Analysis on the Equity of Human Resources for Pharmacy Allocation in Shaanxi Province: Based on the Resource Homogeneity Assumption

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Abstract—**This paper aims to analyze the current situation and the equity of Human Resource for pharmacy allocation in Shaanxi Province in 2017. The descriptive statistical method, Gini Index, Theil Index and Lorenz curve were used to evaluate the distribution fairness of human resources for pharmacy from the aspects of population, geographic and economy. The authors realized that the total number of human resources for pharmacy is insufficient in Shaanxi Province, and there were regional differences among different regions. The distribution fairness of human resources for pharmacy according to population distribution is the best of all and the Gini Index is 0.0866, the distribution fairness of geographic distribution is the worst and the Gini Index is 0.4910. Theil Index distributed in accordance with population distribution is smaller than that with geographic and economy distribution. What's more, people should further increase the cultivation of human resources for pharmacy and improve the professional value of pharmacists. The distribution of human resources for pharmacy should be optimized continuously, and the role of population, geographic and economic factors in the distribution of human resources for pharmacy should also be fully consideration.**

Keywords—*human resources for pharmacy; distribution fairness; Gini Index; Theil Index*

I. INTRODUCTION

Human resources for pharmacy as an important resource in ensuring the quality of medicines during the production, circulation and the use of medicines [1]. Forthermore, human resources for pharmacy can ensure the safety and effectiveness of people's medications and it is an important part of the health human resources system [2]. The distribution fairness of human resources for health is the premise of utilization fairness of health services, and also is the basis for residents to obtain health and fairness. The scientific and standardized distribution of human resources for pharmacy will have an important impact on the overall quality of health services and so as the long-term development of the health care system [3].

In order to measure and evaluate the distribution fairness of human resources for pharmacy in Shaanxi Province, we conducted research from the aspects of population, geographic distribution and economic level, and based on the theory of resource homogeneity hypothesis. The Lorenz Curve, the Gini Index and Theil Index were used in this study. We believe that through our research, the scientific support and suggestions for further distribution of human resources for pharmacy and the healthy development of Shaanxi pharmaceutical industry can be established.

II. MATERIALS AND METHODS

A. Materials

The research data includes the number of pharmacists, the resident population, geographic distribution and economic level in eleven cities in Shaanxi Province in 2017. The data comes from the Shaanxi Health and Family Planning Statistical Yearbook (2018), the Shaanxi Statistical Yearbook of 2018, and the Shaanxi Basic Geographical Situation White Paper (2011).

B. *Methods*

Resource homogeneity hypothesis. The homogeneity of human resources for health refers to the difference between the quality of service and the level of service between health personnel, and the total amount of health personnel was used to represent the total amount of health resources [4]. For example, a pharmacist-in-charge and a pharmacist can provide different levels of medical services, but the two kinds of pharmacist were treated equally in quantity.

Lorenz curve. The statistician Marx Lorenz used the cumulative percentage curve as a way to determine the degree of social income or wealth distribution inequality. Since 1970s, The Lorenz curve was introduced into health economics to assess the fairness of population, geography, and economic distribution of health resource allocation [5]. In this study, the Lorenz curve was based on the cumulative percentage of population, geographic, economy and the human resources for pharmacy as the horizontal and vertical coordinates to construct a coordinate system, and draw a curve connecting the zero points at each coordinate point.

The Gini Index. The Gini Index can be calculated according to the Lorenz curve and the area of the absolute average line surrounding the city [6]. The formula for calculating the Gini Index was used in this study as follows:

$$G = \sum_{i=1}^{n-1}(X_i Y_{i+1} - X_{i+1}Y_i) \quad (1)$$

X_i represents the cumulative percentage of population, geographic, and economic distribution of each city. Y_i represents the cumulative percentage of human resources for pharmacy in each city. According to the Gini Index standard of fairness of economic level, the Gini Index always between 0 and 1. When the Gini Index is 0, the distribution of health resources presents completely fair, and the larger the Gini Index, the more unfair. According to international practice, 0.2 or lower represents absolutely fair (best state), 0.2 to 0.3 represents fair (better state), 0.3 to 0.4 represents relatively reasonable (normal state), and 0.4 to 0.5 represents relatively unfair (alert state). 0.5 or higher represents very unfair (dangerous state).

