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The allocation and fairness of hospital pharmacist human resources in China: a time-series study

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Abstract

Background To address the rational use of medicines in healthcare institutions, the Chinese government enacted legislation for pharmacists in 2021, emphasizing the importance of pharmacists in medical services. The allocation and equity of pharmacist human resources in healthcare institutions directly affect people's accessibility to pharmaceutical services. The study aims to analyze the supply and demand of pharmacist human resources in Chinese healthcare institutions and evaluate the equity of their distribution to provide a reference for the rational management of pharmacist resources.

Methods This was a time-series study that was conducted using data obtained from Health and Health Statistical Yearbook that is performed every year by the National Health Commission of the People's Republic of China. The study included 31 provinces, municipalities, and autonomous regions and 34,354 medical institutions in mainland China, which were classified into different economic regions based on their level of economic development. The study collected healthcare technicians and pharmacist data from national healthcare institutions between 2016 and 2020. The study evaluated the level of pharmacist human resource allocation using the health resource density index. The study explored the equity of pharmacist human resource allocation from two aspects: population and geographic area, using the Gini coefficient and Theil index.

Results The average annual growth rates of healthcare technical staff and pharmacists in Chinese medical institutions from 2016 to 2020 were 5.67% and 3.03%, respectively. The Gini coefficients of healthcare personnel resources based on population distribution were all below 0.119, while those based on geographical area were all above 0.655. The total Theil indexes of pharmacist human resources based on population distribution were all below 0.010, while those based on geographical area were all above 0.511. In addition, the contribution rates of the within-group Theil indexes of pharmacist human resources based on population and geographical area distributions to the total Theil index were all greater than or equal to 50%.

Conclusions The allocation level of pharmacist human resources in China continues to improve, but there are differences in different economic development areas. Currently, allocation based on population shows equity, but allocation based on geographic area shows inequity. In the future, more attention should be paid to the geographic

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accessibility of pharmacist human resources, and resource allocation should consider both the population served and geographic area.

Keywords Pharmacist, Health care institutions, Health human resources, Allocation status, Fairness assessment, China

Introduction

Health technicians in pharmacies are responsible for providing safe, effective, efficient, and responsible medication-related care to patients in hospitals and health systems [1]. In the United States, there are an average of 0.782 pharmacists per 1,000 people [2]. However, in China, there are an average of 0.35 pharmacists per 1,000 people as of 2020. Existing studies have shown that China's doctor and nurse human resources are unevenly distributed [3, 4], so it is necessary to conduct research on the reasonable distribution of limited pharmacist human resources.

In 2016, The State Council of China issued the Outline of the Healthy China 2030 Plan: "By 2030, China will achieve universal health coverage, greatly improve the capacity of health services, and significantly improve the quality and level of health services. Medical quality and safety should be continuously improved, standardization of medical services should be enhanced, and major medical service quality indicators should reach or approach the world advanced level. For example, by 2030, a 15-minute basic medical and health service circle will be basically formed. The premature mortality rate of major chronic diseases (%) will be reduced by 30% by 2030 compared with 2015. The number of practicing (assistant) physicians per 1,000 permanent residents (persons) will reach 3.0 by 2030 [5]. Pharmacists are important members of the health service system. It was proposed in the Pharmacists Law of the People's Republic of China (the Third draft for Comment) issued by the National Health Commission in 2021 that pharmacists should perform their responsibilities of drug quality management and pharmaceutical care in accordance with the law [6]. Therefore, the allocation of human resources and the level of professional service capacity of pharmacists are crucial to the high-quality implementation of the "Healthy China 2030" program Outline. At present, the research on Chinese pharmacist resources mainly focuses on the number, quality and educational composition of pharmacists [7], There is a lack of research on the geographical distribution characteristics and distribution trends of national pharmacist resources. Additionally, most current studies rely on questionnaires and other similar methods [8–10]. These studies focus on the training system of licensed pharmacists and pharmaceutical talents at the provincial level. However, they fail to show the overall level and dynamic changes of pharmacist resources at the national level. They also cannot directly or quantitatively compare the differences and aggregation of pharmacist resources among provinces.

Healthcare systems in the world are facing significant challenges as a result of severe funding pressure, a growing ageing population, societal changes, rising demand and a limited supply of some healthcare professional groups [9–11]. According to the bulletin of China's 7th population census, the total population of China is 1.412 billion, among which 191 million are 65 years old or above, accounting for 13.50% [11–13]. China's population structure is moving towards the direction of aging rapidly, and is about to enter a deep aging society. As of the end of 2017, there were 464 colleges and universities in China that offered pharmacy-related majors, but only 7% of graduates eventually entered medical institutions [14]. As a result, from 1990 to 2021, the total number of pharmacists in China increased from 405,978 to 520,865, with an average annual increase of about 3,706 [15]. Pharmacists will be key in ensuring the safe and effective use of medications, improving patient outcomes, and supporting the overall healthcare system in managing the increasing demand for medical services.

