                         |
| Ningxia   | 637.2                                                        | 615              | 131226                                      | 64.02                         | 13.47                                         |
| Jilin     | 1063                                                         | 634              | 151139                                      | 65.97                         | 15.51                                         |
| Guangxi   | 1438                                                         | 658              | 185082                                      | 68.42                         | 18.99                                         |
| Hainan    | 1474                                                         | 661              | 190093                                      | 68.78                         | 19.51                                         |
| Guizhou   | 1658                                                         | 679              | 219270                                      | 70.61                         | 22.5                                          |
| Sichuan   | 1663                                                         | 727              | 299307                                      | 75.62                         | 30.72                                         |
| Anhui     | 1764                                                         | 741              | 323952                                      | 77.07                         | 33.25                                         |
| Shaanxi   | 1806                                                         | 761              | 361089                                      | 79.21                         | 37.06                                         |
| Hubei     | 1917                                                         | 780              | 396720                                      | 81.14                         | 40.71                                         |
| Chongqing | 2300                                                         | 788              | 415646                                      | 82                            | 42.66                                         |
| Fujian    | 2323                                                         | 800              | 443821                                      | 83.26                         | 45.55                                         |
| Jiangxi   | 2329                                                         | 817              | 482723                                      | 85                            | 49.54                                         |
| Liaoning  | 2441                                                         | 831              | 518335                                      | 86.52                         | 53.2                                          |
| Shanxi    | 2577                                                         | 847              | 558616                                      | 88.15                         | 57.33                                         |
| Guangdong | 2658                                                         | 865              | 606451                                      | 90.02                         | 62.24                                         |
| Hunan     | 2937                                                         | 886              | 668661                                      | 92.22                         | 68.62                                         |
| Zhejiang  | 2947                                                         | 896              | 698724                                      | 93.28                         | 71.71                                         |
| Jiangsu   | 3021                                                         | 907              | 729722                                      | 94.35                         | 74.89                                         |
| Tianjin   | 4150                                                         | 908              | 734411                                      | 94.47                         | 75.37                                         |
| Hebei     | 4181                                                         | 927              | 812896                                      | 96.42                         | 83.43                                         |
| Henan     | 4279                                                         | 943              | 884360                                      | 98.16                         | 90.76                                         |
| Shandong  | 4904                                                         | 959              | 959786                                      | 99.76                         | 98.5                                          |
| Beijing   | 5764                                                         | 960              | 969469                                      | 99.93                         | 99.49                                         |
| Shanghai  | 7824                                                         | 961              | 974398                                      | 100                           | 100                                           |

We can draw a Lorenz Curve for the cumulative percentage of health care institutions by defining the X-axis as the cumulative percentage of the areas and defining the Y-axis as the cumulative percentage of health care institutions according to the data above, and this is shown in fig. 6. Similarly, the Lorenz Curve for the distribution of the number of beds in health care institutions by geographic area and the distribution of medical personnel by geographic area can be drawn, as shown in figures 7 and 8 respectively.

Fig. 6, 7 and 8 show that the Lorenz Curves of the distribution of health care institutions, beds in health care institutions, and medical personnel by geographic area are all located below the line of perfect equality and that the areas between the Lorenz Curve and the line of perfect equality are all much larger than in fig. 3, 4 and 5, means that there is much greater inequality in the geographic
distribution of health care resources than there is by actual population.

![Fig. 6: Lorenz Curve of distribution of the number of health care institutions by geographic area](image)

![Fig. 7: Lorenz Curve of distribution of the number of beds in health care institutions by geographic area](image)

Taken together, the area between the Lorenz Curves for health care resource distribution by population and by geographic area is much smaller than the areas between the Lorenz Curves for health care resource distribution by geographic area and the line of perfect equality. Therefore, we can expect that the Gini Coefficients obtained per unit of population will be far lower than the Gini Coefficients obtained in relation to the geographic area. In order accurately to represent the degree of inequality of health care resource distribution by population and by geographic area, we shall therefore now apply the Gini Coefficient to the study of the inequality of health care resource distribution in China to see this situation in detail.

![Fig. 8: Lorenz Curve of distribution of the number of medical personnel by geographic area](image)

**Calculation of Gini Coefficients for inequality in health care resource distribution in China**

Based on the Lorenz Curve of the distribution of health care resources by population and by geographic area, we calculated the respective Gini Coefficients. For example, the Gini Coefficient determined by the Lorenz Curve of the distribution of health institutions per unit of population is 0.19. The corresponding calculation for the distribution of health care institutions by geographical area provides a Gini Coefficient of 0.616. Similarly, we can obtain the Gini Coefficient according to the Lorenz Curve of the distribution of beds in health care institutions and of the numbers of medical personnel by both unit of population and by geographic area, as shown in Table 6.
Table 6: Gini Coefficients of health care resource distribution

|                         | Number of health care institutions | Number of beds in health care institutions | Number of medical personnel |
|-------------------------|-----------------------------------|-------------------------------------------|----------------------------|
| by population           | 0.19                              | 0.07                                      | 0.07                       |
| by geographic area      | 0.616                             | 0.639                                     | 0.65                       |

Discussions

On basis of the above methods, which use Lorenz Curves to derive the Gini Coefficients, this paper reports on a comparative analysis of the inequality of health care resource distribution in China. It shows that health care resource distribution appears equal when considered in demographic terms than when presented in terms of geographic distribution. All the Gini Coefficients for health care resource distribution by population are below 0.2, the Gini Coefficients for the number of health care institutions, of beds in health care institutions and of numbers of medical personnel being 0.19, 0.07 and 0.07 respectively. However, the Gini Coefficients for health care resource distribution by geographic area are 0.616, 0.639 and 0.65 respectively, which means that the geographic distribution of health care resources in China exhibits a high level of inequality.

We should not say either the demographic or the geographic approach provides a more useful picture separately. They are both useful for investigation on the equality of medical healthcare resource allocation in China. The paper shows that coefficients expressed by population imply there is ready access to healthcare in all regions, whilst the Coefficients by geographical area apparently indicate inequality. This simply is the result of the sparsity of population. Most of China’s health care resources are distributed within the developed provinces, especially in large cities and in large hospitals; while, in the remote and developing provinces, fewer health care resources are allocated.

Conclusion

Based on the analysis conducted in this paper, we find that the equality of China’s demographically assessed distribution of health care resources is greater than that of its geographically measured distribution. Coefficients expressed by population imply there is ready access to healthcare in all regions, whilst the Coefficients by geographical area apparently indicate inequality. This simply is the result of the sparsity of population. Most of China’s health care resources are distributed within the developed provinces, especially in large cities and in large hospitals; while, in the remote and developing provinces, fewer health care resources are allocated.

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