Theil Index. The Theil Index developed from the concept of "entropy" in information theory, and Theil Index also between 0 and 1. The smaller the index, the better the fairness. The Theil Index can be divided into two indicators, Theil-T and Theil-L, which were complementary to the Gini Index. The calculation formula of the Theil index used in this study as follows [7]:

$$T = \sum_{i=1}^{n}\left(\frac{y_i}{Y}\right)\log\left[\left(\frac{y_i}{Y}\right)/\left(\frac{x_i}{X}\right)\right] \quad (2)$$

$$L = \sum_{i=1}^{n}\left(\frac{x_i}{X}\right)\log\left[\left(\frac{x_i}{X}\right)/\left(\frac{y_i}{Y}\right)\right] \quad (3)$$

In formula 2 and 3, y_i represents the i-th region pharmacy human resource within the province and x_i represents the i-th region population, geographic, and economic distribution, Y represents the total human resources for pharmacy within the province, X represents the total population, geographic and economic distribution.

III. RESULTS

A. *Basic Situation of Distribution of Human Resources for Pharmacy in Shaanxi Province*

By the end of 2017, the population of Shaanxi province grew into 38,354,400, and there were 310,309 health technical personnel, 15,360 human resources for pharmacy. The geographical area of Shaanxi Province reached into 205,600 square kilometers. The total GDP was 2,198.88 billion yuan, and the per capita GDP was 57,266 yuan in 2017. The specific conditions of the 11 cities in Shaanxi province were shown in "Table I".

TABLE I. THE SPECIFIC CONDITIONS OF THE 11 CITIES IN SHAANXI PROVINCE IN 2017

City	Population (ten thousand)	Geographical (km²)	GDP (billion Yuan)	Pharmacists
Xi'an	961.67	10106.20	7471.89	4280
Tongchuan	83.34	3881.10	348.43	480
Baoji	378.10	18161.90	2191.61	1575
Xianyang	437.60	10189.40	2292.51	2080
Weinan	538.29	13032.90	1650.63	1814
Yan'an	226.31	37031.30	1312.59	986
Hanzhong	344.93	27091.90	1333.30	1322
Yuling	340.33	42921.10	3361.29	1186
Ankang	266.10	23534.50	974.66	841
Shangluo	238.13	19580.80	757.06	705
Yangling	20.64	93.20	136.96	91

B. *Distribution Fairness According to Population*

The population distribution of pharmacists in Shaanxi province was listed in "Table II". Among them, the top three pharmacists per thousand population were Tongchuan, Xianyang and Xi'an. According to the number of pharmacists per thousand population from low to high, and taking the cumulative percentage of the population of each city as the horizontal axis and the cumulative percentage of pharmacists as the vertical axis. The Lorenz curve of pharmacists according to the population distribution of Shaanxi province in 2017 can be plotted in "Fig. 1". According to the Formula 1, it can be calculated that the Gini Index of pharmacists in 2017 was 0.0866 according to the population distribution. On the basis of the value of Gini Index, the data presented below 0.2, which indicating that the pharmacists were absolutely fair according to the population distribution.

TABLE II.   THE POPULATION DISTRIBUTION OF PHARMACISTS IN SHAANXI PROVINCE IN 2017

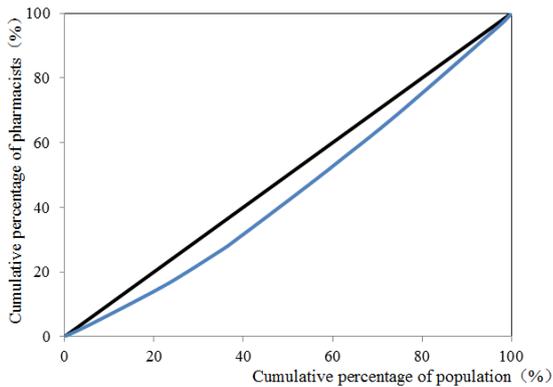| City	Percentage of population (%)	Cumulative percentage of population (%)	Percentage of pharmacists (%)	Cumulative percentage of pharmacists (%)	Pharmacists per 1000 (persons)
Shangluo	6.21	6.21	4.59	4.59	0.296
Ankang	6.94	13.15	5.48	10.07	0.316
Weinan	14.03	27.18	11.81	21.88	0.337
Yuling	8.87	36.05	7.72	29.6	0.348
Hanzhong	8.99	45.04	8.61	38.21	0.383
Baoji	9.86	54.9	10.25	48.46	0.417
Yan'an	5.90	60.8	6.42	54.88	0.436
Yangling	0.54	61.34	0.59	55.47	0.441
Xi'an	25.07	86.41	27.86	83.33	0.445
Xianyang	11.41	97.82	13.54	96.87	0.475
Tongchuan	2.18	100.00	3.13	100.00	0.576