Existing studies on equity have mostly focused on other types of health resources, such as primary health care resources [16], traditional Chinese medicine health resources [17], public health facilities [18, 19], and emergency medical services [20], etc. Several of the studies on health human resources are focused on regional overall health human resources [21, 22], and few studies have been conducted on women and children's institutions. In addition, most of the studies prefer to divide China into three regions according to geographic affiliation to discuss the issue of fairness [23, 24]. Our study on the distribution of medical professionals in maternal and child health care (MCH) institutions revealed significant insights into the disparities and challenges within this sector. While the allocation of MCH human resources in China appeared equitable in terms of population distribution, there were notable inequities when considering geographical area allocation [25]. Building on this foundation, the current study aims to extend the analysis to hospital pharmacists, addressing the unique factors and challenges associated with their allocation and distribution.

Data & methods

Data source

The data on health human resources (health technicians, licensed (assistant) physicians, and pharmacists) in China

health care institutions in this study were obtained from the 2017-2021China Health and Family Planning Statistical Yearbook and the 2017–2021 China Health and Health Statistical Yearbook. Regional per capita GDP and regional resident population data are from the 2017–2021 China Statistical Yearbook. Since publishers publish data from the previous year in the next year's publication, the 2016 data is included in the 2017 data book, The same is true for other years. Between 2016 and 2020, the number of medical institutions counted was 29,140, 31,056, 33,009, 34,354 and 35,394 respectively. The geographic area data is derived from the administrative division information of the Ministry of Civil Affairs of China. In particular, the data included in the study only included 31 provinces, municipalities, and autonomous regions in mainland China, excluding Hong Kong, Macau, and Taiwan. All data links for this study were accessed with confirmation in June 2024.

Variables and operational definitions

The study utilized the following variables in the analysis, with their operational definitions provided:

Number of Pharmacists: The total count of licensed pharmacists working in healthcare institutions across China for each year from 2016 to 2020.

Age: The age of pharmacists, categorized into specific age groups (< 25, 25–35, 35–45, 45–55, 55-60and ≥ 60 years) to analyze the age distribution of the pharmacist workforce.

Educational Level: The highest educational qualification attained by pharmacists, classified into:

Postgraduate: Completion of a master's degree or higher in pharmacy or related fields.

Undergraduate: Completion of a university-level bachelor's degree in pharmacy or related fields.

Junior College: Completion of a junior college education degree in pharmacy or related fields.

Technical Secondary School: Completion of a technical secondary school program in pharmacy or related fields.

High School and Below: Completion of high school or lower education.

Geographic Distribution: The allocation of pharmacists across different provinces and regions in China, allowing for the analysis of regional disparities.

Pharmaceutical talents: The high-level pharmaceutical talents are at the forefront of the development of pharmaceutical disciplines, have strong professional capabilities and professional qualities, and can creatively engage in pharmaceutical-related work such as clinical drug treatment and clinical evaluation.

Health technicians: Health technicians include practicing physicians, practicing assistant physicians, registered nurses, pharmacists, laboratory technicians, imaging technicians and other health professionals. They work together to provide medical services to patients. In order to ensure the efficiency of their collaborative work, they should have an appropriate composition ratio.

Setting

According to the level of regional economic development, mainland China is divided into four regions. Q4 regions refers to the regions with the highest per capita GDP, including Beijing, Shanghai, Jiangsu, Tianjin, Zhejiang, Fujian, Guangdong, Shandong.Q3 regions refers to the regions with China upper quartile per capita GDP, including Inner Mongolia, Chongqing, Hubei, Shaanxi, Liaoning, Hunan, Ningxia, Jilin. Q2 regions refers to the regions with lower quartile per capita GDP, including Hainan, Anhui, Henan, Sichuan, Xinjiang, Jiangxi, Qinghai. Q1 regions refers to the regions with the lowest per capita GDP, including Hebei, Tibet, Shanxi, Guangxi, Heilongjiang, Guizhou, Yunnan, Gansu.)

Allocation level and fairness assessment

The health resources density index (HRDI) was used to measure the allocation level of health human resources in China health care institutions in different economic regions. The fairness of the allocation was evaluated based on the results calculated by the Gini coefficient and Theil index, reflecting the development of Chinese pharmaceutical human resources during the 13th Five-Year Plan period.

Health resource density index

HRDI is an indicator that comprehensively measures the level of health resource allocation by population and geographic area [25]. The calculation formula is:

$$HRDI = \frac{R_i}{\sqrt{A_i P_i}}$$

In the formula, R_i represents the China health human resources owned by region i, A_i represents the geographic area of region i, and P_i represents the number of the resident population in region i. The larger the HRDI value, the higher the allocation level of China health human resources in the region.

Gini coefficient

The Lorenz curve is often used in the medical and health field to explore the fairness of the allocation of health resources [24, 26]. However, the curve can only be

displayed visually and cannot be quantified. Therefore, scholars introduce the Gini coefficient for quantitative evaluation. In essence, the Gini coefficient is the numerical embodiment of the Lorenz curve, with the same geometric meaning [4]. The calculation formula is:

$$G = 1 - \sum_{i=1}^{n-1} (\tau_{i+1} - \tau_i)(\phi_{i+1} + \phi_i)$$

In the formula, G is the Gini coefficient, τ_i is the cumulative proportion of the population (geographical area) of the *ith* region in the country, and ϕ_i is the cumulative proportion of the *ith* region's China health human resources in the country. The Gini coefficient ranges from 0 to 1. When G<0.2, it is fair, when 0.2≤G<0.3, it is fairer, when 0.3≤G<0.4, it is relatively fair, and when 0.4≤G<0.5, it is relatively unfair, it is very unfair when G≥0.5 [27].