Fig. 1. The Lorenz curve of pharmacists according to the population distribution of Shaanxi province in 2017.

C. Distribution Fairness According to Geographic

The geographic distribution of pharmacists in Shaanxi province was listed in "Table III". According to the number of pharmacists per square kilometer from low to high, and taking the cumulative percentage of the acreage of each city as the horizontal axis and the cumulative percentage of pharmacists as the vertical axis. The Lorenz curve of pharmacists according to the geographical distribution of Shaanxi in 2017 can be plotted in "Fig. 2". According to Formula 1, it can be calculated the Gini Index of pharmacists in 2017 was 0.4910 according to the geographic distribution. On the basis of the value of the Gini Index, the data presented between 0.4 and 0.5, which indicating that the pharmacists at a relatively unfair level according to the geographic distribution.

TABLE III.   THE GEOGRAPHIC DISTRIBUTION OF PHARMACISTS IN SHAANXI PROVINCE IN 2017

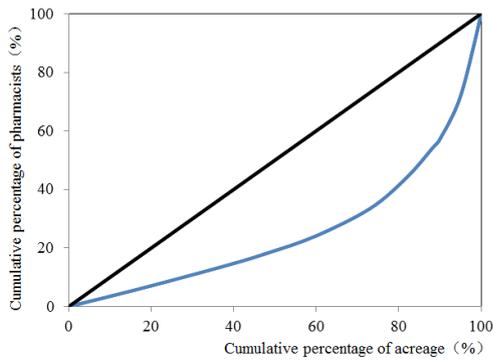| City	Percentage of acreage (%)	Cumulative percentage of acreage (%)	Percentage of pharmacists (%)	Cumulative percentage of pharmacists (%)	Pharmacists (persons/km^2)
Yan'an	18.01	18.01	6.42	6.42	0.027
Yuling	20.87	38.88	7.72	14.14	0.028
Ankang	11.45	50.33	5.48	19.62	0.036
Shangluo	9.52	59.85	4.59	24.21	0.036
Hanzhong	13.18	73.03	8.61	32.82	0.049
Baoji	8.83	81.86	10.25	43.07	0.087
Tongchuan	1.89	83.75	3.13	46.2	0.124
Weinan	6.34	90.09	11.81	58.01	0.139
Xianyang	4.96	95.05	13.54	71.55	0.204
Xi'an	4.91	99.96	27.86	99.41	0.424
Yangling	0.04	100.00	0.59	100	0.976

Fig. 2. The Lorenz curve of pharmacists according to the geographic distribution of Shaanxi province in 2017.

D. Distribution Fairness According to Economic Level

The economic distribution of pharmacists in Shaanxi province was listed in "Table IV". According to the number of pharmacists per capita GDP from low to high, and taking the cumulative percentage of the GDP per capita of each city as the horizontal axis and the cumulative percentage of pharmacists as the vertical axis. The Lorenz curve of pharmacists according to the economic level distribution of Shaanxi in 2017 can be plotted in "Fig. 3". According to Formula 1, it can be calculated that the Gini Index of pharmacists in 2017 was 0.3806 according to the economic level distribution. On the basis of the value of the Gini Index, the data presented between 0.3 and 0.4, which indicating that the pharmacists at a relatively reasonable level according to the economic level distribution.