Theil index

The Theil index is derived from the concept of entropy in information theory and is used to measure the fairness of the allocation of health resources in a region [23]. At the same time, the Theil index can be divided into the Theil index between groups and the Theil index within the group, which further reflects that the unfair allocation of regional resources is mainly caused by differences between groups or differences within groups [28]. Compared with the Gini coefficient, the Theil index can examine the contribution of differences between groups and within groups to the total difference, making up for the limitation that it can only reflect the total difference [16].

The Theil index calculation formula is:

$$T = \sum_{i=1}^{n} \delta_i \lg(\delta_i / \epsilon_i)$$

In the formula, T is the Theil index, δ_i is the proportion of the population (geographical area) of the region i in the whole country, and ε_i is the proportion of human resources for China health in the region i in the whole country. The Theil index ranges from 0 to 1, and the smaller the value, the better the fairness of the allocation of China health human resources in the region [29].

The decomposition formula of the Theil index is:

$$T = T_1 + T_2$$

$$T_1 = \sum_{j=1}^{k} \delta_j T_j$$

$$T_2 = \sum_{j=1}^{k} \delta_j \lg(\delta_j / \epsilon_j)$$

$$\omega_1 = T_1 / T$$

$$\omega_2 = T_2 / T$$

In the formula, T_1 is the intra-group Theil index, T_2 is the inter-group Theil index, δ_j is the proportion of the population (geographical area) of region j to the whole country, and T_j is the Theil index of region j, ε_j is the proportion of China health human resources in region j to the whole country, ω_1 is the difference contribution rate within the group, and ω_2 is the difference contribution rate between the groups.

Data analysis

To comprehensively analyze the allocation and fairness of pharmacist human resources in Chinese healthcare institutions, The SPSS version 26 software were employed. The descriptive statistics involved calculating measures such as means, standard deviations, and percentages to summarize the characteristics of the healthcare personnel and pharmacist workforce data.

We applied SPSS to calculate key metrics such as the Gini Coefficient and the Theil Index, which were used to assess inequality in the distribution of pharmacist resources. The Gini Coefficient was employed to measure the degree of inequality based on both population and geographical distribution. The Theil Index was calculated to further explore disparities in pharmacist resources, and we decomposed the Theil Index to understand the within-group and between-group contributions to the total inequality.

Result

Allocation level of health human resources in China health care institutions

From 27,587 in 2016 to 34,354 in 2020, the number of medical institutions in the country has increased by 5.63%, 6.58%, 6.29%, 4.07%, 3.03% year by year. At this background, Fig. 1 shows the overall allocation of health human resources in medical institutions in mainland China during 2016–2020. By 2020, there were 1,0678,019 health technicians and 496,793 pharmacists in China's medical institutions, accounting for 4.65% of the total. From 2016 to 2020, the number of pharmacists showed an increasing trend year by year, with an average annual growth rate of 3.63%, 3.03%, 3.15%, 3.25% and 2.69%, respectively. However, the proportion of pharmacists showed a decreasing trend, from 5.20% in 2016 to 4.65% in 2020. Compared with the growth of all medical personnel, the growth of pharmacists is slow.

Table 1 shows the health resources density index (HRDI) of healthcare personnel in mainland China in 2020. Overall, Shanghai had the highest HRDI values for both healthcare technicians and pharmacists, while Tibet