TABLE IV.   THE ECONOMIC DISTRIBUTION OF PHARMACISTS IN SHAANXI PROVINCE IN 2017

| City	Percentage of the GDP per capita (%)	Cumulative percentage of the GDP per capita (%)	Percentage of pharmacists (%)	Cumulative percentage of pharmacists (%)	Pharmacists (persons/ Per capita GDP)
Yangling	11.23	11.23	0.59	0.59	0.001
Tongchuan	7.08	18.31	3.13	3.72	0.011
Yuling	16.72	35.03	7.72	11.44	0.012
Yan'an	9.82	44.85	6.42	17.86	0.017
Yan'an	5.38	50.23	4.59	22.45	0.022
Ankang	6.20	56.43	5.48	27.93	0.023
Baoji	9.81	66.24	10.25	38.18	0.027
Hanzhong	6.54	72.78	8.61	46.79	0.034
Xianyang	8.87	81.65	13.54	60.33	0.040
Xi'an	13.15	94.8	27.86	88.19	0.055
Weinan	5.20	100.00	11.81	100.00	0.059
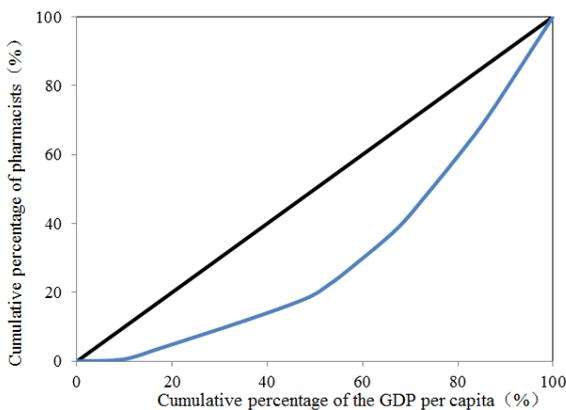
Fig. 3. The Lorenz curve of pharmacists according to the economic distribution of Shaanxi province in 2017.

E. The Comparative Analysis of Gini Index and Theil Index

The Gini Index and Theil Index of pharmacists in 2017 were listed in "Table V". Regardless of the Gini Index or the ThailIndex, the fairness of population distribution represented the best, economic level ranked second, and the geographic distribution presented the worst. Furthermore, the change rules of the Gini Index were consistent with the Theil Index.

TABLE V.   THE GINI INDEX AND THEIL INDEX OF PHARMACISTS IN 2017

Categories	Gini Index	Theil-T	Theil-L
Population distribution	0.0866	0.00869	0.00909
Economic level	0.3806	0.10960	0.15774
Geographical distribution	0.4910	0.20821	0.17385

IV.   CONCLUSION

As the most important part of health resources, human resources for health include doctors, nurses, pharmacists, health administrators, et cl. The fairness of the configuration represented the premise of the utilization of health services and the basic guarantee for achieving "fairness for all population". In the health sector, ensuring people's access to fair and effective health services was one of the government's important goals, and also presented the focus of the reform of health care system [8].

With the increasing demand for medical and health care, pharmacy service talents who have mastered the application of drug application has becoming a shortage of talents in society. According to the "Regulations on the Administration of Pharmaceutical Affairs of Medical Institutions", the number of pharmacists is not less than 8% of the health technical personnel of this institution [9]. In 2017, there were 310,309 health technical personnel in Shaanxi Province, and the number of pharmacists was 15,360. The pharmacists only

accounted for 4.95% of the total number of health technical personnel. The reason can be explained as that the hole health industry pay a lot attention to the medical care and pay little attention to pharmacy. At the same time, with the implementation of the "Three unification for medicine" and "Medicine zero rate sales" management system in our province, the pharmacy department has been transformed from the income department to the non-income department, which makes the pharmacy personnel more marginalized in the hospital.

In order to improve the problem of insufficient total amount of human resources for pharmacy, on one hand, medical colleges should adjust training strategies and increase the teaching of pharmacy professionals [10]; On the other hand, medical institutions should also fully recognize the importance of pharmacy personnel and improve the professional value of pharmacy personnel from the traditional pharmacy service to clinical pharmacy services continuously [11].

This study shows that the Gini Index and Thai Index of human resources for pharmacy according to population distribution were much lower than the geographic and economic distribution and the fairness is the best. While the Gini Index and Thai Index according to geographic distribution were much higher than the population and economy distribution and the fairness is the worst. The reason may be explained that the population distribution has been used for making policy planning on the distribution and development of human resources for health in China for a long time [10]. In addition to considering the total amount during the scientific and rational distribution of human resources for pharmacy, it is also necessary to consider the human resources for pharmacy distribution in different geographic and economic levels [12].

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