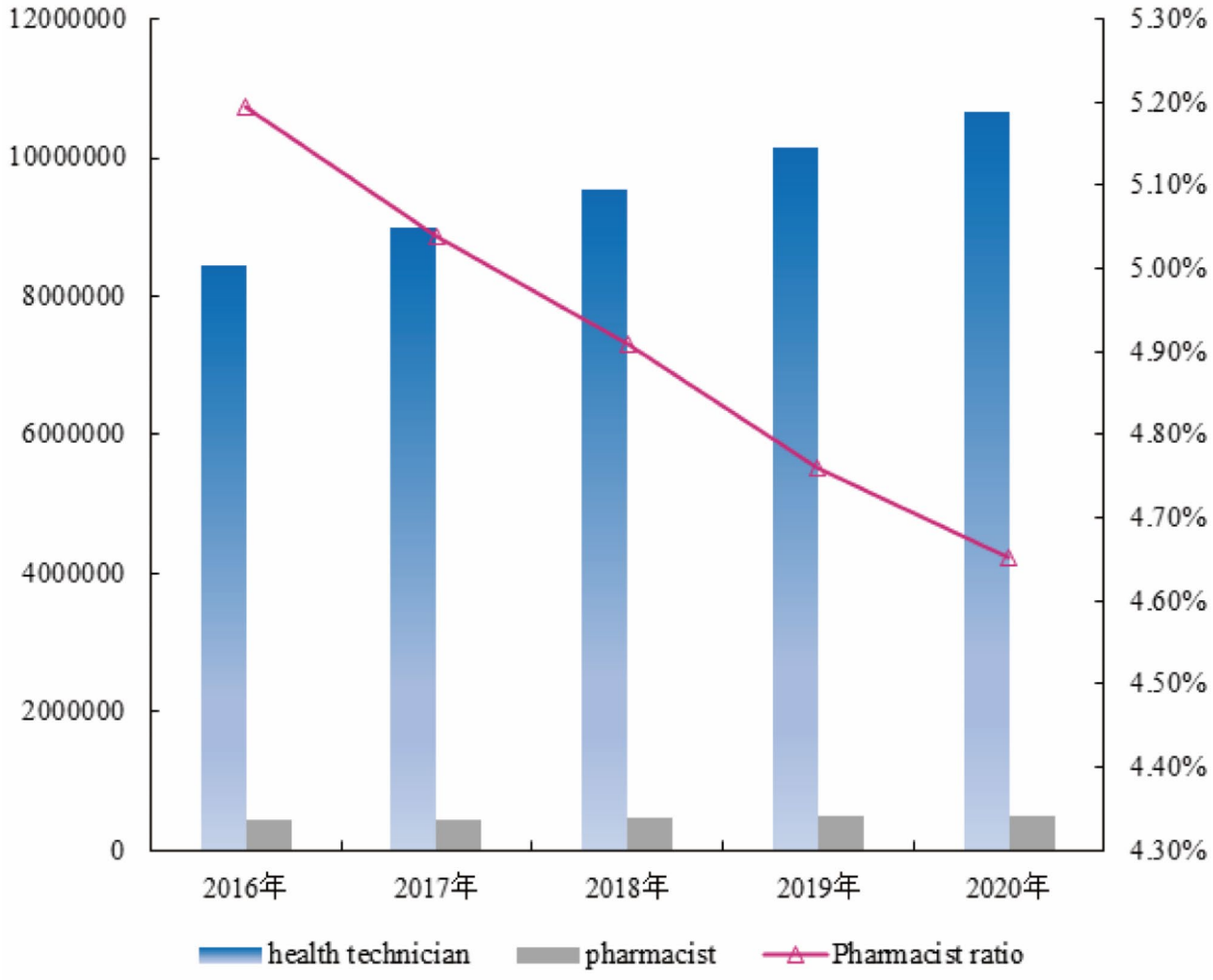

Fig. 1 Human resource allocation of pharmacists in medical institutions in mainland China from 2016 to 2020

had the lowest values. Analyzing different economic development groups, in the high GDP per capita group, Shanghai had the highest HRDI values for healthcare technicians and pharmacists, while Fujian had the lowest. In the medium-high GDP per capita group, Chongqing had the highest HRDI values for healthcare technicians and pharmacists, while Inner Mongolia had the lowest. In the medium-low GDP per capita group, Henan had the highest HRDI values for healthcare technicians, while Hainan had the highest HRDI values for pharmacists, and Qinghai had the lowest values for both. In the low GDP per capita group, Hebei had the highest HRDI values for healthcare technicians, while Guangxi had the highest HRDI values for pharmacists, and Tibet had the lowest values for both.

Table 2 shows the health resources density index (HRDI) of medical institutions in different economic regions of mainland China from 2016 to 2020. Overall, the HRDI values of health technicians have shown a yearly increase, with an average growth rate of 5.62%. However, the HRDI values of pharmacists remained unchanged for several years. When comparing within groups, the HRDI values of pharmacist human resources showed a stepped distribution, with the highest HRDI values in the high per capita GDP areas, followed by the middle-high per capita GDP group, and the lowest HRDI values in the middle-low and low per capita GDP groups.

Quality structure of health human resource allocation in China health care institutions

Table 3 shows the quality structure of healthcare human resources in mainland China from 2016 to 2020. In terms of age, both healthcare technicians and pharmacists are mostly in the 25–34 age group, and their proportion is increasing. In terms of education, healthcare technicians and pharmacists mainly have junior College degree, but

Table 1 Health Human Resource Density Index of China Health Institutions in Mainland China in 2020

Group types	Health technicians HRDI	Rank	Pharmacists HRDI	Rank
Q4 regions				
Beijing	0.461	2	0.025	2
Shanghai	0.540	1	0.027	1
Jiangsu	0.218	4	0.011	5
Tianjin	0.280	3	0.016	3
Zhejiang	0.215	5	0.012	4
Fujian	0.125	17	0.007	9
Guangdong	0.174	7	0.009	6
Shandong	0.202	6	0.009	7
Q3 regions				
Inner Mongolia	0.038	28	0.002	27
chongqing	0.147	9	0.006	11
Hubei	0.130	13	0.006	12
Shaanxi	0.126	15	0.006	13
Liaoning	0.125	16	0.005	18
Hunan	0.133	12	0.006	14
Ningxia	0.085	25	0.005	19
Jilin	0.099	23	0.004	22
Q2 regions				
Hainan	0.127	14	0.009	8
Anhui	0.141	10	0.006	15
Henan	0.172	8	0.007	10
Sichuan	0.099	22	0.004	23
Xinjiang	0.029	29	0.001	29
Jiangxi	0.103	21	0.006	16
Qinghai	0.024	30	0.001	30
Q1 regions				
Hebei	0.138	11	0.005	20
Tibet	0.011	31	0.001	31
Shanxi	0.114	18	0.005	21
Guangxi	0.107	20	0.006	17
Heilongjiang	0.064	26	0.003	25
Guizhou	0.109	19	0.004	24
Yunnan	0.085	24	0.003	26
Gansu	0.055	27	0.002	28

the proportion of pharmacists with a bachelor's degree or higher is increasing. In terms of professional titles, healthcare technicians are mainly at the level of master or senior, while pharmacists are mainly at the level of instructor/assistant, and the proportion of both types of human resources with deputy director or higher titles is also increasing.

Equity of health workforce allocation in China health care institutions

Gini coefficient measurement results

Figure 2 shows the Gini coefficient of healthcare human resource allocation in medical institutions in mainland China from 2016 to 2020. The Gini coefficient of healthcare technicians and pharmacists by population distribution was 0.070–0.092 and 0.103–0.119, respectively. Both types of human resources were in a state of absolute fairness in terms of population distribution. If distributed according to geographic area, the Gini coefficient of healthcare technicians and pharmacists was 0.655–0.657 and 0.668–0.677, respectively. Both types of resources were in a very unfair state. In addition, it was found that the Gini coefficient of pharmacist human resources distributed by population was lower than that distributed by geographic area. It is worth noting that the Gini coefficients of healthcare technicians and

Table 2 Health human resource density index of China health care institutions in different economic levels in mainland China from 2016 to 2020

Personnel category	2016	2017	2018	2019	2020
health technician					
entire country	0.073	0.078	0.083	0.088	0.092
Q4 regions	0.168	0.179	0.190	0.202	0.211
Q3 regions	0.073	0.077	0.081	0.086	0.089
Q2 regions	0.055	0.058	0.062	0.066	0.071
Q1 regions	0.054	0.058	0.062	0.067	0.071
pharmacist					
entire country	0.004	0.004	0.004	0.004	0.004
Q4 regions	0.010	0.010	0.010	0.011	0.011
Q3 regions	0.004	0.004	0.004	0.004	0.004
Q2 regions	0.003	0.003	0.003	0.003	0.003
Q1 regions	0.003	0.003	0.003	0.003	0.003

Table 3 Quality structure of health human resources in China health care institutions in mainland China from 2016 to 2020

Category	Health technician /%		Pharmacist /%	
	2016	2020	2016	2020
Age				
<25	8.7	8.9	4.2	4.3
25~	38.6	40.0	34.1	36.1
35~	26.0	24.8	27.0	26.2
45~	18.4	16.5	24.3	21.4
55~	3.3	4.7	6.0	7.2
≥60	5.1	5.1	4.4	4.8
Education				
Postgraduate	5.0	5.9	2.9	4.3
Undergraduate	27.2	36.2	24.2	37.0
Junior College	39.3	38.4	35.5	33.6
Technical secondary school	26.5	18.4	30.7	21.6
High school and below	2.0	1.0	6.8	3.5
Job title				
Professor of pharmacy	1.8	2.2	0.7	1.0
Associate professor of pharmacy	5.9	6.7	3.3	4.5
Pharmacist-in-charge	20.0	19.8	19.7	21.0
Pharmacist practitioner	29.7	31.1	35.6	35.8
Assistant pharmacist	30.7	31.2	30.8	29.3
Unknown	12.0	9.0	9.9	8.4

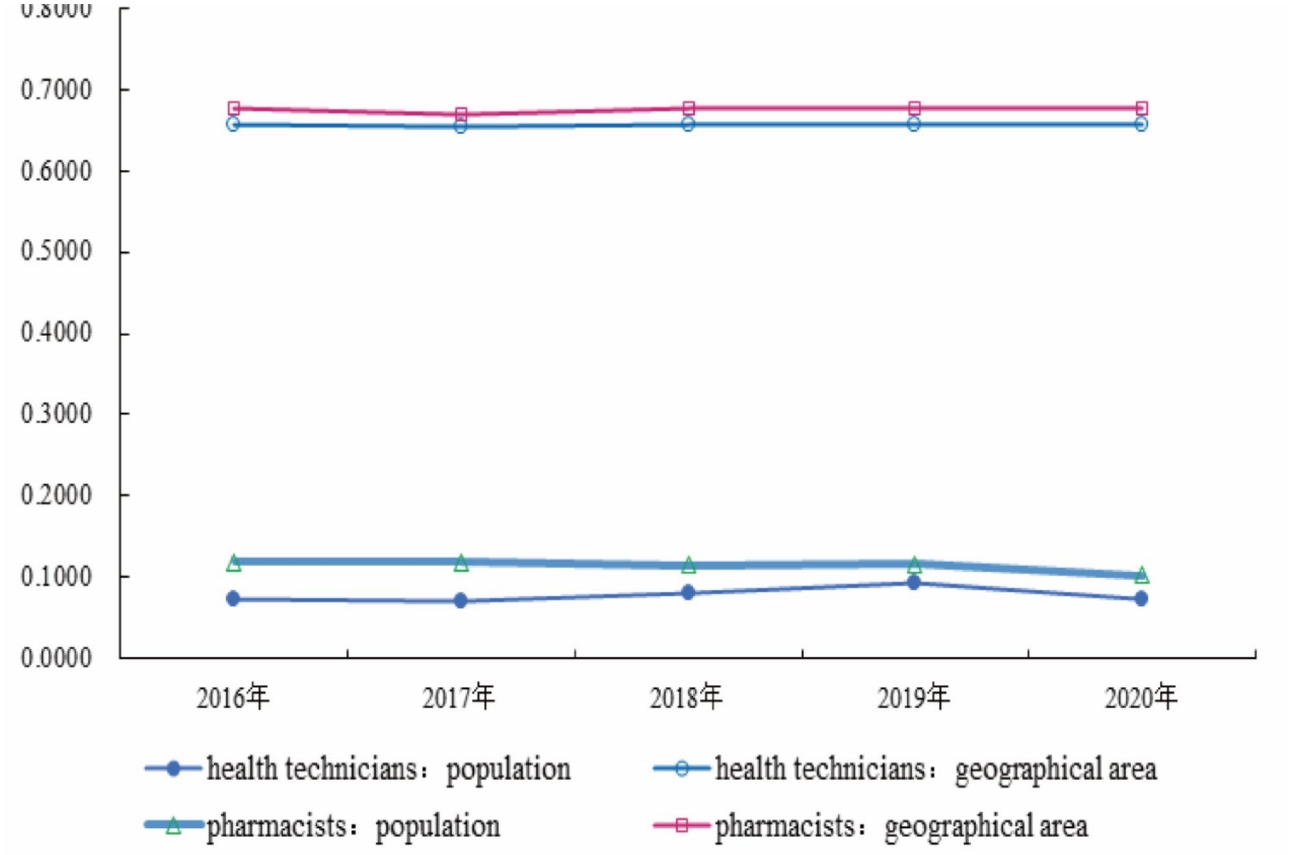

Fig. 2 Gini coefficient of health human resource allocation in medical institutions in mainland China from 2016 to 2020

Table 4 Theil index of the allocation of health human resources in China health care institutions in mainland China from 2016 to 2020

Personnel category	Configured by population					Configured by geographic area				
	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
Health technician										
Total Theil Index	0.004	0.004	0.004	0.004	0.003	0.670	0.662	0.665	0.673	0.675
Theil index between groups	0.001	0.001	0.001	0.001	0.001	0.262	0.256	0.259	0.267	0.265
Group Theil Index	0.003	0.003	0.003	0.003	0.002	0.408	0.406	0.406	0.406	0.410
Pharmacist										
Total Theil Index	0.010	0.009	0.009	0.009	0.007	0.528	0.521	0.516	0.511	0.511
Theil index between groups	0.005	0.003	0.004	0.004	0.002	0.125	0.121	0.123	0.123	0.123
Group Theil Index	0.005	0.006	0.005	0.005	0.005	0.403	0.400	0.393	0.388	0.388

pharmacists distributed by population and geographic area remained basically unchanged over the five-year period.

Theil index calculation results

Table 4 shows the Theil index of healthcare human resources allocation in mainland China from 2016 to 2020. The total Theil index of healthcare technicians and pharmacists by population is 0.003–0.004 and 0.007–0.010, respectively. The total Theil index of the two types of resources by geographic area is 0.662–0.675 and 0.511–0.528, respectively. Overall, the total Theil index of the two types of resources by geographic area allocation is significantly greater than that by population allocation. In addition, the total Theil index of the two types of resources by population allocation and geographic area allocation showed an upward trend during the five-year period.

Breaking down the total Theil index, it can be found that the within-group Theil index of healthcare technicians and pharmacists by population and geographic area allocation is higher than the between-group Theil index. The within-group Theil index of the two types of resources by population allocation contributes 66.67-75.00% and 50.00-71.43% to the total Theil index, respectively. The within-group Theil index of the two types

of resources by geographic area allocation contributes 60.32-61.33% and 75.93-76.78% to the total Theil index, respectively.

Table 5 displays the contribution of Theil indexes of health human resources allocation in medical institutions in different economic regions of mainland China to the total Theil index from 2016 to 2020. The contribution of Theil indexes of healthcare technicians and pharmacists to the total Theil index according to population allocation is in the order of medium-low per capita GDP group < low per capita GDP group < medium-high per capita GDP group < high per capita GDP group. However, the contribution of (assistant) practicing physicians is in the order of low per capita GDP group < medium-low per capita GDP group < medium-high per capita GDP group < high per capita GDP group. If allocated according to geographic area, the contribution of Theil indexes of the three categories of pharmacists' human resources to the total Theil index is in the order of high per capita GDP group < medium-high per capita GDP group < medium-low per capita GDP group < low per capita GDP group.

Discussion

This study utilizes time-series data from 2016 to 2020 and divides regions according to their economic level to explore the configuration and fairness of healthcare human resources in medical institutions in mainland China. Compared with our previous study on maternal and child health care, this study covers a wider range of hospitals across the country and analyzes more health technicians. It also focuses on the distribution of pharmacist human resources in China. The analysis results can reveal current development problems and help to allocate pharmacist human resources more reasonably, provide more fair and accessible pharmacist services, and promote high-quality development of China's healthcare industry. In addition, an extensive search of multiple research databases, including PubMed/Medline, ScienceDirect, Scopus, and others, was conducted to verify that this is the first study to assess the allocation and fairness of pharmacist resources using nationwide time-series data in China.

In 2018, the National Health Commission issued the "Opinions on Accelerating the High-Quality Development of Pharmaceutical Services", emphasizing the strengthening of the pharmacist team and mobilizing the enthusiasm of pharmacists to work [30]. From the perspective of resource allocation, the level of pharmacy human resources allocation in mainland China has been continuously improving. From 2016 to 2020, the number of healthcare technicians and pharmacists in medical institutions showed a year-on-year increase. By the end of 2020, pharmacists accounted for 4.65% of the total number of healthcare technicians. This indicates that the efforts made by the Chinese government in improving the pharmacy service system have been effective.

This is consistent with our previous research results on MCH [25]. The distribution of pharmacists in China shows obvious urban-rural differences. The density of pharmacists is generally higher in urban areas, while pharmacist services are insufficient in rural and remote areas. This uneven distribution affects the accessibility and quality of pharmaceutical services in underdeveloped areas. Similar to pharmacists, the distribution of doctors also shows regional imbalances. The Gini coefficients of medical persons in China are 0.003 and 0.88 by population and by service area, respectively. This shows that the distribution of medical persons is fair basing on population, and there is little difference in the number of physicians per 1000 population in different regions. However, the physician distribution basing on service area is highly unfair and shows a large gap in the number of physicians per square kilometer between different regions. In general, Beijing, Zhejiang, Shanghai, Jiangsu, Shandong, and Tianjin are higher than the overall level of 31 provincial administrative regions. In addition, the number of medical persons in Zhejiang, Shandong, Beijing and Jiangsu is

Table 5 The contribution rate of the Theil index of the health workforce allocation of China health care institutions in different economic levels in mainland China to the total Theil index from 2016 to 2020

Personnel category	Contribution rate by population allocation /%					Contribution rate by geographic area /%				
	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
health technician										
Q4 regions	44.68	47.05	47.79	51.43	65.05	3.80	3.79	3.71	3.68	3.58
Q3 regions	15.51	15.51	15.51	15.51	15.51	20.95	20.95	20.95	20.95	20.95
Q2 regions	30.26	30.26	30.26	30.26	30.26	33.82	33.82	33.82	33.82	33.82
Q1 regions	9.55	9.55	9.55	9.55	9.55	41.43	41.43	41.43	41.43	41.43
Pharmacist										
Q4 regions	31.23	50.6	35.24	35.31	36.46	3.50	4.06	3.67	3.69	3.65
Q3 regions	17.34	17.34	17.34	17.34	17.34	18.49	18.49	18.49	18.49	18.49
Q2 regions	16.23	16.23	16.23	16.23	16.23	35.08	35.08	35.08	35.08	35.08
Q1 regions	35.19	35.19	35.19	35.19	35.19	42.92	42.92	42.92	42.92	42.92

over-provisioned. The level of pharmacist personnel allocation varies across regions with different levels of economic development. In 2020, the HRDI values of health technicians and pharmacists in Shanghai were about 49 and 53 times higher than those in Tibet, respectively. Over the five years, the intra-group comparison showed that the HRDI value was highest in the high GDP per capita regions, followed by the middle-high GDP per capita group, while the middle-low GDP per capita group and the low GDP per capita group had the lowest values. The reasons for this may be related to the economic development level and population density between regions. The more developed the region's economy and the higher the population density, the greater the investment in pharmacist resources. On the other hand, regions with better economic development are more attractive to healthcare talent and have more development opportunities [31]. Therefore, in the future, government health investment should focus on balancing regional differences and tilting towards regions with lower levels of economic development. At the same time, talent incentive policies should be formulated to encourage healthcare talent to go to resource-poor and impoverished areas [32].

It has been found that there is a lack of research on the quality structure of healthcare personnel when analyzing the allocation of healthcare human resources. This study added this aspect to the analysis. The results show that healthcare technicians and pharmacists in mainland China's medical institutions mainly have associate degrees, which is similar to the research results of Ren et al. [33]. A previous study found that in 2005, 97.5% of pharmacists in China only had an associate or technical secondary school education level [34]. Compared with the national average, the educational level of pharmacists has greatly improved, which can provide higher quality pharmacist services. In addition, the titles of healthcare technicians and licensed (assistant) doctors are mainly at the level of teacher/assistant, while pharmacists are concentrated at the level of master. The World Health Organization has recommended that the proportion of titles for healthcare personnel should be 1:3:1 for senior, intermediate, and junior levels [35]. There is still a gap from this standard at present. It is suggested to improve the continuing education mechanism for pharmacists, reasonably regulate the scale and structure of talent training, and continuously improve their knowledge.

In terms of resource allocation equity, this study shows that mainland China's pharmacy technicians and pharmacists are fairly distributed according to population, but unequally distributed according to geographic area. This conclusion is consistent with previous research results [4, 36, 37]. The reason may be that the government health department usually uses the number of health resources per thousand population as the standard for regional planning and allocation, and pays less attention to the geographic accessibility of health resources [38]. This spatial maldistribution raises serious concerns in terms of equity and efficiency. On one hand, it leads to unequal access to healthcare services and may be considered a major factor contributing to persistent inequities. On the other hand, even in a regulated healthcare system, after-entry quality competition entails an inefficient geographic allocation of resources. To limit these deleterious effects of free entry, many governments have implemented public policies to increase the diffusion of physicians across underserved areas. In some countries, such as Germany [39], the number of new physicians in each region is regulated. More generally, these policies are based on supply-side incentives, including subsidizing physicians to deploy in rural and less populated regions. For instance, in France [40], since 2012, a "Health Territory Pact" contains measures to facilitate the establishment of young doctors in underserved areas. Similarly, regionally-differentiated remunerations have been adopted; for example [41], a beginning general practitioner in Quebec may receive up to 130% of the medical base fee if they practice in low-physician-density regions, with the additional revenue potentially reaching 40% after 20 years of practice. Likewise, in the US, additional payments for physicians locating in underserved areas have been introduced by Medicare. Studies on Chinese doctors show that the Gini coefficients of the number of doctors divided by population and service area are 0.003 and 0.88, respectively, indicating relatively fair distribution by population but significant disparities in service area distribution [4]. Overall, Beijing, Zhejiang, Shanghai, Jiangsu, Shandong, and Tianjin have higher doctor densities compared to other provinces, with oversupply in some regions like Zhejiang and Shandong. Several studies have utilized the Gini Coefficient and Theil index to explore the fairness of health resource allocation. For example, changes in the equity of doctor allocation in China from 2009 to 2013 have been investigated, and similar methods have been applied in studies of Taiyuan City and Iran to assess healthcare resource distribution and health spending inequality [42]. However, the equity of allocating health resources according to geographic area is crucial for the utilization rate of health resources. Therefore, it is suggested that in the new era, when formulating pharmacist plans, both the population served and the geographic area should be comprehensively considered, in order to improve the geographic accessibility of pharmacy services and meet the needs of residents for pharmacy services.

This study also decomposed the Theil index. The results showed that the unfairness in the allocation of pharmacist human resources is mainly caused by regional internal differences, which is consistent with previous

research [43, 44]. Further analysis of the contribution rate of different economic regions to the national Theil index was conducted. The study found that if allocated according to population, areas with middle-to-low per capita GDP and low per capita GDP are the main reasons for the unfair allocation of pharmacist human resources. It is worth noting that if allocated according to geographical area, areas with high per capita GDP are the main reason for unfair allocation. This is not difficult to understand, as regions such as Tibet and Xinjiang have vast territories and sparse populations, with a larger service radius, while Beijing, Shanghai, and other areas are the opposite, with a huge gap in economic development level. Therefore, allocating pharmacist resources based on population is clearly advantageous to the latter, while allocating based on geographical area is advantageous to the former. Therefore, it is recommended that policy makers fully understand the impact of regional internal differences on the allocation of pharmacist human resources, increase financial support to areas with middle-to-low per capita GDP, and introduce corresponding employment guidance policies to attract more excellent healthcare professionals.

This study represents the first nationwide time-series analysis of pharmacist human resource allocation in China, providing an essential foundation for future research. We emphasized that the study addresses the fairness of resource allocation across geographical areas and populations, which is a critical aspect of health resource management. However, there are some limitations. First, the study only included 31 provinces, municipalities, and autonomous regions in mainland China, excluding Hong Kong, Macau, and Taiwan. The healthcare systems in these regions have differences from mainland China, and further research can explore their impact on the overall fairness of pharmacist human resource allocation in China. Second, the study divided the regions by economic development level and analyzed the contribution rate of inter-group and intra-group differences to the total Theil index, reflecting the overall fairness impact of economic and non-economic factors. However, we did not study the specific impact of these factors on the fairness of pharmacist personnel allocation.

Conclusion

The findings of this study on hospital pharmacists complement our previous research on maternal and child health care institutions, where similar issues of allocation and fairness were observed [25]. Despite the Chinese government's great efforts in the pharmacy workforce, our research shows that there are still disparities in the distribution of pharmacists in different regions of varying economic development. Population-based allocation is found to be fairer than geographical-based allocation. Additionally, the quality structure of pharmacists still falls short of the standards recommended by the World Health Organization. Policy makers in the future should pay particular attention to the impact of regional disparities on the allocation of pharmacy human resources, and continually improve the geographical accessibility of pharmacy services.

Abbreviations

FA	Fairness assessment
GDP	Gross Domestic Product
G	Gini coefficient
HRDI	Health resource density index
MCH	Maternal and child health
T	Theil index
WHO	World Health Organization

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Authors' contributions

"NI Hengfan and Du Hongling and Qiu Xiang wrote the main manuscript text and Ma Yuan and Peng Wan prepared Figs. 1-2. All authors reviewed the manuscript."

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Data availability

The data for this study came from: a). China National Health Commission official website (https://zs.kaipuyun.cn/s?searchWord=%25E7%25BB%259 F%25E8%25AE%25A1%25E5%25B9%25B4%25E9%2589%25B4&column=%25E5%2585%25A8%25E9%2583%25A8&pageSize=10&pageNum=0&siteCode=N000001752&sonSiteCode=&checkHandle=1&searchSource=0&areaSearchFlag=0&secondSearchWords=&topical=&docName=&label=&countKey=0&uc=0&left_right_index=0&searchBoxSettingsIndex=&isSecondSearch=undefined&manualWord=%25E7%25BB%259 F%25E8%25AE%25A1%25E5%25B9%25B4%25E9%2589%25B4&orderBy=0&startTime=&endTime=&timeStamp=0&strFileType=&wordPlace=0), b). China National Bureau of Statistics official website (https://www.stats.gov.cn/sj/zxfb/202302/t20230203_1901083.html) and c). China Ministry of Civil Affairs official website (https://zwfw.mca.gov.cn/apps/areaWeb/index.html).

Declarations

Ethics approval and consent to participate

Not applicable. The data used in this study is publicly available and no permission is required to access the data.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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